BEFORE THE
OIL CONSERVATION COMMISSION
STATE OF NEW MEXICO
Santa Fe, New Mexico

September 19 and 20, 1957

# TRANSCRIPT OF HEARING

Case 1308

VOLUME 1

DEARNLEY - MEIER & ASSOCIATES
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BEFORE THE
OIL CONSERVATION COMMISSION
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IN THE MATTER OF: Case 1308

Application of Sunray Mid-Continent Oil Company for an Order extending the horizontal limits of the Bisti-Lower Gallup Oil Pool in San Juan County, New Mexico, and temporarily establishing uniform 80-acre well spacing and promulgating special rules and regulations for said pool. Applicant, in the above-styled cause, seeks an order extending the Bisti-Lower Gallup Oil Pool to include:

TOWNSHIP 24 NORTH, RANGE 10 WEST
All Sections 2 & 3
Section 4: S/2

TOWNSHIP 25 NORTH, RANGE 10 WEST
All Sections 19, 26, 27, & 28
Section 31: S/2
All Section 35

TOWNSHIP 25 NORTH, RANGE 11 WEST
All Sections 7, 13, 14, & 15
Section 16: N/2
All Section 24
Section 27: SW/4
All Sections 28, 29, 30, 35, & 36

TOWNSHIP 25 NORTH, RANGE 12 WEST
All Section 3
Section 4: N/2
Section 5: NE/4
Section 7: SW/4
Section 10: E/2
All Sections 11 & 12
Section 17: SW/4
All Section 18
Section 25: S/2

TOWNSHIP 25, NORTH, RANGE 13 WEST
Section 1: SW/4
All Section 2
Section 3: S/2 & NE/4
All Sections 4 & 11
Section 12: S/2 & NW/4

TOWNSHIP 26 NORTH, RANGE 12 WEST
Section 31: N/2
All Section 32

TOWNSHIP 26 NORTH, RANGE 13 WEST
Section 26: N/2
Section 29: S/2, NW/4 & W/2 NE/4
All Sections 30, 31, & 32
Section 36: NE/4

The applicant further seeks the establishment of temporary 80-acre well spacing in the Bisti-Lower Gallup Oil Pool with units to run either North and South or East and West and with well locations on diagonal quarter-quarter sections within a governmental quarter section; and further, for the promulgation of special rules and regulations for the said Bisti-Lower Gallup Oil Pool, including but not limited to, the taking and reporting of gas-oil ratio and bottom hole pressure tests.

BEFORE:

Mr. A. L. Porter
Mr. Murray Morgan
Honorable Edwin L. Mechem

TRANSCRIPT OF HEARING

MR. PORTER: The hearing will come to order. The Commission will consider next Case 1308.

MR. COOLEY: Application of Sunray Mid-Continent Oil Company for an order extending the horizontal limits of the Bisti-Lower Gallup Oil Pool in San Juan County, New Mexico, and temporarily establishing uniform 80-acre well spacing and promulgating

special rules and regulations for said pool.

MR. CAMPBELL: If the Commission please, I am J. M. Campbell, Campbell and Russell, Roswell, New Mexico, appearing on behalf of the applicant. I would like to enter an appearance also for L. C. White; Gilbert, White and Gilbert, and for Mr. Burns Errebo, Tulsa, Oklahoma, attorneys for the applicant.

With the permission of the Commission, I would like to make a brief statement of the position of the applicant in this particular case. Most of the spacing cases of this nature which this Commission has heard in the past have involved deep reservoirs with effective water drive mechanism. The testimony here will show that in this particular reservoir, which is approximately 5,000 feet, there is a solution gas drive. There is another element present in this case, which to my knowledge, has not been present in any other spacing case before this Commission. A few weeks ago, months ago, this Commission entered its order authorizing a pilot pressure maintenance program in the Bisti-Lower Gallup Pool. This project, of which the applicant is operator, is now in operation. It is the primary position of the applicant here that in order to effectively develop that program of pressure maintenance and obtain the greatest ultimate recovery of oil from this reservoir, that the spacing which has been developed to date on a general 80-acre density should not at this time, at least, be disturbed, and to disturb might injuriously affect the operation of this effort

at pressure maintenance, which applicant's information indicates, and as will be presented in the evidence, is the only method by which a reasonable recovery of investment can be obtained from this reservoir.

We have two witnesses which we would like to have sworn at this time, and Mr. Errebo will interrogate these witnesses on behalf of the applicant.

MR. PORTER: Mr. Cooley, will you swear the witnesses?

MR. COOLEY: Are there any other witnesses in this case? Any other testimony to be presented?

MR. SETH: If you would like to swear the witness, we would enter an appearance on behalf of Shell, Mr. Oliver Hill and Mr. Oliver Seth, Seth and Montgomery. We do have some witnesses.

MR. MALONE: Ross Malone for Gulf Oil Corporation. We would like to enter Gulf's appearance in opposition to the application and to enter the appearance of Mr. Booth Kellough, Division Attorney from Denver, in addition to Ross Malone. Both of us expect to participate in the hearing, and Mr. Willard Bauman is our witness.

MR. SULLIVAN: Just one moment. The reason I didn't rise earlier is I didn't want to interrupt. My name is R. W. Sullivan. I am a lawyer from Denver representing the British American Oil Company, and I will have two witnesses, Mr. Thomas Hogan and Mr. Stein that I ask to be sworn with the group.

MR. SELINGER: I would like the record to show that George Selinger appears for Skelly Oil Company.

MR. PORTER: No witnesses?

MR. SELINGER: Perhaps a witness.

MR. COOLEY: Would you have your witnesses stand up and be sworn.

(Witnesses sworn.)

MR. BUSHNELL: Bushnell, attorney for Amerada. I would like to enter an appearance, no witness.

MR. KELLAHIN: Jason Kellahin, appearing on behalf of the Phillips Petroleum Company. At the present time we do not contemplate having a witness.

MR. HINKLE: Clarence Hinkle of Hervey, Dow and Hinkle, and I would like to enter an appearance on behalf of Humble, although we don't expect to put on any testimony.

MR. WADE: H. N. Wade, Texas Company.

MR. LEWERS: Robert Lewers, attorney for Sun Oil. I would like to enter an appearance for Sun here. I don't believe we have any witnesses at this time.

MR. KEELER:: E. P. Keeler, Magnolia Petroleum Company. I would like to enter an appearance. We will have no witnesses.

MR. WOODS: : A. W. Woods, Monsanto Chemical Company. I want to enter an appearance. We have no witness.

MR. TOMLINSON: Tomlinson for Atlantic. We will have no

witnesses but would like to enter an appearance.

MR. PORTER: Anybody here who isn't appearing in the case? Mr. Errebo, you may proceed with your witness.

MR. ERREBO: As the applicant's first witness, I would like to call Mr. L. G. Finfrock.

If it please the Commission, we have passed out to the members of the Commission and to your Staff all of the exhibits which will be offered in testimony and in evidence by our first witness. These exhibits are copies of the exhibits which you see on the wall and which will be used by the witness in his testimony. The only difference being that they are on a smaller scale. We would like to make one set of these exhibits on the smaller scale, the official exhibits for the Commission.

L. J. FINFROCK

called as a witness, having been first duly sworn, testified as follows:

DIRECT EXAMINATION

By MR. ERREBO:

Q Will you state your name, occupation and by whom are you employed?

A L. J. Finfrock, Staff Geologist, Sunray Mid-Continent Oil Company in Tulsa, Oklahoma.

Q Will you please state briefly your background of education and experience?

A Graduated from the University of Illinois in 1940 with Bachelor of Science degree in geology and received my Masters of Science degree in geology from University of Illinois in '48. I worked for the Carter Oil Company for a period of seven and one-half years as a subsurface geologist, and have been with Sunray Mid-Continent for a period of seven years, at which time I served six years as a District Geologist and the past year as a Staff Geologist in the Tulsa Office.

Q Mr. Finfrock, are you familiar with the geology of the Bisti-Lower Gallup Oil Pool? A Yes. I am.

Q Have you ever previously testified before this Commission?

A I have.

MR. PORTER: His qualifications are acceptable.

Q What is the geographic location of the Bisti-Lower Gallup Oil Pool?

A The Bisti-Lower Gallup Oil Pool is located twenty miles south and slightly east of the City of Farmington in San Juan County, New Mexico.

Q A map which has been marked Exhibit No. 1 has been placed on the wall. Will you please go to this map and identify and explain it?

A Exhibit No. 1 is an area map of the Bisti-Lower Gallup Oil Pool located in portions of Township 24, 25, 26 North, Ranges 10, 11, 12, 13 West of San Juan County, New Mexico. We have shown

on this exhibit in the heavy red border, the outline of our proposed area for 80-acre spacing. We have shown here in the green border at the common corners of Township 25 and 27 North, Ranges 12 and 13 West, the area of our pilot injection program which has previously been okayed by this Commission. We have shown also on this map in colors the various types of leases in this area. Shown in red are the Federal leases. Shown in green are the State leases, and in orange are the Federally administered Indian leases in this area.

Now, we do not find any patented land within the area of this proposed application. Within this area there is 46,720 acres, approximately, of which 4200 acres belong to the State, which is approximately 9% of the total. The Federally administrated leases, approximately 23.3% of the total within this area, and the Federal leases, 67.7% of the area within this proposed 80-acre spacing program.

Q What was the discovery well for this pool, Mr. Finfrock?

A The discovery well for this pool was the El Paso No. 1 Kelly State, located in Section 16, Township 25 North, Range 12 West, San Juan County, New Mexico, which was initially completed on October 7, 1955 with an initial production of 180 barrels of oil flowing after fract treatment.

Q Are all of the completed wells shown on this map completed in the Lower Gallup?

A Yes, all of the wells shown on this map are completed from the Lower Gallup formation. We have, according to the best information available to us, as of September 4, 1957, 134 wells drilled within this area, of which a total of approximately 120 were oil wells, 5 shutin gas wells, and 9 dry holes.

Q Is present development on an 80 acre lease density?

A Yes, the present development of the pool is on an 80 acre density. However, we have a few areas within the outline of this map of which locations have been established for 40 acre locations, and should these locations be drilled, they would violate the 80 acre density pattern that has so far been adhered to by the operators in the Bisti-Lower Gallup Oil Pool.

Q What companies have established those locations?

A To my knowledge, these locations were established by the Shell Oil Company in and around the Carson Unit area.

Q How was the proposed spaced area determined, Mr. Finfrock?

A The proposed spaced area, which is outlined here in red, was determined from the following conditions: As a result of engineer's studies of the Bisti, Engineering Committee results of geologic study, results of sand studies, and also the results of the drilling of the exploratory and development wells within this area to roughly define this pool.

Q Will this pool probably extend southeastward from its present limits?

A I feel that this pool will very likely extend further in a southeasterly direction inasmuch as it has not been definitely defined by the drill.

Q Will you please refer to Applicant's Exhibit No. 2 and identify and explain it?

A Exhibit No. 2 is a reproduction of a portion of electric log of the Shell Oil Company No. 1 Carson Well, a wildcat, located in Section 24, 25 North, 12 West. This well was chosen as our type well inasmuch as it penetrated completely through the Lower Gallup formation. We have shown here, or indicated in yellow, the extent of the Lower Gallup formation, the top of which we have shown here at 4860 feet, and the base of the Lower Gallup formation at 5143 feet. The Lower Gallup formation in this area of the Bisti-Lower Gallup Oil Pool has an approximate average thickness of 380 feet. The sands in the Lower Gallup formation are composed of fine, light grain, fine to medium sands, with clean, well sorted sands in the central portion or core of the bar deposit. These sands grade laterally from the core of the bar into finer grained sands, silt stones and shaly sands.

Q Mr. Finfrock, have you read the application in this matter?

A Yes, I have.

Q The Shell No. 1 Carson is one of the wells in which the top of the Lower Gallup was identified in that application, is it not?

A That is correct.

Q Will you please refer to Exhibit No. 3 and identify and explain it?

A Exhibit No. 3 is an isopack of the upper sand of the Lower Gallup formation, contoured with a contour interval of two feet, based on the microlog separation as seen in the Schlumberger wells that were available to us. We have shown here also the outline of the proposed spaced area. As can be seen from this exhibit, the attitude of this upper sand in a northwesterly, southeasterly direction is that of a bar type deposit with the thicker sequence of beds going through the central portion or core of this deposit, of which a maximum of 22 feet of separation had been noted.

As you can also see from this exhibit, they grade laterally down to the zero isopack line, which is shown here to the northeast and to the southwest, by a dashed line. We find in these Lower Gallup sands, particularly in the uppermost sand of the Lower Gallup, that the permeabilities and porosities of the sand are better developed in the central portion or core of this bar, and in the subsidiary sands in this formation, and as we approach the outward limit of the bar, the sands become less permeable and less porous.

Q In other words, what we have here then is simply a buried sand bar, is that correct? A That is correct.

Q Do you find any interruption in the sand development from one end of this pool to the other?

A On the basis of our geologic study of the sand in the

Lower Gallup formation, we have found no evidence of a break in this deposit throughout this entire area of approximately 30 miles.

Q Will you please refer to Exhibit No. 4 and identify and explain it?

A Exhibit No. 4 is an isopack map of the second sand in the Lower Gallup formation, also contoured on a two foot contour interval and based on microlog separation. This sand, as can be seen on this exhibit, also reflects the same general strike pattern of that, of the upper sand, although this sand is not as well developed as the upper sand, nor does it continue completely across the area as does the upper sand.

Q This sand does appear to be continuous throughout the entire area to the best of your knowledge, which you now have available to you, is that correct?

A We have seen in our study no definite evidence that this sand is terminated in the core part of this deposit.

Q Will you please refer to Exhibit No. 5, which I believe is the structural map, and identify and explain it?

A Exhibit No. 5 is an aerial structure map of the Bisti-Lower Gallup Oil Pool with the datum on the top of the Lower Gallup formation on which these structural contours were made. The contour interval of this map is 20 feet. We have also shown hereon by the red border, the proposed area for 80 acre spacing, and by the yellow border here we show the area presently classified by the Commission

as the Bisti-Lower Gallup Oil Pool.

We also refer to the outline of our LPG gas injection at the location of the common corners of 25, 26 North, Range 12 and 13 West. Also shown on this map in the longitudinal direction is the blue line A, $A_1$, which represents the trace of our cross section, Exhibit 6-A. The transverse line on this map, B, $B_1$, C, $C_1$, D, $D_1$, E, $E_1$, and F, $F_1$, represent the traces of the transverse cross sections labeled Exhibit B, C, E, D, and F.

As can be seen from the structural map, we see an anticlinal dip into the basin in a northeasterly direction. We show no evidence of structural closure within this entire recommended area.

We believe that the trap for the Lower Gallup oil was afforded by nature of a stratigraphic trap rather than that of structural closure, with the buried sand bar being the reservoir and the bounding impermeable silts and shales affording the impermeable barrier needed to make this trap. We also show here in the southeastern portion of this map by a dashed red line and a dashed green line, the area which we label here and zone of oil and gas production, within this bounds we would find wells drilled should encounter both gas and oil, with wells drilled to the northeasterly direction from the dashed green line encountering only oil and wells drilling to the updip or southwest direction from the red line to its limitations would encounter gas.

Q Mr. Finfrock, will you please refer now to Exhibits 6-A

through 6-F inclusive, and identify and explain them.

A Exhibit 6-A, which Mr. Devlin will point out to you on our structural map, is the longitudinal cross section A, $A_1$, as shown here. This is a northwest, southeast electrical log cross section of the Bisti-Lower Gallup Oil Pool, San Juan County, New Mexico. We have shown here by this heavy dark line the top of the upper Gallup formation, and by this second heavy dark line the top of the Lower Gallup formation. We have shown hereon in a dark yellow color the upper sand in the Lower Gallup formation, which is the predominant reserve of this Lower Gallup reservoir.

We have shown in a pale yellow color the subsidiary sands in the Lower Gallup formation as they occur throughout this area. As can be seen from this exhibit, you will note that in each and every well on this cross section you will find that this upper sand of the Lower Gallup formation is present and well developed, and this sand has a very near uniform thickness throughout the area represented by this cross section.

Those who are closer will be able to see that within each of the well bores we have shown here the zones that have been perforated or tested for completion, and each of the sands that we have indicated in a yellow color have had perforations or tests made in them. This section is only to show those sands within the Lower Gallup formation of which perforations or tests had been made, and is not a straight stratigraphic section of the entire

Lower Gallup formation.

This section, as you can see here, has a difference of approximately 300 feet between its low portion and its high portion, which is in the area of the gas cap. Exhibit 6-B shown there by Mr. Devlin on our structural map, is the first of our transverse sections, and we show here the same features that we did on cross section A, $A_1$, with the deep yellow being the upper sand member. You can see here from this section that we do have the northeast dip into the basin. Cross Section C, $C_1$, also reflects the same information of the previous two exhibits, with the upper sand being shown in dark yellow. This cross section occurs in Sections 12 and 6 in Township 25 North, Range 26 West, San Juan County, New Mexico.

Exhibit D, $D_1$, third of our transverse sections, located in Sections 13 and 7 of Township 25 North, Range 11 and 12 West also show the same sequence of beds in the Lower Gallup formation, and this also shows the northeast dip into the basin as well as thinning of the Lower Gallup sand section as we go further away from the central portions of this bar.

Also shown here in this exhibit is one of the situations of which we feel there are probably many in the Bisti area, of which we have sands that are separated at the core of the bar in the Shell 14, 13 Carson, correlating and intermingling with the Shell 11-13 Carson, showing we do have direct communication of sand to sand in some areas within the Bisti Pool, or the Bisti-Lower Gallup Pool.

Cross Section E, $E_1$, is the essential north-south cross section through Section 20, and 17 of township 25 North, Range 11 West, San Juan County, and this exhibit also shows the northeasterly dip into the basin and the thinning of the sand sequence section as we leave the central portion of the bar proper.

You will note here on this exhibit that this is one of the instances where we find the uppermost sand member shaling out on the flank of the bar, and this occurs on this cross section between the Shell 23, 17 Carson and the Magnolia No. 1 sand wall test.

Exhibit F, $F_1$, is the essential southwest-northeast section through sections 27, 22, 25 and 14, San Juan County, New Mexico. This cross section shows a gentle dip and then a more abrupt dip into the basin as we go in a southeasterly direction. We also show here the evident thinning of the Lower Gallup sands as we go in a northeasterly direction. We also show on this exhibit the shaling out of this upper sand member at the outer fringe of the bar deposit between the Texas Company M-1 Navajo Well and the Benson, Montin and Greer No. 1 Harvey at the extreme north end of this section.

Q Is it your opinion then, Mr. Finfrock, that these cross sections show a continuous sand development of the Lower Gallup formation throughout this entire area?

A It is my opinion that this cross section shows that we have in the longitudinal direction, continuity of sand deposits

throughout the entire area with, as I pointed out in Exhibit 6-E and F, we do show the lateral gradiation as we leave the bar proper of some of the sand bars which is to be expected in this type of deposit; as you leave the core of the deposit and move out you will find the sands disappear on the flanks. That is to be expected.

Q Will you please refer now to Exhibit No. 7, the three dimensional drawing, and identify it?

A Exhibit No. 7 is a three dimensional drawing of the Bisti-Lower Gallup Oil Pool, San Juan County, New Mexico. This drawing was made up of all of the available Schlumberger logs that we could get ahold of to prepare this drawing.

Q Actually, Mr. Finfrock, that represents a large number of cross sections, doesn't it, on one exhibit there?

A Actually this map, as you can see here, shows innumerable areas of cross section within this dimensional map connecting the individual wells.

Q Will you please tell us how that three dimensional drawing was prepared?

A In looking at this drawing, I would like to orient you that on a map these heavy dark lines are the township lines in the north direction, with these being the east-west lines. You will be looking at this plane in a northeasterly direction. This plane surface we have depicted here is as if we had cut a slice out of the earth and an elevation of plus 1660 feet in elevation.

On this plain surface we have located on there surface location the individual wells that have been drilled within this Bisti Pool. After these wells have been spudded, we took their true subsea depth and plotted each individual well in its actual subsea location, and as you can see from these exhibits in the northeasterly or back portion of this map, we have much greater area shown by the dashed line between the actual location of the test and the top of the sand, whereas you move updip into the southwest you find that these locations actually approach into the top of the sand, showing that the beds have a dip here which we are attempting to show in this three dimensional view, dipping back to the north and northeast.

After these individual Schlumberger logs were traced upon this map in their new location, we then correlated from the top of the upper Gallup sand, which is the dark yellow sand in our cross section, we correlated each individual well to show the structural attitude on the top of the upper sand in the Lower Gallup formation. We then connected the base of the sand sequence where penetrated by another line, by a green line, this giving the aspects of individual cross sections. We then colored in green that portion of the Bisti-Lower Gallup Oil Pool which is oil productive.

We have shown in red that portion of the reservoir that is gas, and we have shown on this exhibit the gas-oil contact approximately plus 1530 feet, and have been able to show from this designation of

colors the projected outer limits of this gas cap.

All of this has been put on this plane map at this elevation of approximately 1660 feet to give you a picture, as we see it, of the structure of the Lower Gallup formation, the existence and the continuity of the sands as shown in each and every individual log, as well as to show the attitude of the contact between the oil and gas columns.

Q Mr. Finfrock, what would you say then is the significance of this exhibit?

A I feel that the significance of this exhibit is that it shows to us in one drawing the structural aspects of this field as well as showing us the continual type of deposition that we have within the Lower Gallup formation with our sand sequence gradually building up in each and every well into the uppermost sand, or predominant sand, in this bar deposit. And we can show from this exhibit that these sands are continuously developed, and we feel that a well drilled on 80 acre spacing in any position through this field would encounter the same sand conditions as a well drilled on closer spacing.

Q Will you please refer to Exhibits 8A through 8F and explain and identify them?

A Exhibit 8A is a distribution map of the upper sand member of the Lower Gallup formation. This is the same sand member we have referred to in our cross sections as the deeper colored yellow sand

in the upper portion of the Lower Gallup formation.

We have also shown hereon the outline of our proposed area for 80 acre spacing.

Q When you call that a distribution map, you mean that is a map that simply shows in orange where the sand is found, is that correct?

A I made a detailed study of each log that was available to me to study, and see what sands were present in each well. I then plotted this information on a work map and compiled from that work map these six individual distribution maps which we have here as Exhibit 8. We have only attempted to show on this map by this method the areas where we have encountered this sand developed in the individual wells. We have not tried to define the quality of the sand. We have wanted to show where the sand was developed, and as you will note on this exhibit in the area of Section 30 of 26 North, Range 12 West, we have a solid line shown which defines the northeasterly limit of this sand at that point inasmuch as it was not present in the El Paso No. 1-B Well in Section 30, also in Section 16 of 25 North.

We show a solid black line to indicate that in the Skelly State Well No. 8 this sand was not present, defining in that position a portion of the southwesterly limits of the bar deposit. Also in Section 25 North, Range 11 West, we find a portion of this area defined by a black line indicating the sand was not present in this

area. Also in Section 14 of 25 North, 11 West, we find that same area where the sand was not defined, but in the rest of the entirety of this exhibit we find the sand present as shown by the shaded orange area.

Exhibit No. 8-B is the sand distribution map of the second sand member or bench in this Lower Gallup formation. We have also shown here the outline of our proposed unit, and show here in orange the distribution as proven in the individual well logs of this second sand member. In the northwestern portion of this field you will note that we have a solid black line extending from Section 29 in 26 North, 13 West through in a southeasterly direction into Section 5 of 25 North, Range 12 West, at which point we were able to define the outer limit of this sand.

Exhibit 8-C is a distribution map of the third sand member in the Lower Gallup formation, also showing the outline of the proposed area, and in orange showing our known distribution of this sand. We have here two instances where the outer limits of this sand was defined in Township 25 North, Range 12 West on the north flank of the bar and in 25 North, 11 West in Section 25 on the south flank of this bar deposit.

Exhibit 8-D is the distribution map of the fourth sand member of the Lower Gallup formation showing also the outline of our proposed area for spacing. This map also shows in orange the distribution of this member of the Lower Gallup. In the extreme northwest

portion again we show by a solid black line Section 29, 28 and 27, the northern limit of the sand in that portion, and at Section 30 of 26 North, 12 West, the northeastern limit of the sand at that area.

Exhibit 8-E is the distribution map of the fifth sand member of this Lower Gallup formation; also shown on this exhibit is the outline of our proposed area for spacing with the area known occurrence of the sand shown by orange. We have shown here Section 29, 28 and 33 of Township 26 North, 13 West, a portion of which on the southwest flank this sand was not identified.

Exhibit 8-F is the distribution map of the sixth sand member of the Lower Gallup formation, and like the other maps, in this exhibit, shows the area of our proposed spacing and shows the area of known sand by orange, with the solid black line extending from Section 3, Township 25 North, Range 12 West in a southerly direction into Section 20 of 25 North, Range 11 West, where this sand is defined on the northeast flank.

As you can note from observance of this Exhibit 8, you can find that these sands all lay in approximately the same position along this bar deposit in a northwest-southeasterly direction, and that these sands are present in approximately the same positions, but by some varying degree on each member they are not exactly stacked on each other. There is some variation as can be seen from the discussion of these exhibits.

Q I take it then, Mr. Finfrock, from these various exhibits that you have presented here today, that you have examined the logs of all the wells in this field, is that correct?

A I have examined 134 electric logs of wells in this field.

Q Actually there are other logs of some of the more completed wells which you haven't had an opportunity to examine?

A That's correct. There are some wells that have been completed in this field which the logs have not come to us as yet. It takes awhile between the completion of the well and the time that you are able to get a Schlumberger log for study. We do not have logs of every well in the field.

Q Have any of these sands been found to be absent in any well in this field?

A In a longitudinal direction we have found no evidence of these sands being present, but as I pointed out in the discussion of this exhibit, we find that in a lateral direction we have found instances where these sands do shale out as we approach the outward limit of this deposit.

Q To correct the record, you said you found no evidence of these sands being present, you mean absent?

A Absent, yes, sir.

Q Have you found any faults in this general area?

A I have seen no evidence of faulting in my study.

Q Is it your opinion then that the main sand body and each

of the other subsidiary sands are present and probably present or probably present throughout the entire area covered by this application? A That is my opinion.

Q Is it your opinion that these sands are continuous and form a common source of supply? A Yes, it is.

Q Would you call the Lower Gallup reservoir a lenticular reservoir?

A No, I would not call the Lower Gallup reservoir a lenticular reservoir inasmuch as we have been able to define its presence over an area of approximately 20 miles in length. I do not consider that a lenticular type of deposit inasmuch as in a lenticular type deposit you do not anticipate the sand in the lenticular nature in offset locations, and this is not the case here in this study.

Q You believe that the 80 acre proration unit and plan of well location, as proposed by Sunray Mid-Continent in this application, is reasonable? A Yes, I do.

Q Were all of the exhibits which have been offered as a part of your testimony here today prepared by you or under your supervision? A They were.

MR. ERREBO: We will at this time like to offer these exhibits, I believe 1 through 8, in evidence.

MR. PORTER: Any objection to the admission of these exhibits? They will be admitted.

MR. ERREBO: That's all the direct examination we have

of this witness.

MR. PORTER: Does anyone have a question of Mr. Finfrock?

MR. SETH: I would like to ask several questions, please.

CROSS EXAMINATION

BY MR. SETH:

Q Mr. Finfrock, you indicated at the outset that the field had been developed so far on an 80 acre density --

A Density.

Q What do you mean by that I'm not familiar with that term?

A By that term we mean that this field has been developed in a manner such that any well drilled at this time in this field can be assigned an 80 acre unit.

Q Then by so arranging the 40's you can assign acreage to any well?

A To any well that has now been drilled.

Q That, if I understand it correctly, is what you wish to accomplish by your application here, is to continue that same method throughout the life of the field, is that right?

A That 80 acres be assigned to each well?

Q Yes, just as you testified has been done heretofore.

A Well, before it's, as I understand, it has been on a voluntary basis and these wells have been drilled at a density at which 80 acres can be assigned to them, and under our application we would define 80 acre units which they have not been defined as

such to this point.

Q Now, had you made any examination to see how many wells are off pattern if a regular 80 acre spacing program had been put into effect?

A As if --

Q (Interrupting) When I say 80 acre, I mean limited to the northwest, southeast quarter or northeast, southwest.

A I do not have a figure at hand, but there are several locations I know that are not drilled on a stated location as you suggested there.

Q Would you say half of them, half of the wells in that field?

MR. ERREBO: If I could, Mr. Seth, I would like to state at this time Sunray has made a count of the wells which would be located off pattern, which are located off pattern according to our best information, and that would be 15 wells.

MR. SETH: Off what pattern?

MR. ERREBO: Well, that would be wells which would be located, for instance two wells located in the same half of a quarter section.

MR. SETH: But you have made no study, if I understand it correctly, on a strict northeast, southwest, northwest, southeast basis?

MR. ERREBO: Yes.

MR. SETH: Fine, that was the question.

Q As to the nature of these particular sands, would it be

your opinion that they are relatively undisturbed sands that have been layed down under quiet conditions, or how would you characterize them?

A I would say these sands have been layed down in what we would call a near shore position which they have been reworked and sorted with the better sorting and larger grain size near the central portion of the sand bar and with these sands as they go in a lateral direction from the core, decreasing in size to a finer grain sand, and finally to silt stones that we have separation of the sands by water action.

Q Then there was a certain amount of wave action which disturbs the sands from time to time, is that correct?

A Very probably.

Q Were they disturbed by marine organisms of any sort, do you know?

A Well, now, not to the extent that we were just discussing as disturbed by deposition. Now marine organisms, minute microscopic marine organisms are known to be present in the Gallup formation. Personally, I can't see that there would be much in the way of disturbance from this presence other than being there in the reservoir itself.

Q I see. Have you examined the actual cores that have been taken?

A Personally, I have not examined the actual cores.

Q Then you wouldn't know whether there was evidence of disturbance of any character?

A I have not made that examination myself.

Q I believe that Sunray has testified in previous hearings that there is a wide range in the well bore of porosity and permeability, is that correct? A That is correct.

Q Now, in presenting the Exhibits, I believe it's 6-A, this longitudinal cross section? A Yes.

Q You have colored in yellow there the entire upper Gallup sand, is that correct, based upon an electric log?

A Electrical log correlations.

Q In doing that you have not taken into consideration any variations vertically in the character of the sand, is that right?

A If you were closer to the cross section you could see that we have shown by indentations and also by little zones of white within the yellow where you do have change in the overall thickness of the formation. In other words, where it varies from well to well we have shown that variance.

Q I wasn't thinking of the thickness of the formation. I was considering more the character of the sand. You have drawn a fairly continuous yellow band across there, which if I understand it correctly, is the upper Gallup? A That is correct.

Q That is as far as you have gone in coloring the exhibit?

A That is right.

Q Likewise on your exhibit which you called a distribution map of the sands, you have approached it similarly, is that right?

A Yes, that is not a quality analysis.

Q What would you say the ranges are of permeability and porosity, or will another witness consider that?

A Well, our Engineering witness will testify on permeability and porosities in this reservoir.

Q Generally such structure as the dips to the northeast, did you say?

A Yes.

Q Would you point out, I don't recall where the gas wells are, would you point those out?

A Yes, sir. In the southeast quarter of section 21, in the southwest quarter of Section 22, in the southeast quarter of 22, in the southwest quarter of 25 in Township 25 North, Range 11 West, in the southwest quarter of 30, Township 25 North, 10 West, five gas wells.

Q Now, are there any, considering those gas wells, are there any upstructure oil wells in that vicinity?

A To my knowledge, no.

Q There are not.

A Upstructure, you mean in a southwesterly direction updip?

Q Yes.

A On the map it is different.

Q I mean upstructure as far as the dip upstructure is concerned

A No, that is correct.

Q You are aware of no oil wells upstructure then, is that correct?

A No, we have no knowledge of any oil wells above this area which we have defined as the zone of oil and gas production.

Q Now, referring again to your eight service there, your distribution, you have cut off the lateral extent of those sands by your finding that they did not occur in the offset well, is that correct? A That is right.

Q Does that necessarily mean that they might not again re-occur as we get further north?

A No, it does not mean that. This study just means that in this bar which we have defined here in the Bisti Pool does shale out in these areas we have shown, and as it is disappearing in a basinward direction, we would not expect them logically to appear again, but that does not rule out the possibility that there may be some sand deposits in that direction.

Q You conclude, I believe, or it was your opinion, that the sand was not lenticular because you found it throughout a considerable area here. Now in that testimony you are again referring merely to the occurrence of the upper Gallup sand or whatever member concerned, and not with perhaps the lenticular character of the permeability and porosity, is that right?

A We are defining these maps on sand continuity in these

exhibits here, and on the Exhibit No. 3 which was an isopack of this upper member, the isopack was made on a microlog separation which shows permeability, and we found that by microlog interpretation we found that the upper deep yellow zone was present and permeable throughout this entire area as we showed on Exhibit 3.

Q It was present throughout. Would you turn back to 3 please?

A Exhibit 3, yes, sir.

Q Now, if you'll just select one isopack near the center of the field there and trace it out, if you would, for the Commission.

A A certain thickness?

Q Yes.

A Contour. Well now, we have here our 20, this is our 20 foot contour at this position, and at this position, at this position and now, that is not going into the record so good.

Q Well now, when, you are referring to Exhibit 3, are you not?

A Exhibit 3 which I am defining --

Q (Interrupting) You are pointing now to the isopack, what is the number or the contour?

A The 20 foot contour, which is --

Q (Interrupting) What township?

A We have the 20 foot contour shown in Township 26 North, Range 13 West, also in 25 North, 12 West and in 25 North, 10 and 11 West, we do not show the 20 foot contour. The sand is beginning to thin in the southeastern direction. We do not show the 20 foot

contour in Township 25 North, Range 10 and 11 West.

Q Now, in tracing those out you have indicated that they cover relatively small areas, especially in the northwest part of the field. Doesn't that indicate there are considerable local variations throughout the field as shown by your Exhibit 3?

A There are variations in the thickness of this bar sand which you would expect to find due to the fact that it is a shallow water type deposit, and you have sorting and the affect of current action, and you would not expect in my estimation to find this sand to be exactly a 20 foot thickness over a period of 20 miles; geologically we wouldn't expect it to be that consistent over that great an area.

Q That is not a continuous sand. You, I believe, testified that it was a continuous --

A (Interrupting) Well, yes.

Q (Continuing) -- sand deposit?

A It is a continuous sand.

Q The sand is continuous, but its character varies locally, is that a correct statement?

A The character varies as you leave this central portion as you go towards the outer edges of the bar.

Q It varies from east to west? A Laterally.

Q East to west also. You traced out the particular contour up there?

A It varies in thickness, yes, sir, from northwest to southeast.

Q You are not testifying now as to whether the quality permeability, porosity likewise varies laterally?

A No, this exhibit is not based on porosity and permeability figures.

Q Now, on the character of the sands, again, would you say they're uniformly cemented or what about the cementing?

A I would say about the character of the sands themselves that in this central portion of this deposit these sands are fairly clean, fairly well sorted with better permeability and porosities, and as you approach the flanks of this deposit you find increasing amounts of silt stones and exclusion of gray shales which would impair or lower the permeability factor.

Q Then again your exhibits, as 6-A over here, you again make no differentiation as here on the quality of the sand. You are showing the Commission here the occurrence of the Gallup sand and you are testifying that it is fairly continuous throughout this particular area. Now, it does not, or I might ask you, does the sand likewise occur outside the limits of your structural map over there, which is Exhibit No. 5?

A Outside the limits?

Q Of the red border.

A We haven't defined the outer limits of the Lower Gallup formation, but as you know, the Lower Gallup formation outcrops on the surface and it is present in the subsurface in New Mexico

Q Then its being a relatively common formation, we would expect if you trace just the formation or just the sand itself it would recur over a considerable area, is that correct?

A That is correct.

MR. SETH: I believe that's all.

MR. PORTER: Anyone else have a question of the witness?

By MR. MALONE:

Q Mr. Finfrock, when did you first have occasion to begin a study of the Lower Gallup sand in the Bisti Field?

A In the earlier part of June of this year.

Q When did Sunray drill its first well in the pool?

A In 1956.

Q And you have, since June of 1957, devoted yourself to a study of the conditions as to which you have testified?

A That is correct.

Q I believe you said that you are familiar with the application which Sunray has filed? A I have read the application.

Q Have you given any consideration to the effect of that application as it relates to the protection of correlative rights or the prevention of waste? A Yes.

Q Do you recommend the application as made to the Commission as protecting the correlative rights of the various owners of sands in this field?

MR. ERREBO: Excuse me. Isn't that asking the geological

witness a legal question?

MR. MALONE: The question of the occurrence of saturation in the sand formation and its distribution with relation to an 80 acre development pattern would seem to be a geologic rather than a legal question. I agree with you the question of what will protect correlative rights may be a legal question, but whether a well on 80 acres is going to let a man get all the oil that he is entitled to as layed down geologically, would seem to be a geological question.

Q Is it your opinion that development on the proposed spacing pattern will protect the correlative rights of the operators in this pool?

MR. ERREBO: Mr. Malone, I fail to see, I think you could ask this question a little better. This witness does not know about correlative rights from the legal standpoint.

MR. MALONE: All right, I will be glad to.

Q First I might ask the witness if he knows the meaning of correlative rights.

A I am not an attorney, but I understand that the correlative rights means the protection of the individual where there is a royalty owner or working interest of his portion of the pool or his reserves or what he should get out of it. I couldn't give you a correct definition.

Q I didn't expect a legal definition. You have testified before this and other commission on previous occasions, have you not?

A Yes, I have.

MR. SELINGER: I would like to make a formal objection to the Commission that this witness is incompetent, irrelevant to testify on matters of correlative rights. He is presented purely as a geological witness and we would like to make a formal objection to this line of questioning from this witness.

MR. MALONE: I have no intention or desire to ask this witness to testify as to anything that he does not purport to be qualified to testify to. He stated in answer to my question that he recommended to the Commission 80 acre spacing. I was asking him whether or not on the basis of the geological information to which he has testified, that spacing would recover, would protect the correlative rights by permitting each owner to recover his equitable share of the oil.

MR. SELINGER: We renew our objection.

MR. MALONE: If the witness states he is not in a position to answer the question, I will save it for another witness.

A I believe that is getting into the field of engineering more than pure geology.

Q Perhaps we can get at it from another point of view then. May I invite your attention to your Exhibit E, $E_1$ that you testified to over there. If I recall your testimony correctly, that that upper and thick yellow band was the principal and most prolific sand member in the Lower Gallup, is that correct?

A That is correct.

Q And that the lower band was additional sand members which are saturated and from which production has been obtained?

A Yes.

Q I believe you also testified -- may I inquire what the last well to the extreme right, your right, of that is?

A The Magnolia No. 1 Sanda Wall I believe.

Q Now, if you would indicate the well which you are now indicating, what is the designation of that well?

A The Magnolia No. 1 Sanda Wall, located in Township 18, 25, Range 11 West, San Juan County, New Mexico.

Q I believe you testified in that well the upper sand member had pinched out between the Shell No. --

A (Interrupting) 23-17.

Q (Continuing) -- 23-17 Carson and the Magnolia well, is that correct?

A That was my testimony.

Q The lower member was continuous over to the Magnolia westward?

A That is correct.

Q Now you mean that the upper member extends on to the 80 acre location on which the Magnolia well has been drilled, but that it does not extend to the location of that well, the Magnolia well will not obtain any portion of the oil that is in that upper member will it?

A This location of this well here in relation to the location

of this well, you asked me to state if this well would be able to get any, I mean this well, being the Magnolia well, would be able to get any of the oil that was present in the upper zone?

Q That is correct, and which might exist on the 80 acre spacing unit on which the Magnolia well is drilled.

A Now, we have, I don't know whether it would be my position to state or not, but we have in additional exhibits to come forward in this hearing, some exhibits on porosities and permeabilities in which we show that there is vertical permeability through this entire section, and I don't know whether that should be in the realm of me to answer the question about drainage.

Q I'll be glad to direct that question to a later witness. Can you testify whether or not in your opinion the Magnolia well would recover the oil from the upper sand member?

A I would say in primary operations it would not likely be, but under secondary recovery operations you would expect a program with vertical permeability there to sweep through the field and recover the oil that was not recoverable under the primary operation. That is as far as I can go into that.

Q You are not prepared to testify as to any barriers that may exist vertically to communication? A No.

Q That will come from another witness?

A Yes.

Q But insofar as your testimony goes, I just want to be sure

that I understand it, it is through primary operations the Magnolia well will recover none of the oil that may be in the upper member of the Gallup sand? A As far as I can see.

Q Now, with reference to the several sand members that you have testified to, what is the relative thickness of those sand members as you have found them?

A I would say the average thickness of the upper sand throughout this field average would approximate 15 feet, and of the secondary sands, these individual zones or benches would probably average four to six feet.

Q Is it --

A (Interrupting) I haven't made a study to get an average. That is just an estimate.

Q I'm not sure that I understood the delineation of those members. Now, is the first member that was shown on your Exhibit 8-A, that is the 15 or 20 foot principal member?

A That's right.

Q From which the best production will be obtained?

A That is correct.

Q The additional five members compose the lower yellow band that you have showed on your A, $A_1$ longitudinal cross section?

A That is correct.

Q Are the lateral limits of those various segments uniform or are they stacked on top of each other with various lateral

limits or aerial limits?

A Using your term they are stacked on top of each other, but their vertical limits are not precisely at the same point above each other. There is a variation.

Q There is a variance. So a well drilled at a given location might encounter one of those members but not encounter the next member even though an offset location would encounter both of them?

A In speaking of these reservoirs, we're dealing with marginal reservoirs here, and if you were looking for say one of these reservoirs or say two of these reservoirs, you very probably would not be looking at a commercial reservoir.

Q My question was whether the lateral edges of the sand barriers are so irregular that a well which penetrated one might not penetrate the same ones which were penetrated on an offset well.

A I do not have a definite figure, but based on my study of the logs and the preparation of the distribution maps, my estimation would be that out of the 134 wells that I studied that very probably, I don't know, maybe 90% of them encounter all the sands. That is just an estimate and it may be more than that.

Q Of the wells that have been drilled to date?

A The wells drilled to date. Those would be the wells on the marginal limits of this bar deposit.

Q If I may invite your attention to the Exhibit 3, the pinch out of the sands or the sand members which occur, occur as you proceed

away from the center of the sand bar, do they not?

A That is correct.

Q So that as we get out on the north and south flanks we find that one or more of those six members may have pinched out a little sooner or a little later than the next one, and they would not be coexistent in a given location as we come along the edge of the zone of saturation?

A That is correct. I would not be a precise point at which all members would shale out.

Q That lack of uniformity in those various oil-bearing members would exist along the flank of this entire field both north and south, would it not?

A Yes, that would exist on the marginal flank of the field.

Q So that wells drilled along the marginal flank of the field have no assurance of encountering all of the sand members which an offset well might encounter?

A Would not get all of the sands that an offset well near the central portion.

Q Near the central portion --

A Of the bar?

Q Yes. Did you testify as to the range of permeability which you found to exist in these sands?

A No, I did not.

Q Are you prepared to testify on that?

A We have exhibits. I could give some estimates. We have exhibits prepared and a witness who is to testify on that phase of the reservoir.

Q You have not studied permeabilities yourself?

A Not personally. I have read figures.

Q So you couldn't testify as to the range of permeability or porosity that may exist?

A No, other than figures that I have read, that would be all.

Q Your entire testimony is based on figures that you have read and logs that you have studied, is it not?

A Well, it has been my personal interpretation. I haven't measured permeability, I'm not an engineer. I have not measured any permeability.

Q All right. We will address that question to a later witness, thank you. In connection with your study of the Schlumberger logs, have you studied micrologs as well on these wells?

A I did not personally study the micrologs inasmuch -- I studied a few, I will say about fifteen, to familiarize myself with the picks that have been made by our geologist in our district office, of which the Bisti Field is under their guidance.

Q So that the testimony which you have given is not based upon an examination of micrologs of these wells to any extent?

A That is correct.

Q Do you have any opinion as to the relative value of

micrologs and electric logs?

A Yes. I would be lost without it.

Q Do you think that the information which might be disclosed by microlog study would be of value in the questions which the Commission is here considering?

A Yes, I think that microlog information as well as electric log information is a great help to the Commission and to anybody who does make a study of it.

Q Referring again now to the six members which compose the Lower Gallup Sands, you said that you had not examined any cores, I believe.

A That is correct.

Q Are you in a position to testify what, if any, barrier or division exists between those members?

A We find that in this section, as I mentioned in my testimony, that the Lower Gallup formation is composed of sand, sandy shales and silt stones throughout its entirety, and we have endeavored to show here the sand members which are the members which we are interested in inasmuch as they do show the greater permeability and porosities, although it has been found by engineers, and based upon core analysis studies and microlog studies, that we do have a vertical permeability range through this section.

Q But the fact that you have divided the lower segment into six members and the upper segment in a single member indicates that there are barriers between those lower members which do not exist

in the upper member, is that correct?

A We have divided the Lower Gallup, for the purpose of this display, into the upper member, the five. There is a total of six, the five subsidiary members which we feel are part of one and the same formation. We have only done this to show the outline of the better developed portions of this sand.

Q Why, then, did you not divide the upper member likewise into a group of members?

A Because we did not see a continuity in the change that was in the formation there, whereas you can see from our cross sections that you will find that these silt stone and shaly sand breaks, as we call them, are consistently present in their position in the section throughout this.

Q It is true, I think we are in agreement, but I can't get you to say so, that the reason you recognize several members in the lower segment is because of shales and silts which separate the sands which are the zones of saturation from which you do produce.

A These do stand out on our electric log in our means of correlation.

Q And because there is a separation of some type between them, can it mean a loss of porosity or permeability shale or silt?

A Yes, because there is a facies change.

Q There is a facies change. That change does exist in the lower segment made up of the five members?

A That is correct.

Q You find them, call them barriers, call them separations, call them facies, they still exist in a tier of a five-layer cake down there, is that correct?

A These facies changes exist and are correlative, but we do not define them as barriers.

Q Well, I believe you said that you were not prepared to testify on that? A That is true.

Q And since you cannot testify as to communication that would exist there, you would not be able to say whether they were barriers or not?

A Not from the electrical log basis alone, no, I wouldn't.

Q Would you like to withdraw that answer then?

A Well --

Q (Interrupting) That's all right.

MR. CAMPBELL: If the Commission please, I believe counsel has to take the bitter with the sweet.

MR. MALONE: I might suggest that the witness answered a question he wasn't qualified to answer.

Q Can you testify whether or not in your study of the relationship betweenthe gas well and the oil wells producing from this reservoir, whether or not there may be oil wells producing from perforations, at a higher level than gas wells on adjoining land?

A I am not in a position to answer that question.

Q You have not made a study of the logs of any of the gas wells down in Section 20 and 22?

A Yes, I have studied the logs.

Q Have you found that condition to exist?

A I think what you mean, have we found wells in which sands have been perforated lower in the column to complete as oil wells?

Q No, that wells which have been perforated and completed lower that adjoining wells are producing gas from a lower level than the lower wells producing oil.

A Oh, I have seen nothing of that.

Q You have seen no example of that?

A To my knowledge, no.

Q Would that have any significance to you if you did find that situation to exist?

A Well, it depends on if it were the same reservoir.

Q Well, you testified this is all one reservoir, have you not?

A Yes. The Lower Gallup Reservoir, that is correct.

Q If you found that condition to exist in this reservoir, would it have any significance to you?

A Well, it would show that we do not completely understand the mechanics of oil and gas migration, and if one did find gas production below the oil production, that it could be a result of the test or something like that, I'm not familiar with what type

of equipment was used and what testing was made or how these tests might have been conducted.

Q Would you agree with me that a condition of that kind might indicate either a lack of continuity or a lack of communication as between those wells?

A Well, I think that it would more likely be a result of a fract treatment going from one zone into another in opening up another area into the bore of the well to get your --

Q (Interrupting) It could have been caused by that, but it likewise could have been caused by a lack of communication, could it not?

A By lack of communication, I don't quite get your question.

Q Well, I understood you to testify that communication in your opinion existed throughout this reservoir?

A That's right.

Q That is was one common sand bar and that communication existed throughout it? A That is correct.

Q Now, if communication does exist, could the situation I asked you about likewise exist?

A It doesn't sould plausible, but geology is not an exact science. I've seen strange things in my career as a geologist.

Q That would have some bearing on it if the situation existed?

A If the situation existed you would be aware of it and wonder what caused such.

Q You are not prepared to testify it doesn't exist in this reservoir?

A To my knowledge, no.

Q You don't have any knowledge of wells of that?

A I have no knowledge of that.

Q Have you had an occasion to study other sand reservoirs in New Mexico?

A In New Mexico this is the only field that I have studied.

Q So you would not be able to testify whether there is any particular characteristic of this sand bar that does not exist in the numerous other sand horizons from which we are producing in New Mexico?

A I have spent a lot of my life studying cretaceous sands of which these are, and I feel that the type of deposit and the age is just as important as the geographic location, I mean, from the geological standpoint. Geographically I haven't studied any other field in this state.

Q How does this pool compare with the sands in the pool with which you are familiar?

A This is much longer reservoir than I have been able to study before, a larger reservoir, but it is also a reservoir which the permeabilities, as reported, are not as high as I've seen in other portions of the country, but as far as the geology of the deposit is concerned geologically, it is the same type deposit that we find

in this type of --

Q (Interrupting) You find nothing particularly out of the ordinary about this?

A No, it has fallen in every well with our concept of the geology of the field.

MR. PORTER: We will take a ten minute break.

(Recess.)

MR. PORTER: The hearing will come to order. Mr. Malone, will you proceed?

A I have one further question, if the Commission please. With reference to your distribution maps, Exhibits 8-A through F, am I correct in understanding that the area which you have delineated in orange as indicating the existence of a sand deposit, does not take into consideration in any respect the character of the sand or the porosity or the permeability of the sand?

A That is correct.

Q And the same thing is true of the three dimensional drawing up here? A That is correct.

MR. PORTER: Anyone else have a question? Mr. Utz.

By MR. UTZ:

Q Mr. Finfrock, referring to your Exhibit No. 1, the red outline designates your proposed pool limits?

A That is correct, for the 80 acre spacing.

Q Are you aware of the fact that your proposed outline is

substantially larger than the pool outlined as defined by the Oil Conservation Commission? A That is correct.

Q I note that in some instances your outline as you propose is substantially over a mile from the nearest producing oil well, is that correct? A It is correct.

Q On what basis do you believe that it would justify a pool limit that far away from a producing well?

A This border was arrived at because of the fact that as of now at this stage of the development of the field we do not know the definite limits this field will take, and based upon the studies of the sands which we have made, we feel that the sands are present over most of this area and would very likely, under field development, would include most of this area within the Bisti-Lower Gallup Oil Pool at a later date by further development.

Q But you are not sure that that whole entire area is productive, are you? A No, sir.

Q Would it not be better then to extend the pool as completions would justify on the basis of say 150 acres at that time?

A This outline is not definitely submitted as the finalized outline to be arrived at by the Commission, but it was a line that we thought would be reasonable in lieu of future development, but your suggestion would very likely be a good one to follow in enlargement of this field.

Q If we go too far in we might have a lot of dry acres inside

the pool? A That's possible.

Q Are you prepared to discuss this gas cap which I believe you've --

A (Interrupting) Well, that will be discussed under engineering testimony in the latter part of this hearing.

Q As to the means of producing those gas wells?

A That is correct.

Q Referring to your Exhibit 6-F, referring in particular to your cross section on your Shell 5 Carson in 27, 25 North, 11 West, is that a completed well?

A We show it as a location here although I don't believe the well has been officially completed, although it was tested, we do not show it as a completed well officially. According to the records we have available, 27, 25, 11, yes, that is correct, we show an initial production on this well, but we were never able to find an official completion for the well and did not show it as a completed symbol.

Q Is that an oil or gas well?

A I. P. 33 barrels of oil per day. It is listed here on our data. The gas-oil ratio is 17,000 to 1.

Q What was your answer?

A This Shell No. 5 Carson in Section 27 of 25 North, Range 11 West which we do not show as a completed well, has initial

production of 33 barrels of oil per day and a gas-oil ratio of 17,000 to 1.

Q Referring to the Es-Ka-Nel-E-Wood, Section 22, 25 North, 11 West, that was a gas well, was it not?

A Which one, we have Es-Ka-Nel-E-Wood- No. 1 and 2.

Q It is the No. 2.

A The No. 2 is a gas well.

Q Do you know what the gas-oil ratio was on that well?

A 1020 to 1.

Q 1020 --

A (Interrupting) No, wait, that's that 1020 to 1 is the ratio for the No. 1 Es-Ka-Nel-E-Wood. I do not have a figure for the No. 2 on my exhibit here, for the No. 2 Es-Ka-Nel-E-Wood.

Q Do you know if it produced any oil or not?

A 4500 MCF of gas per day initial production.

Q No oil reported? A No oil reported.

Q That is undoubtedly a gas well, is that correct?

A Yes.

Q We have a well which is structurally higher than the well we have just discussed, the Es-Ka-Nel-E-Wood No. 2, which produces oil, how do you explain that? This is a gas cap.

A The perforations in the Es-Ka-Nel-E-Wood No. 2 were at plus 1572 to plus 1568, plus 1566 to 1562, plus 1542 to plus 1535, those perforations were throughout considerable amount of section.

In the Carson well we show perforations here plus 1577 to plus 1613, and I don't know, I don't know where those are in the section on the log.

Q Doesn't your Exhibit 6-F show the structural position of your known completion?

A In the Shell 5 Carson we show these perforations, 9112 to 30 and from 5141 to 48. And the No. 2 Es-Ka-Nel-E-Wood we show the perforations 4923 to 29 and 4929 to 33, 4953 to 60, which according to this information, these two are in the same zones of the Lower Gallup formation.

Q Which well is structurally higher?

A This well is structurally higher, that is the No. 5 Carson.

Q No. 5 Carson is structurally higher and that is the one that you reported as producing oil from the 17,000 to 1 ratio?

A This is the report we got through the scout service.

Q If the Es-Ka-Nel-E-Wood No. 2 is a dry gas well and is structurally lower than Shell No. 5 Carson, then does that indicate a gas cap?

A I couldn't give you a definition of a gas cap. I don't know if I am qualified to define what actually constitutes gas cap. We have gas production in this well.

Q Do you have any explanation as to why a well structurally higher would produce oil?

A Based on this exhibit here, both sands were perforated

at the same position within the section I can't answer, give a definite answer as to the reason why there would be that difference. I don't know.

Q But nevertheless that is a fact?

A That is the facts as reported to us, that is correct.

Q In your opinion could there be communication between those two wells?

A Based upon the location of the No. 2 Es-Ka-Nel-E-Wood Well is in the southeast quarter of 22, 25, 11, and the Shell No. 5 Carson in the southeast quarter of Section 27, these wells are almost directly, the Carson well is almost directly north of the Es-Ka-Nel-E-Wood Well, coming away from the bar deposit in going into the marginal area of the bar.

Now, we have found in our studies that, as I mentioned before, that in the core of the bar we have the sand as a coherent body and as it goes out towards the limits of the bar we have found inerfingering of the sand into the shale near the limits, and we feel there is communication, but as you approach the outer limits of the bar you may find this interfingering affect will be shown somewhat, but I don't know. That's the only position that I'm able to take on that is that we're approaching the outer limits of this bar here and possibly in the geology there with the differences in what you would suppose to be the permeability between these two wells, it might lead to the fact of encountering some oil in lows out here

which we have shown as would be in a gas area.

Q Then your answer is that you are not sure?

A I am not sure, no.

Q Do you believe that both those wells are in the same common source of supply?

A Well, that's our belief.

MR. ERREBO: Mr. Utz, if I could interrupt to make that determination seems to me like it would take some engineering evidence and information which I believe this witness here has not had any disposal of, and he is not qualified to give it. We have an engineering witness who perhaps can give you better satisfaction on those questions.

MR. UTZ: All right. That's all the questions I have.

MR. PORTER: Anyone else have a question?

MR. SELINGER: I would like to ask the witness a few questions.

By MR. SELINGER:

Q I believe you stated on direct examination that you felt that the area was approximately 43,000 acres more or less?

A I think that was about 47,625, 46,720.

Q Approximately 47,000 acres, and it had approximately 134 wells or thereabouts? A To date.

Q So that the vast majority of the area is yet to be developed, is that correct? A That is correct.

Q And I believe you stated on cross examination that with reference to the upper pay that it averaged approximately 15 feet in thickness if you had to use an average figure?

A That is correct.

Q And that as to the secondary sands, it averaged if you had to use an average figure, in thickness, of four to six feet?

A Four to six feet.

Q Now, referring to Exhibit 3, on cross examination you were asked on the isopack map to trace one of the isopack lines, and you picked at random a 20 foot pay thickness. Can you likewise at random say, pick a 10 foot pay thickness and trace that across the field?

A Yes.

Q Laterally from the northwest to the southeast. Will you do so indicating on that exhibit, for the benefit of the Commission, the 10 foot?

A Indicating by sections?

Q No, just a continuous line with your pointer.

A The 10 foot contour line is this heavy line here on the north flank of the structure extending in a southeasterly direction as I am showing here, following all along across Township 25 North, 12 West, coming on across Township 25, 11 West, down to Section 29 which it turns and comes back up.

Q Where does that point stop?

A The point here of the furthermost southeasterly direction of this 10 foot contour point stops in the southeast corner of

Section 29, 25 North, 10 West, and we have shown here isolated 10 foot contour closures to the southeast with this original 10 foot contour line coming back up on the southwest flank of this bar on up to the extreme northwest limits of the field as defined by the drill.

Q So that your 10 foot contour line or isopack line can be traced practically across the entire northwest-southeast with the exception of the extreme southeast corner?

A That is correct.

Q Can you at random pick either the 12 or 14 foot isopack line and similarly trace it for the benefit of the Commission?

A The 14 foot contour line is the second contour line above the 10 foot line. I will start at this position and trace it around here and then start at this point and take the 14 foot contour line, trace it back through this large area here, then continue with the 14 foot contour line on across Township 25, 12 West, on through until we get into the southeast quarter of Section 18 of 25 North, 11 West, which we can turn this contour back, come back up in a northeasterly direction, then back to our point of beginning. And also we are able to trace the 14 foot contour point on beyond the break we show in 18 so that it will pick up here and go down in a southeasterly direction on across to this point here in Section 26, which contour line comes back upon itself again, and in Township 25 North, 10 West we do not show any 14 foot contour interval, and

this area here to the southeast is also the area of the less densely drilled portion of the field, and I'm certain, and I certainly would not want to say what the maximum development of the sand would be in this portion of the field.

Q Now, in between your points of control on your isopack map there are areas, you have undrilled area, is that correct?

A Yes, that are areas within this outline which have not been drilled or which we do not have information available to complete a map.

Q If subsequent development takes place and permits the drilling of additional wells in these areas and you have undevelopment, you will have additional information upon which to draw your isopack lines throughout the area, is that correct?

A That is correct.

MR. SELINGER: I believe that's all.

MR. PORTER: Any further questions of this witness? Mr. Errebo.

RE-DIRECT EXAMINATION

By MR. ERREBO:

Q Now, Mr. Finfrock, the question of lenticularity has come up this morning. You discussed that briefly in your direct testimony. I would like for you to discuss that a little more thoroughly as to what you mean by lenticularity. I would like to ask you this question, would you say that a lens is a very small local

deposit of sand, would you say that?

A A sand lens?

Q A sand lens.

A Yes, I would.

Q That is different from the surrounding sand, is that correct?

A Well, now, different in character or --

Q (Interrupting) Different in sand character, it may or may not be, is that right?

A A sand lens itself doesn't necessarily have to exhibit different characteristics. It may or may not, depending on the deposit.

Q Will you describe in more detail then what you mean by a sand lens?

A A sand lens or a lenticular sand in my opinion is a sand that in its deposition was not deposited over a wide area. It is normally a thin sand associated in a section which is predominantly sand and shale. Its lateral and longitudinal distances are very severely curtailed. It is, I would say, a local deposit not of a regional nature whatsoever.

Q Then sand extended throughout the entire area of that proposed spaced area, would you call that a lens?

A No, I would not.

Q Would you call it a lens if it just extended over half the area?

A No, not as a sand lens as we are thinking today.

Q That is also generally recognized by geologists and engineers?

A That is correct.

Q What if you had say six sections, would you call that a lens as it is generally regarded? A Not in my opinion.

Q How about one section, do you think that then you might be getting close to what you call a lens?

A We are getting down to the sands that I have dealt with as leaning sands, say where in a section area you drilled numerable wells and found this sand was present in a portion of these wells but not distributed evenly throughout, and that you would find that this sand is present in one well and not necessarily in an offset.

It is erratic in nature.

Q It doesn't necessarily mean it is lenticular, does it, just simply because a sand is erratic doesn't mean it is lenticular, does it?

A In order to have body to a sand you have to define a border of the sand as well as the main portion of the body, and it would, I would say, assume a lens shape.

Q Well, let me ask you one other question then. If this is an engineering question I wish you would state that you don't know. Do you generally conceive that the area contained within a sand lens or that the pressure within a sand lens is connected to that part of the reservoir outside the sand lens?

A Would you repeat the question, please?

Q Do you believe that a sand lens is pressure connected with the surrounding reservoir?

A I don't think I can answer that question.

Q Then now it is not surprising actually in any reservoir, is it, to find somewhat of a wide range of permeabilities and porosities?

A That is correct.

Q You can find that in any reservoir in any part of the country?

A I believe so.

Q You would be surprised if you didn't find it?

A I would certainly be surprised to find a field developed with the same permeability and porosity throughout.

Q As you approach the outer limits of this field, you were asked in cross examination whether or not you knew whether or not once the sand lensed out or shaled out that it reoccurred again.

A The sand that shales out here to the northeast does not reoccur again in this immediate vicinity. It is present several miles off, but in this immediate vicinity as far as our studies shows this sand is completely shaled out for quite some area.

Q Then once it shales out, you have no evidence here that in the immediate vicinity it does reoccur again?

A That is correct.

Q If it does reoccur, it is a number of miles off?

A That is correct.

Q This may seem like an obvious question, but it seems

to have been brought into question this morning. All reservoirs have to end somewhere, don't they? A That is correct.

Q They just don't keep on going. That is the reason you drill dry holes? A That is one reason.

Q You can't always tell where they end?

A No, you can't.

Q The extent of reservoirs is no respecter of property lines, is it? A That is correct.

Q If that is a case then a little bit of a reservoir may be a surface acreage of five acres could extend over across a property line, couldn't it? A Yes.

Q Now then, if that were the case, it might even extend further, might it? A That is true.

Q Depending on how much you had extending across a property line would depend on how many wells you had to drill in order to adequately recover that oil, wouldn't it?

A That is right.

Q Or at least to penetrate that sand body?

A Penetrate that sand.

Q It is possible that you may have to drill on a five acre spacing to penetrate a sand body which existed below a lease, is that correct? A That is true.

Q And even 40 acre spacing might miss?

A That is true.

Q Now then, you stated that you had studied, I believe, 15 micrologs out of the wells in this field?

A Yes.

Q That is a little less than 15%, 10 or 15%?

A Yes.

Q You consider those micrologs are representative of the sand conditions in the other micrologs that are in existence and available for the field? A Yes, I did.

Q I believe counsel asked you if this might not be like a five layer cake, this reservoir? A Yes.

Q Don't you think in this reservoir the icing on top is really the best part of this cake? A Yes, I do.

Q It's really not very good icing though, even at that, is it?

A That is correct.

Q Now, do you know of any other Lower Gallup oil fields in this area, do you know of any others in New Mexico?

A According to the best information that I can recall off hand, I think there is a small one-well pool in the Gallup formation approximately several miles to the north. I don't know the Section, 18.

Q In other words, there might be another one, but there are not very many, are there? A No, that is correct.

MR. ERREBO: That's all I have.

MR. PORTER: Anyone else have a question of Mr. Finfrock?

The witness may be excused.

(Witness excused.)

The hearing will recess until 1:15.

(Recess.)

AFTERNOON SESSION

MR. PORTER: The meeting will come to order, please. Mr. Errebo, will you call your next witness?

MR. ERREBO: For our next witness, we would like to call at this time, Mr. T. W. Brinkley.

T. W. BRINKLEY

called as a witness, having been first duly sworn, testified as follows:

DIRECT EXAMINATION

By MR. ERREBO:

Q Will you state your name, your occupation, and by whom you are employed?

A My name is T. W. Brinkley, Chief Reservoir Engineer, Sunray, located in Tulsa, Oklahoma.

Q Would you give us a brief background of your education and experience as a reservoir engineer?

A 1940 I received a Bachelor of Science degree in petroleum engineering at the University of Tulsa. During the last twelve years I have been a reservoir engineer. Ten of those years was with Carter Oil Company, five being Division Reservoir Engineer, three

being Laison Reservoir Engineer with Carter Research the production field operations and management, two years engineering in charge of Secondary Recovery Group where we evaluated secondary recovery possibilities, and the last year and a half I have been with Sunray, currently as Chief Reservoir Engineer.

Q Have you made an engineering study of the Bisti-Lower Gallup Oil Pool? A Yes, I have.

MR. ERREBO: Are his qualifications acceptable?

MR. PORTER: Yes, sir.

Q Now, Mr. Finfrock, has stated that this pool was discovered in December of 1955. What development has taken place since that time?

A As Mr. Finfrock stated, the pool was discovered in December, 1955, with the El Paso Kelly No. 1. Since then we have drilled, I say we, the operators have drilled 134 wells throughout this area, being bounded by the red line which represents our spacing area. Out of those total 134 wells, 120 of them are completed as oil wells as shown on our exhibit as solid circles. We have identified five completed gas wells down in the southeastern portion of the field. Also there have been nine wells completed as dry holes within the boundary as we have shown here in red.

Hence, we have a pool approximately 20, 25 miles long, contains oil, it contains a gas cap down the southeastern portion, and to date it is not completely defined, but we feel that the future

development necessary in order to completely define this field will be accomplished within the red outline.

Q What development pattern have the operators been following?

A To date the operators have followed a voluntary 80 acre lease density. This means that every well drilled so far can be assigned 80 acres from its own lease. Most wells drilled have been located in the center of diagonal quarter, quarter sections within each Governmental quarter section. On the basis of 80 acres assigned to each of the wells completed to date, would indicate that we have approximately 10,000 acres developed.

Q Mr. Brinkley, do you have any information that this voluntary 80 acre density will not be continued?

A Yes. Section 22, Township 25 North, Range 11 West, northwest quarter, Shell has publicly announced four locations on the 160 acre tract which is 40 acre spacing. Likewise in Section 9, Township 25 North, Range 12 West, the north half, Shell has publicly announced four additional locations in the north half of the section, putting that on 40 acre spacing. In addition, Section 10, same township, Shell has publicly announced at least three additional locations in the southwest quarter, which puts that quarter on a 40 acre spacing.

Q Does this constitute a serious threat then to our present voluntary 80 acre density that the other operators have been following in this field?

A Yes, it constitutes a threat to the lease owners adjoining this closer spacing by requiring offset development.

Q Mr. Brinkley, at what point are we now in the life of this pool?

A We are in the early stage of development in this reservoir not only by incomplete development, incomplete defining of the reservoir, but also the accumulated oil to date represents a probable less than one percent of the oil in place.

Q I refer you to Exhibits 9 and 10 and will ask that you identify and explain them.

A Exhibit 9 is a tabulation of production statistics for the Bisti-Lower Gallup reservoir, San Juan, New Mexico. The data was gained from the New Mexico Oil and Gas Engineering Committee monthly engineering reports. The data shown on Exhibit 9 consists of seven columns which are identified as follows: First one on your left is the year and month, the second column the number of wells produced during the month, the third column is the oil production in barrels per month, the next column is the cumulative oil produced to the end of that month, the next column is the gas production in MCF per month, the next column is the accumulated gas produced in MCF, and the last column is the average gas-oil ratio for that month. The table lists the discovery month, which is December, 1955, when one well produced; immediately below that we have the months for the year 1956, and below that the months-

through July, 1957.

Now, if you would look in the fourth column at the bottom, you will see where the Lower Gallup reservoir has accumulated 903,689 barrels of stock tank oil. The next to the last column on the right-hand side, 543,260 MCF. That is an average ratio of approximately 600 cubic feet per barrel. This again demonstrates that the accumulated oil to date is a small percent of the original oil in place, again meaning that we are in the early stage of development.

Exhibit No. 10 is a graphical representation of some of the data carried on Exhibit No. 9. You will notice the graph is in two parts, an upper part and a lower part. The upper part represents the monthly gas-oil ratio, the dates of course are on the bottom of the graph, and the scale on the left side on the vertical side for the upper portion shows produced gas-oil ratio in cubic feet per barrel.

An inspection of the upper part of the graph indicates that the average ratio to date has been roughly 600 cubic feet per barrel. Also it indicates that for the last month that we have on this graph, being July, 1957, has indicated an advancing trend of the produced gas-oil ratio. The lower portion of the graph contains the produced oil and the produced gas, the former is shown as a heavy line, a bar graph, if you will, and the later the produced gas is in a hashered area, the produced gas is shown as a hashered area.

This is only a graph showing the same data presented in Exhibit 9, but some people prefer a graph, some prefer a table. Hence we have included both.

Q The allowables in this field are pretty low now, aren't they?

A Yes, the allowables have been low.

Q Do you know what they are for this month, Mr. Brinkley?

A I'm not sure, but I think they are seven barrels per well a day.

Q Have all operators been requested to furnish their information?

A Yes, the Engineering Committee for the Lower Gallup reservoir, Bisti, of which Sunray is the Chairman, have agreed, all the operator members of this Engineering Committee have agreed to furnish all available test information to permit an engineering evaluation of the Lower Gallup reservoir. I might mention the members of this committee, the following operators are members: British American, Phillips, Amerada, Gulf, Lyon, Shell, El Paso, and Sunray.

Q In other words, the operators have agreed to exchange information, is that correct? A That is correct.

Q Then your testimony today is based on such information as has been made available to you by the operators?

A That is correct.

Q What information do you have on the characteristics or the fluids which are contained in the Lower Gallup?

A We have the results of two bottomhole samples. The first sample was taken on Sunray Mid-Continent C-21, located in Section 8, 25 North, 12 West. The second sample is the British American Mayre No. 1 located in Section 1, 25 North, 13 West. Both of these bottomhole samples have been analyzed in the laboratory. The significant results of these laboratory tests are summarized as follows: The bubble point pressure, 1207 pounds per square inch absolute. Solution gas-oil ratio, 405 cubic feet per barrel. Reservoir volume factor, 1.26, reservoir barrels per stock tank barrel. Viscosity of the reservoir oil, 0.83 centipose.

Q Based on the engineering information now available, and the studies which you have made, what spacing do you recommend that this Commission adopt?

A It is my opinion, based on present information, that 80 acre spacing is proper for this pool. I feel we have sufficient data to justify that a permanent order would be proper and fitting, but no objection to a temporary order since we believe any additional data would confirm our present conclusions.

Q Do you recommend that this Commission, in its issuance of an order, extend the present area defined as the Bisti-Lower Gallup Oil Pool to include the area which is contained within the red outline on the various exhibits which Mr. Finfrock presented this morning?

A Yes, as Mr. Finfrock presented this morning, the yellow boundary represents the present known, or the presently defined boundary of the Lower Gallup reservoir. We have enlarged the area as shown by our red spaced outline. It is my recommendation that the Conservation Commission enlarge the presently known or identified yellow boundary to include the boundary as we have defined it here in the heavy red line.

Q Do you concur in Mr. Finfrock's testimony that the Lower Gallup formation is continuous throughout this area?

A Yes, I do.

Q Do you have any engineering information showing the quality of the sand which is covered by this application?

A Yes, I do.

Q Will you please refer to Exhibit No. 11 and identify and explain its significance?

A Before we open Exhibit No. 11, I would like to make some opening remarks. Exhibit 11 is the bound booklet of core analyses. This exhibit contains the results of cores taken on 26 wells. Bearing in mind now we have drilled and completed 134 wells, yet we have core analyses on only 26 wells. I believe that is enough information to permit a reasonable interpretation of the sand quality and sand characteristics for the Lower Gallup reservoir.

The first eleven pages in Exhibit 11 contain the results of core analyses for wells located along the longitudinal axis of this

reservoir. Now, that part of the reservoir contains the best quality rock in the entire reservoir. Also, as we will show later, not only is it better quality rock contained in the wells located along the longitudinal axis, but also it is more or less confined to only the upper portion of the reservoir. In addition to that, these cores which we have shown on the exhibit, represent the rock that has been taken as we drilled down through these wells, and we have taken the cores and had them analyzed and many many instances in our core analyses we find and can identify permeability throughout the entire section.

Furthermore, we find that as we move from the center, better-developed sand in the upper portion of the reservoir, to the northeast edge, we grade into inferior rock characteristics. Likewise, as we move a long way from the longitudinal axis to the south portion of the reservoir, we again grade into inferior rock characteristics. Which means if you take a transverse section across the reservoirs, you will go from inferior to the best you have got back to inferior rock characteristics.

Let us turn to page one of Exhibit 11. This sheet represents the electric log with the core analysis superimposed for the Phillips Petroleum Company Benally No. 2 located in Section 5, 25 North, 12 West. Mr. Devline will point to the location of the well. Bearing in mind again that the first eleven pages that we talk about, these wells represent the best wells that we have. They will all be

contained along the longitudinal axis of the reservoir. Page one shows the electrical log. In the center we have, we might say, the well bore and the depth. Also we have identified the upper sand with a one, and then the subsequently lower sands with numerical numbers, on the left we show the porosity graph. It is a bar graph plotted with depth according to the electrical log. The base line, which is on the right-hand side of the bar graph, represents zero percent porosity. As we move to the left, each division represents ten percent of porosity. You can see from this porosity graph that we have identified porosity throughout the entire cored interval.

On the right-hand side we have the permeability plotted as a bar graph. The base line representing zero millidarcies permeability, the next line to our right, one millidarcy, the next line ten millidarcies, the next 100 and the next 200 and the next 300 millidarcies. As you can see there looking up and down the permeability graph throughout the vertical section, we have identified permeability.

I direct your attention also opposite the sand which we identify as one being the upper member of this reservoir, the porosity is greater, also the permeability is greater.

Let's turn to page two. Here again we identified similar charactersitics. This well is the Amerada Petroleum Joan White No. 2 located in Section 9, 25 North, 12 West. Again the porosity graph illustrates higher porosity opposite sand No. 1, yet we have

porosity throughout the vertical section. On the permeability graph we have identified greater permeability opposite sand No. 1, and also we have identified permeability throughout the vertical section.

I might mention possibly the average permeability for this upper member is of the order of 100 millidarcies. You will notice that the permeability in the lower portions of the reservoir is inferior to this 100 millidarcy sand.

Page three is the British American Douthit No. 11 located in Section 29, 26 North, 13 West. Again we display the same rock characteristics, better porosity and better permeability opposite the better sand, the uppermost sand. In this well the complete section was not cored. Sometimes we don't always core in the entire section, but what is there does show porosity and permeability.

Page four shows the similar thing, that is the British American Douthit B-2, located in 28, 26 North, 13 West. Without taking too much time, it is obvious that the upper portion of this reservoir identified as sand 1, is better developed in porosity as well as in permeability, and the relative values of each of these wells are consistent with one another.

Page five, the British American Mayre B-5, located in Section 35, 26 North, 13 West. Again we have a duplication of the similarity that we have been through.

Page six, the British American Mayre B-1 located in Section 35, 26 North, 13 West. Again a repetition of the preceding

information, namely that the upper sand is better developed both in porosity and permeability, and we have porosity and permeability in the vertical section.

Q Could I interrupt you for a moment, Mr. Brinkley?

A Yes.

Q On page five, on Mayre B-5, that shows an interval in approximately the center of the section shown with no porosity and no permeability. That means that no core was taken there?

A There was no core taken in that interval. We sometimes take what we can get and we try to do the best we can, but that's all we got.

Page 7, British American Producing Company, Mayre No. 1, located Section 1, 25 North, 13 West, again the upper sand shows better development. The lower portions show porosity where we have taken cores and we show permeability in some of those sections. Now, it's expecting too much from nature to have permeability every place. We take the reservoir as we get it, and in this section we found no permeability, very normal.

Page eight, Sunray Mid-Continent Oil Company Federal C-1, located in Section 6, 25 North, 12 West. Only the upper portion was cored, but again we have better-developed porosity and better-developed permeability, and those values are consistent with the previous illustration.

Page nine, again the same thing, which is the Sunray

Mid-Continent Federal C-10, located in Section 6, 25 North, 12 West.

Page 10, Sunray Mid-Continent Federal C-14, Section 8, 25 North, 12 West. Again the upper sand is better developed in porosity and permeability than the lower sections.

Page eleven, which is the last well now along this longitudinal axis that we have cores on that permit us to compare and conclude that that is the better-developed sand and that the relative values of the porosity and permeability throughout the longitudinal section where we have these cores shows consistency in values. So that at page eleven is Shell Oil Company Carson No. 1 located Section 24, 25 North, 12 West. Here we have better-developed porosity and permeability opposite the main body of the sand and below.

Now, pages twelve through twenty-four represent wells in the southwest flank. We have 13 wells that are between the longitudinal axis where the better sand is, and the southwest edge of the field, so these 13 wells in this inferior rock area will be studied next. Again we will attempt to show that although all these 13 wells show inferior rock characteristics when compared to the center of the pool, when we take them one at a time there is a great similarity as we go from northwest down to southeast.

Page twelve is El Paso Natural Gas Products Company Kelly State No. 1, the discovery well, located Section 16, 25 North,

12 West. Opposite Sand 1 we have a porosity about equivalent to the remaining porosity throughout the vertical section. On the permeability we have a permeability opposite the upper portion of the sand, which is also consistent in value with the lower portions of the reservoir. I should like to remind you that the previous examples we had average permeabilities of 100, 200 millidarcy range. Here we are talking about one millidarcy range. Again we show permeability in the vertical section.

Page thirteen, Anderson Prichard Begay No. 1, Section 25, 25 North, 11 West. This is an interesting well. The upper sand, you will notice, has inferior porisity and it also has inferior permeability. In fact, there are three sections in here, three intervals that the permeability hardly shows, the field has kind of slipped off, but there are three samples that did show this permeability. But this well is completed in the section immediately below the No. 1 sand. The No. 1 sand, you will recall, is the heavily colored yellow section shown on the cross section. This is the only well, to my knowledge, that is completed in the second sand which is the sand immediately below this better-developed upper sand, but even so, the second sand has inferior rock characteristics, namely down to the order of ten millidarcies. That is only one tenth of the average permeability in the upper sand. The porosity still remains inferior to the center located wells.

Section CM and W Drilling Company Elliott located 30, 26 North,

13 West. Here we find inferior porosity throughout the vertical section and inferior permeability throughout the vertical section.

Page fifteen, CM and W Drilling Company Elliott No. 1, Section 30, 26 North, 13 West. Again we find inferior porosity with zero permeability. According to the core analysis, actually they made a well.

Page sixteen, British American Oil Producing Company Salge B-5, 33, 26 North, 13 West. Here we find poor sand development, although it is better than the lower sections, it is still inferior for the upper sand member. The same is true with the permeability, yet throughout the vertical section that was cored, we have permeability, also porosity.

Page seventeen, El Paso Natural Gas Products Company Kelly State No. 11, located in Section 22, 25 North, 13 West. Here opposite Sand No. 1 we find permeability and porosity, yet of inferior quality, but consistent with the previous values for the wells along the southwest portion of the field. Sunray Mid-Continent Federal C-18, a similar condition exists.

Page nineteen, the El Paso Natural Gas Kelly State No. 2, Section 16, 25 North, 12 West. A similar condition exists here, also. The same for page twenty, which is the El Paso Kelly State No. 3 located in Section 16, 25 North and 12 West. Here possibly the upper sand is better developed than the lower portions, but yet inferior to the wells located along the longitudinal axis.

Page twenty-one, El Paso Kelly State No. 4, Section 16, 25 North, 12 West. Again we have inferior rock characteristics and consistent with the other wells along the southwest portion of the field.

Page twenty-two, El Paso Kelly State No. 6, the same condition exists there. Page 23, El Paso Kelly State No. 7 located in 16, 25 North, 12 West. Here we find porosity and zero permeability. F R Anderson Petroleum Federal 21, 29, Section 29, 25 North, 12 West. This is the last well of the 13 that I explained that we have core analysis for along the southwest portion of the field. The same condition exists in this well, namely the rock characteristics for all wells completed in the southwest portion of the reservoir are, contain sand characteristics inferior to the wells along the longitudinal axis, yet when we examine wells along that trend, that they are generally similar to one another. We have two wells remaining which are the two wells along the northeast portion of the reservoir. Amerada Petroleum Gle-Na-Nup-Nah No. 2, Section 5, 25, 12 West. Here we find that the porosity and permeability are inferior to the wells located along the longitudinal axis, yet they resemble a similarity to those wells located along the southwest flank of the pool.

And the last well is the El Paso Natural Gas Sullivan No. 1-B, Section 30, 26 North and 12 West. Here we find better development in the No. 2 sand as far as porosity is concerned, yet it is of

inferior quality and we find, you might say, very little permeability in either the first or second sand.

In summary, we find that the better sand development occurs along the longitudinal axis. We find that there is great similarity in the values of the better quality sand as we proceed along the longitudinal axis, as we go to the southwest part of the field we find we get into inferior sand characteristics, yet have a similar quality from well to well. Also in the northeast part of the pool where we have the data, we find a similar condition, namely inferior sand characteristics, yet similarity between the wells.

So, in summary, it is my conclusion that the Lower Gallup reservoir consists of a thick sand section and the entire section contains permeability with the better development in the upper sand, and the upper development further confined only to the longitudinal axis. Although the better quality of the sand is contained in the upper sand, we do find an inferior gradiation as we proceed to the southwest, and an inferior gradiation as we go further to the east.

It is further my opinion, it is my opinion predominantly the reserves in the Lower Gallup reservoir will be contained in the upper sand and further the recoverable reserves will be regained predominantly out of the upper sand.

Q Mr. Brinkley, do you find evidence of well interference?

A Yes. Exhibit No. 12 has four wells circled, and the wells are located roughly along a transverse section at Section 6, Township

25 North, 12 West. The wells circled, starting from the top, are the Sunray 2-C located in Section 31, Section 6, No. 4, No. 6 and down in Section 7, C-18. These wells have been shutin for about a year. I would like to direct your attention to one little statement here that two of the wells intermittently produced a small amount of oil during that one-year period. They are the two wells, No. 4 and No. 6, but they are the only wells that we know of that we can estimate interference. I should like to direct your attention also that No. 18, located in Section 7, is in the inferior rock character area. Also Well No. 2-C is located in the northeastern portion of the field, again where the rock characteristics are inferior. Wells 4 and 6 are located in the area where the rock characteristics are good.

Briefly, we have observed pressure interference in all four of these wells across this transverse section, indicating that the pressure reduction occurs equally as good in the inferior rock characteristics as well as in the good rock characteristics, and the magnitude of the interference is sufficient to warrant us to conclude that interference will extend over a large area.

Let's take some detailed data. The insert on Exhibit 12, you will notice the insert on Exhibit No. 12, the first well C-18 which is the southerly-most well. Again it is located in the inferior sand characteristic area. I think we had six feet of sand, something like that. Five or six feet, perhaps one millidarcy of sand. The

table states that on October 22, 1956, over in the fourth column we measured a bottomhole pressure, 1535 pounds after the well was shut in thirty-three days. Approximately a year later, September 5, 1957, we measured the bottomhole pressure and it was 1430 pounds. That's a drop of 105 pounds per square inch throughout this period, the accumulated oil was 640 barrels, namely it did not produce during that eleven-month period. So we have experienced a draw-down of 105 pounds per square inch, and that draw-down is due to the production of offset wells only.

Now, if we consider that pressure draw-down as a result of producing the offset wells and taking the nearest offset well that produced and use that distance as a radius and circumscribe a circle around that well, that would give us an effective area. Now, that effective area is 250 acres in the inferior rock characteristics area. Let's take the last well, Sunray Mid-Continent Federal C No. 2. That well, on October 24, 1956, we measured a bottomhole pressure of 1512 pounds. On August 15, 1957 we measured 1207 pounds, a drop of 105 pounds per square inch.

I shall direct your attention again that this well is in inferior sand characteristics area. The interference, the drop in pressure being due to production, this well being shut in, hence the interference was due to the production in areas surrounding that well.

Again taking the radius of an area of drainage equal to the

closest well that produced during this period, we got an effective drainage area of 126 acres, the same condition exists for No. 4 and No. 6 where on the table in similar fashion we have identified drop of 82 pounds and 97 pounds. That's in the good quality sand. So in my opinion we have evidence that drainage occurs even in the inferior sand characteristics areas for a minimum of 126 acres. That's considerably in excess of 80 acres.

Q Then, based on this information, Mr. Brinkley, is it your opinion that one well will drain 80 acres economically and effectively?

A It is my opinion that it will with what information we have, and even in the inferior rock characteristics area will effectively drain an area in excess of 80 acres.

Q Then, Mr. Brinkley, if wells are drilled on a 40 acre density, will unnecessary wells be drilled?

A Yes.

Q How many?

A Approximately 300. Now, that is only an approximate figure, we don't know precisely what the definition of the boundary of this reservoir is, but it will be conservatively estimated that we will drill at least 300 unnecessary wells if we go to 40 acre spacing.

Q How much would it cost the operators to drill these unnecessary wells?

A We are looking at a minimum of twenty million dollars.

Q Will economic waste result if unnecessary wells are drilled?

A Yes. If we have to drill these unnecessary wells, this minimum of twenty million dollars could be more prudently spent in exploring for new oil finds or in purchasing equipment or materials for pressure maintenance and secondary recovery operations.

Q Have you made a study of the economics of drilling this pool to an 80 acre density as compared to a 40 acre density?

A Yes, I have.

Q Please refer to Exhibit No. 13 and identify and explain it.

A Exhibit 13 is an economic comparison of 40 acre development versus 80 acre development for the Lower Gallup reservoir. On the right-hand side we have two columns, one for 40 acre values and one for 80 acre values. The first number is the original oil in place, 40 acre wells and 80 acre wells. Now, the original oil in place at Footnote 1 means that we determine the oil in place volumetrically from the isopacks that you have seen this morning, core analysis, which I have presented, the fluid analysis that I also presented. The ultimate recovery which is Item 2 under Footnote 2, we have calculated a probable recovery. I would like to emphasize that probable. Now, in my opinion it is a probable number. A 40 acre well, 44,000 and 80 acre well, 88,000 barrels. The value of the recoverable oil, $111,000 for the 40 and $222,000 for the 80 acre well.

Investments to drill and complete a flowing well, based on an

average of nineteen wells, that we have drilled where we have the closed out accounting records, have averaged $55,000 each. The surface equipment, Footnote 5, consists of artificial lift, $10,000, miscellaneous surface equipment flow lines, proportionate share of tank battery, roads, water wells and various and sundry things, $11,000 per well. A total cost for the nineteen wells that we had adequate records to analyze, was $76,000 per well.

Operating expense, lease and well costs and taxes, we have estimated at $37,000 for a 40 acre well and $75,000, roughly, for an 80 acre well. Now, when we take the total revenue from the production and subtract out the investment and the operating expense, it indicates that a 40 acre well is a bread-even proposition. In fact, with our figures we show a loss. An 80 acre well shows a profit of some $70,000. That profit is a non-discounted profit, based on future earnings; in order to get an economic comparison of your present investment and your future earnings, we convert the future earnings back to the present condition. Hence, using a present worth compound interest factor of six percent, we show a material loss of 40-acre development and a very modest profit on an 80-acre well. Let me point out also that these economics do not include the cost of acquiring the leases. Also may I point out that there is differences of opinions among operators as to investment values, operating costs, various things like that which are inherent to the operation of different companies. This represents our

interpretation as a, may we say as a preliminary economics based on only what we know today. I don't think our economics would be materially affected with any reasonable differences in operating techniques and things like that, or even with additional information.

Q In view of the economic picture which you have presented, is it economic waste to drill on 40 acre spacing in this field?

A Yes.

Q What has been the industries success ratio of wells drilled compared to discoveries made?

A That success ratio is commonly referred to as demanding industry to drill ten wildcat wells in order to achieve a new discovery oil well.

Q Actually, your economics show a rather low profit even on 80 acre spacing, don't they, is that correct?

A That is correct.

Q In your opinion then, is the profit which can be made on 80 acre drilling commensurate with the risks which an operator must take to find oil and stay in business?

A No, it is not.

Q In other words, will the expected profit from this pool on 80 acres be sufficient to support exploratory drilling in New Mexico and elsewhere? A No, it will not.

Q Is there anything that can be done to increase the expected recoveries from this pool and improve this situation?

A Yes. By the application of secondary recovery operations with pressure maintenance at as early a date as possible.

Q What are the operators now doing to determine if secondary recovery will be feasible?

A At the present time Sunray, Phillips and British American are conducting a missible phase displacement test. That test is located at the intersection of Township 25 and 26 North, Range 12 West, 12 and 13 West. We went in and drilled a well in the center of four closely located oil wells. We have injected approximately 30,000 barrels of LPG. It is our plan to follow that LPG with injected gas. The gas will drive the LPG slug through the reservoir, displacing the reservoir oil and improve the recovery.

To date, in fact, today we will complete the injection of the 30,000 barrels of LPG a few days ahead of schedule. We have equipment arriving and will start gas injection in a very few days. This program, this test will continue so that we can evaluate and see if this reservoir is susceptible to this improved recovery method.

In addition to Sunray, Phillips and British American physically participating in this test, three other companies are contributing money to this test. They are namely the Shell, Amerada and El Paso.

Q Mr. Brinkley, if this is successful, how much do you expect this process to increase recoveries?

A My opinion, we can reasonably expect more than twice the recovery with this process than by natural depletion. That, in

effect, is just like picking up approximately two more oil finds with the wells already drilled.

Q Has Sunray had any experience in other types of secondary recovery that lead you to believe that LPG injection will be successful?

A Yes. This missible phase displacement is not a mysterious thing. It has appeared in magazines, papers and whatnot as a new recovery method. Missible phase displacement can be applied in several forms. Sunray has practiced missible phase displacement for several years. Several other companies have too, but they don't realize it. Our gas cycling pressure maintenance operations are nothing but a missible phase displacement operation where we have a reservoir field with wet gas and we inject dry gas to displace the wet gas, that very simply is a missible phase displacement. You are using a dry gas to displace something of more value, wet gas, and missibility means that they mix that is all it means. You can effectively displace the wet gas with the dry gas. Something that we have done for a number of years.

This LPG test that we have is a little bit different than that because not only are we pushing the slug forward by wet gas driven by dry gas, but in addition to that we have the extraction process ahead of it where the LPG extracts or washes out, if you will, the oil ahead of it. So we have no apprehension as to the applicability of this process, but it does require a field test to see if the

reservoir is susceptible to it and see if the reservoir fluids will react like we think they will.

Q You expect this program to be successful, don't you, Mr. Brinkley?

A The evidence we have to date, there is nothing available yet that would indicate that it will fail. Now we are in the early stage of this test and we don't have all the information we intend to get to fully evaluate the test, but to date there is no evidence to the contrary.

Q Now, in the event it should not be successful, you are not fully relying on this program of LPG gas injection to recover additional oil, are you?

A No, we are not relying entirely on the missible phase displacement program. It's customary to evaluate several recovery methods and pick the optimum one for prudent operation. So we have investigated the possibility of injecting the produced gas and the results of that engineering study indicates that if we should go that route, that we can improve the recovery by fifty percent as compared to primary methods which economically is better than the present competitive methods.

Q In other words then, gas, just straight gas injection is a proven method, is that correct?

A It is a proven method and people have become educated to it and have accepted it.

Q You are of the opinion it would work here?

A Yes.

Q Now, Mr. Brinkley, what effect does close spacing have on the success of an LPG gas or just a regular gas injection program?

A In my opinion close spacing would offer a hazzard to the effectiveness of achieving the maximum possible recovery. In other words, 80 acre spacing would be advantageous because the greater the distance between your injection well and your oil well the greater will be your overall flushing efficiency, because it minimizes the channel, the channeling nature of your driving fluid. I have observed that in many water floods. I have observed it in our cycling projects, and other experts who have published their opinions, recognized experts if you will, have made the same statement.

In checking the overall flushing efficiencies of several gas cycling projects, we have defined overall flushing efficiencies within the swept portion as high as 80 percent. So in my opinion it behooves us to follow as wide a spacing for secondary application whether it be gas drive or whether it be LPG injection, or water flooding or what you may want to use, it would behoove us to use as great a distance between the injection wells and the producers as possible.

In addition to that, the Sacroc Engineering Committee have also observed in their flooding operations quick break through on

first row offset and prolonged displacement flushing efficiencies at a high value on the second row offsets, and they have gone to shutting in near wells in order to achieve the higher flushing efficiency.

Q Can you name any of these experts that agree with this theory of yours, Mr. Brinkley, that the wider spacing is conducive to a higher ultimate recovery?

A The theory is not unique with me. I have learned from the other people, but I have observed that the statement that these recognized authorities have released, and my association with the research people as well as the practical operators leads me to believe that the wide spacing is the prudent thing to follow. Now, specifically, one recognized expert that I can mention who has made this statement is Morris Muscat in his book Physical Principles of Oil Recovery. I believe that is about the name of it, but he makes that statement.

Q Who is Mr. Muscat employed by or affiliated with?

A Dr. Muscat is connected with the Gulf Oil Corporation in their research facility.

Q Then would 80 acre spacing increase the oil recovery which could be obtained under secondary recovery programs which the operators are now considering?

A In my opinion it would assure a maximum flushing efficiency, whereas a closer spacing would hinder it.

Q Mr. Brinkley, what other rules do you have at this time to offer to the Commission for the regulation of this field?

A The location of the wells to be in diagonal 40 within a Governmental 160 acre tract, no closer than 330 feet from lease lines. The location in diagonal 40's will encourage uniform spacing, 330 foot formations will permit flexibility of well location where needed, especially near the edges of the field or at the gas cap. Most of the wells drilled to date are in the center of 40's. In addition I would recommend that we have original bottomhole pressures, better state it this way, originally completed bottomhole pressures and gas-oil ratio tests and semi-annual gas-oil ratio and production tests fitting a schedule consistent with what the Commission would desire. Also a limiting statewide gas-oil ratio of two thousand to one.

Q Then, based on your testimony today, Mr. Brinkley, is it your opinion that the granting of this application is necessary to prevent waste and secure the greatest ultimate recovery of oil from this pool?

A It is.

Q Were all exhibits offered by you today as a part of your testimony prepared by you or under your supervision?

A Most of them were prepared personally by myself. Some of them were delegated and I supervised them.

MR. ERREBO: If it please the Commission, at this time we would like to offer Exhibits 9 through 13 in evidence.

MR. PORTER: Are there any objections to the admittance of these exhibits? They will be admitted to the record.

MR. ERREBO: That's all we have.

MR. PORTER: Anyone have a question of Mr. Brinkley? Mr. Seth.

CROSS EXAMINATION

BY MR. SETH:

Q I would like to ask just a very few questions. First, on the secondary recovery test you referred to Sacroc. Would you compare the permeability existing there with this pool here?

A That is a very dangerous statement to make because of the heterogenity of rock characteristics. Now here we have very good permeability, here we have very poor, we have observed in Sacroc we have very good permeability, we have very poor.

Q Can you compare the two, the good there and the good here?

A No.

Q The bad here? A No.

Q Do you have any figures on that at all?

A No, I don't.

Q Well, how can you compare with the Sacroc for your secondary recovery to this pool then if you have no basis of comparison as far as permeability is concerned?

A I can answer you best this way, that fluids follow a freedom path, that is they will follow a path of least resistance.

Now their path of freedom would be affected by pressure differential and distance. Now, that physical condition has been observed in many, many reservoirs with many kinds of rock characteristics. I'm afraid that I would mislead people if I got down to a minute rock characteristic because to me it is irrelevant.

Q It is just pressure and distance are the only factors as far as you are concerned? A That is the important thing.

Q You are assuming, in your testimony, about the sweep efficiency and so forth that this is entirely a homogenous reservoir?

A No reservoir is entirely homogenous.

Q Are you assuming it or are you not?

A I beg your pardon.

Q Can you answer the question first and then explain your answer?

A I am not assuming that the reservoir is homogenous.

Q You are not? A No, sir.

Q Go ahead and explain.

A Since we recognize that fluids follow a freedom path, then it is up to the engineers to direct the flow of the fluids and encourage them to follow a definite path, which is what we try to do.

Q How do you try to do that?

A By the proper location of our wells and withdrawal rates and injection rates.

Q But your initial wells where you pilot flood are for all practical purposes on the 20 acre spacing, is that right?

A Yes, the oil wells are located in centers of 40, but the injection well --

Q The injection well is a five spot?

A That is correct, yes.

Q Why didn't you begin it on a wider spacing if you are going to direct the course of this LPG as you stated?

A That is a very interesting question. Don't misunderstand me, we can explain it. We searched around for an area where the wells were closely located.

Q Why did you do that?

A We wanted our results quickly. We were experiencing rapid reservoir pressure drop and we had to get our rules soon enough so that we could apply this method, if it can be proven applicable, before sufficient pressure drop had occurred that would prevent the application of this method. That is the reason we did it.

Q Then does time of the recovery of the LPG, is that a factor in a project of this character?

A I don't understand what you mean about time of recovery.

Q This LPG I assume costs considerable amount of money. If you inject it you are interested in getting it back, I assume, in reasonable time.

A Economics are not only based on recovering the LPG, but

recovering more oil.

Q Can you answer the question directly?

A What is your question?

REPORTER: Reading: This LPG I assume costs considerable amount of money. If you inject it you are interested in getting it back, I assume, in reasonable time.

A Yes, we are interested in getting it back in a reasonable time, and LPG does cost money.

Q Then isn't that the case the closer the spacing the quicker you will get back the slug and the recovery of oil?

A So that I don't confuse the Commission --

Q (Interrupting) I don't believe the question will be confused if I may say so, they have a lot of witnesses. Just go ahead and tell us the story.

A All right. We are interested in making money. Now, there is an economic optimum spacing which would keep our investments at a minimum yet provide a maximum recovery in revenue that would permit us then to define the spacing so that we could get the maximum amount of oil, make the maximum amount of money with the minimum amount of investment. We can't always achieve precisely the optimum condition, but we have to assure ourselves of the best chance of getting the most oil out within a reasonable period of time, and the 80 acre spacing qualifies for that decision.

Q Would you testify, or would you state that you would get it

back sooner if it were on 40 acre spacing, or would you not?

A You might get it back quicker on 40's than you would on 80's. It is also a function of how fast you inject it and how fast you withdraw. It is a complex thing. I don't want to be evasive with you.

Q The reason I asked the question was you testified that you pick the four close wells because you wanted a quick answer?

A Yes.

Q From that I assume the closer the wells the quicker you get an answer, so consequently the closer the ultimate spacing the quicker you get back the secondary recovery oil?

A No.

Q The quicker you get back the LPG?

A No, I misled you.

Q I'm easily misled.

A One thing we are interested in is channeling, we want to know when the LPG breaks through to the oil wells, by knowing how much we have injected and the time at which it broke through, then that will give us some idea of the flushing efficiency. Another thing we wanted to know, and know fast, was the pressure. We have to maintain roughly 1250 pounds pressure before this method will work. Another thing we wanted to check and learn quickly would be the injection capacity of these wells. If we can't get the LPG in we want to know it now. If we can get it in, we want to know it now.

So for the reasons we picked the wells that were closely spaced, so we can find the answer in six-month's time rather than wait a year and a half or two years when the pressure is down so far we couldn't apply the method.

Q Well, Shell is participating in the program?

A Yes.

Q You are using some of their money at least?

A Yes.

Q Now, I want to refer to your Exhibit 13. Do you have one handy there? That's the well cost. Do you have that there?

A Yes.

Q Now, would you please state the factors that you use in making these computations? A Yes, I'll be glad to.

Q Will you start with the oil in place?

A Start with the first one, oil in place?

Q Yes.

A We find that the better quality sand is along the center part of the reservoir, so we took the isopack and said that the sand contained within the 20 foot isopack line was better quality than the sand contained between the 10 and 20 contour line, the inferior rock then would be along the edges of the field where the isopack thicknesses were less than 10 feet. Now that is a means of dividing the reservoir up into three parts where we studied the inferior rock, we studied the best rock and then the rock in between. So we

determined the oil in place in the best quality rock, the oil in place in the poorest quality rock, and then the oil in place in between and added them together, which would define the oil in place.

Once we defined that, then we followed the solution gas drive performance equations.

Q Excuse me, give me a little detail on how you determined the oil in place between the bad and the good section, what thickness did you use and all the factors?

A Between the zero and 10 foot line that would be the poor quality sand, we found or measured 14,203 acres which had 17,016 acre feet. The rock properties were 10.6% porosity, 6.2 millidarcies permeability, 43% connate water, and it contained 26,600,000 barrels of stock tank oil in place. Between 10 and 20 foot contours on the isopack, we had 9,736 acres, 146,045 acre feet, a porosity of 12.7%, permeability of 43.6 millidarcies, connate water of 23% with 83,200,000 barrels of oil in place. For the best sand where we had 20 or more feet or in that area we had 732 acres, 15,376 acre feet, a porosity of 14%, a permeability of 100 millidarcies, connate water of 10% with 12,000,000 barrels of oil in place.

Now then, out of that reservoir volume I had to subtract the gas cap volume. Now, the gas cap covered 3,906 acres approximately, or 24,390 acre feet, or roughly 16,400,000 reservoir barrels.

Q Now, on your first point zero to ten foot contour, how

did you arrive at this 10.6%?

A I took all of the core analyses that were on wells located between the zero and ten foot isopack line, of which there were thirteen. I added them up for the porosity and permeability and divided by thirteen and got arithmetic average porosity and permeability.

Q It is not a weighted average?

A No, sir, just an arithmetic average.

Q The same on your permeability?

A Precisely.

Q Do you feel that a more accurate analysis could have been made if you had used the weighted average? What were the maximum and the minimum porosity within that area?

A The maximum value between the zero and ten foot isopack line was 18% porosity and 70 millidarcies permeability, the minimum value on a producing well was 6% porosity, and zero millidarcies permeability.

Q Then your average of zero and 70 is your arithmetical average, is that a very true picture of the situation?

A Well --

Q (Interrupting) How much of the interval was 70 and how much was zero, is that a factor or not?

A Well, that is only one of the thirteen samples. The other twelve average one millidarcies.

Q You are using just bare averages and you disregard entirely, if I understand you, the thickness of the particular formation for which that factor is given, is that right?

A I don't understand you.

Q You are just using a maximum and minimum, you disregard how much of the interval is the maximum and how much is the minimum, is that right?

A No, I'm afraid I haven't made myself clear.

Q Tell me how you arrived at your average again.

A I got the average porosity for each of thirteen wells, I got the average.

Q How did you get the average?

A By reading the core graphs we have here.

Q What figures did you use, the maximum and the minimum?

A Well, the maximum -- let me check here -- I'm sorry, I misled you. This is 7 millidarcies instead of 70. What I did was just by inspection, take the sand interval, the average value from the bar graph, just by inspection, I didn't try to refine it, and I did that for each of the thirteen wells completed within the zero isopack line. And I take the averages for each well and add them up and divided by thirteen.

Q The selection and the manner of getting the average would have quite an influence on your final figure, would it not?

A No, it would not.

Q It wouldn't have any influence?

A Oh, one percent maybe. It's a nebulous thing.

Q If the same is true for both porosity and permeability, wouldn't it have an effect on your figures in a substantial amount?

A With the data we have, no. Now, if every well were cored we could construct iso-permeability maps, iso-porosity maps, and set up a grid network and run it through the electronic computer, which we do in many cases. But I have observed where we have, I'll put it this way, usually by arithmetic averaging, if you have enough samples that you are still representing, shall we say, the average rock properties, I hold no apprehension as to the average values I have used.

Q Does that hold true where there is a great spread between the maximum and minimum which we have here in which you say the spread is great here?

A We have minimized the spread that you are referring to by breaking the reservoir up into three smaller segments, so we have eliminated that hazzard.

Q Do you have any figure on the per acre oil in place within the zero line or within any other particular area?

A The stock tank oil in place?

A Yes, the corrected stock tank.

A I would say that the in place oil on an acre basis, assuming an average acre would be someplace in the neighborhood of

5,000 barrels.

Q We're talking about per acre feet, per acre foot.

A Per acre foot?

Q Yes.

A Yes, I can give that. In the neighborhood of 520 barrels per acre foot. That would be for an average acre foot.

Q Now, would you say that since it is an average it would hold true pretty well throughout the area that you have defined here?

A No. No, no, not at all.

Q That's perhaps, I might state it this way, in the testimony of Sunray at the LPG hearing, you had a slightly different figure I believe. Would you explain the difference?

A Do you have an exhibit?

Q Is that a different area?

A I would have to refer to the previous exhibit.

MR. ERREBO: If it please the Commission, I think the record will show that a different witness testified.

Q I believe a Mr. Brooks testified. Are you acquainted with Mr. Brooks?

A Yes.

Q He testified, I am reading from page sixteen of the record in Case No. 1280, now this is the case on the LPG understand. We will assume that it is limited to that general area, although it doesn't express it as so. You say that other witnesses have said it is pretty much the same all throughout the reservoir, we can

use this figure. He testified that there are 670 barrels per acre foot of original oil in place.

A Yes, I certainly appreciate that statement. The pilot area is in the better quality sand. Now, if you take the better quality sand of 670 per acre foot and add to it the poorer quality sand which has less than 100, the overall average is still consistent with the figures that were presented at the previous hearing.

Q Sunray, in a letter to the various operators dated July 8, 1957, indicated that the original stock tank oil, this is a sentence, recovery by primary depletion is calculated to be 20.9% and recovery by LPG is estimated to be 50% of the original stock tank oil, or 234,000 barrels. Original stock tank oil would be 468,000 barrels according to this letter. This letter was written by Mr. Penn. Would you like to look at the letter?

A I'll be glad to look at the letter.

Q Do you have any comment on it?

A I don't know.

Q Do you have any comment on figures used there as compared to your figures?

A No, they are consistent with my figure.

Q You feel they are. Now, referring still to Exhibit No. 13, ultimate recovery, could you give us a time factor on that? How long it is going to take to recover 44,000 barrels?

A For the 40 acre well, thirteen years.

Q How long for the 80 acre? A Twenty years.

Q Twenty, did you say? A Yes.

Q Now, I hate to burden the Commission with this, but our figures are on a little different basis, but I would like to have the witness compute the stock tank oil within the isopack, the zero to 10, the 10 to 20. Would you do that for us?

A You want the oil in place between the contour lines?

Q Separately on a per acre foot basis.

A All right.

MR. PORTER: Let's take a short recess.

(Recess.)

MR. PORTER: The meeting will come to order. Do you have your answer computed, Mr. Brinkley?

A Yes. The original barrels of stock tank oil in place for the zero to 10 foot isopack interval will average 370 barrels per acre foot. For the 10 to 20 foot interval they will average 570 barrels per acre foot. For 20 feet or more, 780 barrels per acre foot, an average for the entire reservoir, 520 barrels an acre foot.

Q Thank you for the calculations. That gives us a little better basis to compare our figures. Now, in making these computations did you use your isopack map that was introduced in evidence --

A Yes.

Q (Continuing) -- earlier in the hearing?

A Yes.

Q On that isopack map those thickness figures, are they based on the net microlog?

A They were based on the net, they're based on the spread in the microlog, logs.

Q It purports then to be the total of the microlog pay?

A Yes.

Q At the point through which the line is drawn, is that correct? A That is correct.

Q Just a few more questions. We have divided this up in the hope of saving time. I have about two more questions. How many wells would you say that you have listed that are in the inferior rock area, as you call it? A Thirteen.

Q How many of these would you regard as being profitable wells? A None of them.

Q None of them?

Well, if a substantial portion of this reservoir and the data that you have used is in areas that are not profitable, do you think that should influence the rate of development of the better portion?

A I'll state this, that they are non economic on 40 acre development. I didn't make myself clear to you.

Q Were you testifying on an 80 acre basis then on the economic?

A That is a good question.

Q Well, you are a good witness, can you give us an answer?

A On primary recovery I would judge that they would be non economic under competitive type operation.

Q Then in our data, though we have used those wells and we have used the area inwhich they're located, though, to arrive at an overall figure. A Exactly.

Q Just one more question. On the electric log data, I believe that was Exhibit 11, do you have that?

A Yes.

Q You have been referring to several of the pages there. I believe on page twelve, for example, page two also, I understood your testimony to be that there was permeability throughout the Gallup sands as shown by that exhibit, is that right?

A We have identified permeability throughout the vertical section on page two of Exhibit 11.

Q Let's stay with page two a moment.

A All right.

Q What do you mean by the statement that you have identified permeability?

A Anything greater than zero millidarcies.

Q Is the permeability of zero millidarcies, is that significant for your purposes here? A Yes.

Q It is? A Yes.

Q Then you would also testify that there is and can be

vertical migration through the sections since you have identified permeability throughout the sections?

A I would state that there is communication throughout the entire reservoir by virtue of the inherent permeability of the reservoir rock.

Q Will you also state that since you have identified permeability on page two of Exhibit 11, that there will be and can be vertical migration adjacent to that well bore?

A I hate to use specifically vertical migration. Fluids are freed to travel a freedom path. It might be vertical, it might be horizontal, it could be anything in between. There is freedom of travel when we have permeability.

Q Then there is freedom of travel, if you prefer to use that term, vertically adjacent to the well bore?

A There could be.

Q Although the permeability in the area may vary from zero to 50 or 100, is that right? A Exactly.

Q Do you disagree then with Mr. Finfrock on his, as I understood his testimony, that there were barriers existing between the lower five sands, the lower four sands?

A I don't recall exactly what Mr. Finfrock said.

Q Let's put it this way, if he did so testify, I'm not saying that he did or he didn't, if he does you would disagree with that?

A I am not saying I would disagree. I would state my opinion

on what I think the reservoir rock contains. I would rather restrict my testimony to my belief rather than me make a comparison with what he said.

Q If there is silt stone or some other formation between these sands of zero permeability, or a little more permeability than that, you say that is not a barrier, is that correct?

A A barrier is a matter of degree. Now, in any reservoir rock we find a normal hetorogenity in reservoirs we say are homogenous, we still find portions that have zero permeability, it is accepteble. We are just thankful to have what we have got. I don't consider zero permeability in some place in a section like this as a barrier.

Q You don't consider it a vertical barrier?

A No, fluids are still free to flow horizontally to some other place than vertically.

Q Then let us assume that they are some distance from the well bore, there is an area they could rise vertically and get back up to the upper sand or the lower sand as the case may be?

A The fluids follow a freedom path.

Q Is my statement correct? A It could be.

Q Is it or isn't it? Can you answer the question? If you can answer it -- A I don't know.

Q But you feel throughout the reservoir this will occur, you have so testified to that?

A I feel that we can consider this reservoir as possessing permeability in the vertical section as displayed from the core analyses that we have.

Q But if the oil has to move laterally before it can move vertically, why that would assume that there is some sort of a barrier there, would it not be of a lenticular nature or shape, and if there are discontinuities within the reservoir, that is what you are testifying, are you not?

A I don't want to seem vague, actually we don't know what is in the reservoir between our wells. We do know that fluids do follow a circuitous path in the freedom path in reaching an outlet, you might have a barrier right here, but no barrier there. I don't know.

Q Since we don't know, the more wells that are drilled into the reservoir, the more likely we are to encounter these permeability areas, are we not?

A Not necessarily, no, sir.

Q Aren't the chances better the more you drill?

A The more chance you would have of not experiencing them too.

Q Don't you think the odds are better at all?

A No, I don't.

Q To drill twice as many wells?

A No, I don't.

MR. SETH: That's all.

MR. PORTER: Mr. Malone.

By MR. MALONE:

Q I would like to establish the identity of some of the names that have been used in the examination. Mr. M. B. Penn, what is his capacity with Sunray Mid-Continent?

A I should like to ask my counsel to correct me if I am wrong, or perhaps maybe he would be better qualified to give you his complete title.

MR. ERREBO: His complete title is Chief Unitization Engineer.

Q Chief Unitization Engineer. Both you and he are in the Engineering Department of Sunray then?

A I would prefer counsel to answer.

MR. ERREBO: No, sir. As a matter of fact, he is in a separate section from Mr. Brinkley's section.

MR. MALONE: He does have authority to speak for Sunray?

MR. ERREBO: Yes.

Q Mr. Brooks, who testified here in the former hearing?

A Yes.

Q What is his capacity?

A He is in my section as a Senior Reservoir Engineer.

Q Are you his superior or he is your superior?

A I am his supervisor.

Q Were you present when he testified here in the hearing

on the LPG project? A Yes, sir.

Q You heard his testimony at that time?

A Yes, sir.

Q Referring to page sixteen of the transcript, I invite your attention to the following question and answer that appears there. "Q Please refer to Exhibit No. 7 and identify and explain it." "A Exhibit No. 7 is a summary of the average reservoir and fluid characteristics of the Bisti-Lower Gallup Oil Pool. Some of the pertinent information on this exhibit is that 20 wells have been cored and we have shown the average rock properties, the bubble point pressure of fluid analysis was 1207 pounds per square inch, and the bottomhole pressure in April 1957 was 1319 pounds. We have shown that there are 760 barrels per acre foot of original oil in place." You heard him so testify? A Yes.

Q And he stated that he had taken into consideration the average reservoir and fluid characteristics of the Bisti-Lower Gallup Oil Pool, did he not? A That's right.

Q And the core analysis that he considered are the same core analysis that you have based your testimony on here today, are they not? A That is correct.

Q Would you then take 670 barrels per acre foot and compute the oil in place under a typical 40 acre location?

A Yes.

Q Let's assume, for the purposes of the question, a 20 foot

thickness, which I believe you testified was approximately average.

A No, I did not.

Q You did not? A No, I did not.

Q Did Mr. Finfrock, I believe it was Mr. Finfrock who testified to 20, use 20 feet.

MR. SELINGER: He averaged 15 for the upper and 4 to 6 on the lower.

Q For the purposes of the question, would you compute it at 20 feet, please?

A Would you like the original oil in place?

Q Original oil in place.

MR. CAMPBELL: If we are going to have some calculations to establish the case for the protestants, I think they should be based upon what the witnesses have testified as to the average rather than the highest thickness of the pay.

MR. MALONE: I will be glad to state what I had in mind, the economic comparison offered in evidence is based on average oil in place figure on some 210,000 barrels on the 40 acre location. The computation on the basis of the 670 figure used in the former hearing by another representative of the same company gives us a figure of some 536,000 barrels, based upon a 20 foot thickness, which we believe the evidence testified to will support. The question of whether a 40 acre location is profitable or not profitable depends on how much oil there is under it, the difference between

536,000 barrels and 210,000 barrels is very substantial, and we felt that under those circumstances since the testimony from representatives of the same company showed that big an apparent disparity, it would not be unreasonable to ask the witness to verify the fact.

Q Can you give me an answer to that?

A I'm confused what you are asking for now.

Q I'm asking if you would agree with me that assuming a figure of 670 barrels of oil in place per acre foot on a 40 acre location with a 20 foot thickness of the oil sand, whether you would agree that 536,000 barrels would be the oil in place.

A In answer to your questions, I would say, no. In the first place I do not agree with the 20 foot sand thickness.

Q I asked if you would assume that for the purposes of the question.

A It's dangerous to take hypothetical cases. I would prefer limiting my testimony to the facts of the case.

MR. MALONE: If the Commission please, I believe I'm entitled to ask the witness to make the computation or to agree or disagree with the figure given. I don't want to be unreasonable. If the Commission has any question about it, I'll leave it.

MR. PORTER: Mr. Brinkley, go ahead and compute the figures using a 20 foot thickness.

Q What figure do you get?

A Using 640 barrels per acre foot, is that the figure?

Q 670.

A I beg your pardon. I have used 640. 670 barrels of stock tank oil in place, and assuming a hypothetical thickness of 20 feet, and assuming that would be representative for an average 40 acre well, you would have assumed oil in place, calculated on that data, of 536,000 barrels.

Q And that would compare with the figure of 210,000 on Exhibit 13, would it not?

A It depends on how you use the word compare. It would be used in lieu of this, but we are not on the same basis.

Q But both figures relate to stock tank oil in place, do they not?

A Yes.

Q Yes, sir. Now, would you compute the recoverable oil that would underlie a 40 acre location on that basis?

A Using my same recovery figures?

Q Using the oil in place figure which you have just obtained. I believe it was 21% that you used in your calculation.

A Yes, 21%. That would give 113,000 barrels of recoverable stock tank oil for that condition.

Q And assuming that condition to be correct, that would compare to a figure of 44,000 barrels which you have shown on Exhibit 13, would it not?

A That is correct.

Q And now, would you compute this figure of value of net 7-8

oil recovered for the figure that you have just obtained?

A 280,000 dollars.

Q That would compare with the figure of $111,000 which you have used on Exhibit 13, would it not? A Correct.

Q If that figure was used in lieu of $111,000, the economics of drilling on 40 acres would be apparent, would it not?

A That is correct.

MR. MALONE: Will counsel for Sunray stipulate for me that their geological witness, Mr. Finfrock, that he testified that there were 15 feet in the upper sand and 4 to 6 feet from the lower segment of sands?

MR. ERREBO: I think the record will show, of course.

MR. MALONE: I didn't want to search the record on it.

MR. ERREBO: Fifteen feet for the average for the upper sand.

MR. MALONE: And 4 to 6 feet to the lower?

MR. ERREBO: I think that would be all right.

MR. MALONE: And I am sure that we can stipulate that fifteen and four make nineteen and fifteen and six make twenty-one, and that twenty is halfway between them.

Q So that if we use as a figure for recoverable oil in place the figures which you have just computed, development on a 40 acre basis would be economic, would it not?

A Assuming this condition, correct.

Q Now, referring to the letter of Mr. Penn from your company,

which was heretofore referred to and which I would like to identify and offer in evidence.

(Marked Gulf's Exhibit No. 1, for identification.)

Q Will you examine the exhibit and see if you can identify the signature of Mr. Penn? A Yes, I do.

Q That is a letter that was sent out to the operators in the Bisti Field, is it not? A Yes.

Q I read you the paragraph beginning on the first page of that letter: "In the 40-acre area to be swept lying within the 160-acre pilot area, our engineers estimate the original oil in place to be 468,000 stock tank barrels." Am I correct in construing that is a statement that in 40 acres that lies between your four wells up there in the pilot -- A That's correct.

Q (Continuing)--That the original oil in place was 468,000 barrels? A That is correct.

Q That will compare to figure of 210,000 barrels used on Exhibit 13, will it not? A No, it will not.

Q Bearing in mind that this refers to a particular portion of the field? A Exactly.

Q And that you have used an average as to the remainder of the field? A Exactly.

Q But with that difference it has the same reference, does it not? A Exactly.

Q So the figures do relate to the same thing?

A No, they do not.

Q Well, I believe you will agree with me that your figure is your computation of the number of barrels of oil in place under an average 40 acre location in this field.

A That is correct.

Q And that the figures stated in this letter relate to the number of barrels of oil in place under a particular 40 acres?

A That is correct.

Q And as between the average that you arrived at and the particular 40 acres, there is a difference on your own statements of 210,000 as against 468,000 barrels of oil in place?

A That is exactly right.

Q You would agree that the 468,000 acre reserve would justify the drilling of this field on a 40 acre basis, would you not?

A At that particular location, yes.

Q Now, in arriving at your estimate and allocating the reserves throughout the field, how much of the field have you treated as being production? In other words, what was the area that you have used in dividing your oil in place over the field or the pool? How many acres? A 24,671.

Q How did you arrive at that figure of 24,000, by measuring the isopack?

A By measuring the isopack, yes.

Q Did you take into consideration the portion of the field that had the rich upper sand as well as the portion that had the less desireable lower segment?

A I took that into consideration, yes.

Q You have in effect allocated the production from the good sand out over the area which is not actually overlain by that good sand? A Would you restate that?

Q That is the effect of your allocation is to allocate it over the entire area whether the good sand exists there or not?

A We have allocated, we have computed the oil in place for the productive reservoir, yes.

Q And you have allocated it without reference to the boundaries of this upper segment of sand? You have allocated it over the whole 24,000 acres and not just a portion overlain by the --

A (Interrupting) That is correct.

Q (Continuing) -- by the good bar that you have testified to?

A That is correct.

Q This figure of 24,000 acres compares to what figure, that is the total for the entire proposed field which you have outlined?

A The area within the area we asked to be spaced represents 46,720 acres, or 73 Governmental sections.

Q You have treated 24,000 of that as being productive for the purpose of this allocation? A At the present time --

Q (Interrupting) Well, is that the figure that you did treat?

A Yes.

Q Thank you. Go ahead and explain your answer, I wanted to find out if that was going to be correct.

A The only thing I was going to say is that based on the information that we have, the productive boundary to date is the 24,671 acres, but I want to qualify that and state that before we could adequately define productive boundary, it is going to take more development, and it will be concentrated within the area we have asked to be spaced.

Q So your answer is that is true. Now, Mr. Brinkley, I believe you testified to a serious threat that occurred when Shell announced some 40 acre locations. You are aware of the fact that the rules of the Commission provide for 40 acre location in absence of other order by the Commission, are you not? A Yes.

Q So there was not a threat to do anything except what the rules provided, was there?

A There is a caution signal since our evaluation certainly spells caution to us to not drill on 40 acre spacing, and we consider it a threat.

Q Yes, well that subjectively you considered, but insofar as the rules of this Commission are concerned, Shell was perfectly entitled to do what they did do, were they not?

A Yes.

Q Now, with reference to the hearing on this 40 acre pilot

gas LPG injection system, you were present at the hearing, you testified? A That is correct.

Q And you now say that because of the possibility that a large part of the recovery will have to be secondary, it is your opinion that this field should be developed on 80 acre spacing?

A Exactly.

Q That ties into the repressuring project of Sunray's?

A Exactly.

Q Did you or any other Sunray witness at the time of the meeting in which you got the Commission to approve that project, testify that you expected if it worked it was going to require 80 acre spacing?

A I didn't testify. Now, the man, Mr. Brooks, who did testify, I don't recall what he said in that regard.

MR. MALONE: I believe the record in that case has been incorporated here?

MR. COOLEY: No, it has not.

MR. MALONE: We would like to ask that the record in that case be considered a part of the record in the case now before the Commission.

MR. CAMPBELL: For what purpose?

MR. MALONE: For the purpose of disclosing the fact that there was no statement of a proposed 80 acre spacing plan in connection with the LPG pilot.

MR. CAMPBELL: I wasn't within the call of the hearing. It wasn't suggested there we will stipulate that. Rather than encumber the record any further with the entire record of the other case.

MR. MALONE: If it can be stipulated the witness said he didn't know what had been testified to, if it be stipulated that there was no reference in that hearing. That is the thing we wanted to establish by the record.

MR. COOLEY: Does Sunray so stipulate?

MR. ERREBO: So stipulate.

MR. CAMPBELL: Yes.

Q Would you agree, Mr. Brinkley, that the results which you will get from your pilot test as it is now set up, will be more applicable to the results you would obtain on 40 acre development than on 80 acre development?

A You speak of results. Would you like to ask me specifically what results?

Q Well, the results which you felt you must get in a hurry, and hence you had proceeded on that basis. My question is will the information that you obtained be more applicable to 40 acre or to 80 acre spacing when you receive it?

A Yes. Without the results --

Q (Interrupting) It will be more applicable to the 40 acre development?

A No, it would be more applicable to the 80 acre.

Q Now the density of those wells is one to each 40 acres, isn't it? A Yes.

Q You have an injection well in the center of the four wells?

A Exactly.

Q It is your testimony the results you obtain from that pilot project will be less applicable to 40 than it would be to 80 acre?

A I will state it this way, that as an example, a specific example, we will need to know the injectivity capacity of the injection well before we can go to 80 acre spacing, and hence we have to qualify the well. Now then, if we were unable to get insufficient volume of LPG into the injection well, it would automatically throw out the 80 acre spacing. We know from our experience that 80 acre spacing is desireable and warranted, fitting and proper, but we were waiting on the injection well to qualify itself to show and display sufficient injection capacity in order to completely achieve that.

Q My question was when you do know that, it will be more applicable to 40 acre development because those wells are on 40 acre?

A No.

Q You do not agree to that? A I do not agree.

Q Can you tell me whether or not you feel that the information which you obtained from this pilot project will be a sound basis for you to recommend to your management development if the field is developed on an 80 acre basis? A Yes.

Q You feel the information will be adequate?

A Yes.

Q I believe you testified that it's your opinion that any well or any pool can better be subjected to secondary recovery and LPG flood or recirculating if it is developed on 80 acre locations than on 40 acre locations?

A If I said any pool, let me rephrase my statement that we would confine that to a reservoir.

Q Then any --

A (Interrupting) Then with --

Q Excuse me.

A Then within the reservoir, which by definition would imply continuity, then you would achieve greater overall flushing efficiency as you increased the distance between the injection and the producing wells.

Q So that it is your testimony that you favor 80 acre spacing in all fields where a single reservoir is involved in order that secondary recovery may be more sufficient?

A Yes.

Q Now, you are aware of the fact that the policy of this Commission is to develop the field on 40 acre location, are you not?

A I think that is a legal decision, and I am not a lawyer.

Q Do you have knowledge of any sandstone fields in New Mexico which are developed on an 80 acre basis?

A I'm not acquainted with all the pools or fields in New Mexico. I feel unqualified to answer the question.

Q You do not know of any yourself, though?

A No, I do not.

Q The testimony you have given then as to why you feel that the Commission should adopt 80 acre spacing, would be equally applicable to any other single reservoir pool in New Mexico, would it not?

A Let me answer it this way, each reservoir possesses its own inherent problems, and each reservoir has to be evaluated with its own characteristics. It would be dangerous to make a blanket statement for promiscuous use. I would be hesitant to make a statement like that.

Q You did state on direct examination that 80 acres would make for a more efficient second recovery program than 40?

A In the Lower Gallup, yes.

Q You quoted an authority, that was Mr. Muscat from Gulf. He was not referring to this particular reservoir, I assume?

A It was Dr. Muscat, and he was not referring to this pool.

Q Do you or do you not feel that as a general proposition 80 acre spacing is desireable in order to make secondary recovery more efficient?

A Generally, but let me make a qualifying statement on this. The spacing problem in industry as well as with Commissions is an educational problem. Years ago we had close spacing, no conservation,

the spacing has grown wider and wider as we have become better acquainted with the recovery mechanism in the recovery of oil. We have all become educated along these lines, both from a recovery, conservation and economic standpoint. It's been a tough battle, but I think you will have to agree that the trend toward wider spacing has prevailed and we will experience wider and wider spacing even in the future.

Q I appreciate your statement. I'm not sure it answers my question. But I won't repeat the question. May I ask you how many fields that were developed on 80 acre spacing you have had experience with in secondary recovery projects?

A The McKenny patent field in Louisiana is on possibly 160 or 640 acres the way it is being operated. I completely evaluated that on it.

Q That is not an 80 acre field?

A It is greater than 80 acres.

Q It is greater? A Yes, sir.

Q Have you had experience with any spaced on 80 acres?

A We have ....

MR. CAMPBELL: May I ask that he be permitted to continue his answer to the question.

MR. MALONE: It wasn't responsive, but I'll be glad for him to answer.

A Maybe it would be better if I summarize it that in most gas

condensate reservoirs in liquifying operation, which is a missible phase operation, spacing is considerably in excess of 80 acres, the flushing efficiencies are upward of 80%.

Q This is not a gas condensate reservoir?

A No, it is not.

Q Have you ever had an experience with a reservoir of this type? A Yes.

Q Which is spaced 80 acres and which you have had a secondary flood project? A Yes.

Q Now, that is my question.

MR. CAMPBELL: What is that field?

A Of course I have had a few years experience, but I kind of forget the names of the pools. But I might cite that I have investigated several pools where part of the pool would be developed on 40 acres, part of it on 80 acres, in water flood operations, and the recovery within practical limits have been identical. When I was with Carter --

MR. PORTER: Excuse me.

A When I was with Carter, we evaluated one like that where the pool was separated, they were separate, but the rock properties, the reservoir properties, the structural conditions, pressured, things like that very similar, again we found that the recoveries was independent displacement.

Q So that is the basis of the testimony which you have given?

A Yes.

Q You have testified with reference to some interference tests on four wells. Will you refer to Sunray's Exhibit 12? The copy of that exhibit, which I had, did not have the wells marked on it and I may not have gotten them correctly.

A I am sorry.

Q No, that's all right, I am just leaving myself a way out if I need it. If you will refer to Well 2-C, which I believe was one of them on which you based your testimony.

A Yes, sir.

Q In Section 31? A Yes.

Q Well, now, that well is offset by two direct 40 acre offset and one diagonal 40 acre offset, is it not?

A That is correct.

Q Would or would not the interference to which you testified have resulted from those 40 acre offset wells?

A That is precisely what I used.

Q So that your testimony merely established that there is communication between 40 acre locations?

A No. No.

Q The wells which were the basis of your testimony are spaced on 40 acre locations, are they not? A Exactly.

Q And the interference which resulted was between those wells, was it not? A That is correct.

Q Would you give us then your interpretation of that interference?

A Certainly. Take the south offset well, if it would drain 40 acres, the radius of effective drainage would not reach beyond the 40 acre tract, but this radius of drainage extended beyond that and engulfed the next well which is not 660 feet apart, but 1320 feet apart. It's a common misconception.

Q You have not used, well, let's refer, what were the other wells that you used here?

A The No. 18 which is in Section 7.

Q And how is it offset?

A It is offset to the northeast and it's offset to the southeast.

Q Those are on 80 acres, what would be the equivalent of 80 acres or 40 acres?

A They would be the normal 80 acre locations.

Q Are any of the other wells that you used in the interference tests besides 2-C the equivalent of 40 acre locations?

A The other 40 acre location would be at well location 2-C.

Q That was the well you listed as the fourth well on the interference measure?

A That is correct.

Q Thank you. Do you know whether or not under-saturated oil has been encountered in any of the wells which have been drilled in this pool?

A Yes.

Q Where has that been encountered?

A The two wells that I mentioned where we had bottomhole samples each displaced under saturated conditions.

Q There is a gas cap in other portions of the field, is there not?

A Correct.

Q Do you have any difficulty in reconciling the existence of a gas cap in one portion of the field with under-saturated oil in the other portion if there is good communication?

A Not at all, it is very common.

Q How do you reconcile the two?

A We have observed it.

Q It is not an unusual phenomenoa in your experience?

A None whatsoever.

Q In connection with the question which was asked by your counsel as to whether or not you considered the 80 acre locations would prevent waste, you answered that in your opinion they would. You were not asked whether or not in your opinion the granting of this application would protect correlative rights. Have you given any consideration to that question?

A I think you would have to define correlative rights. Maybe it's a legal question, I don't know. Now under certain conditions it might be important.

Q I will ask you then, if you are not in a position to answer the question, please merely say so, whether or not in your opinion, if the application is granted, each of the owners in this

field will recover his just and equitable share of the oil underlying the property?

A I would like to decline that question at this time.

Q All right. Now, in your Exhibit 11, let's refer to page number four, I notice in the center portion of the exhibit the numbers one, two, three, four, five and six. To what do those refer?

A One would be the upper sand, two would be the second sand, the one immediately below the one, three would be the third sand from the top, four, five and six would be the successive lower and lower sands consistent with the cross sections as we have previously presented.

Q So that regardless of whether the frosting or the cake is the best part, you will agree we have layers here?

A That's a matter of degree.

Q Do we have some layers, isn't that what is indicated when you can make one, two, three, four, five and six here?

A In a way. I am not apprehensive in referring to them as layers, that is all right.

Q I just want to get your opinion as an expert as to whether in fact those are separate sands, and if they are, whether communication vertically exists between them throughout the area included in this application.

A I don't know -- now this is my view, I'm not a geologist. I'm not going to get into geological work.

Q I wouldn't want you to.

A But from a reservoir standpoint, flow of fluids, permeability measurements, core analyses, things like that, I am hesitant in thinking of this thing as a layer type sand. You got a sand body, period. It displays permeability through the vertical section, that's it. That's the way I look at it.

Q You don't look at it as your geologist, Mr. Finfrock, in any event you prefer not to adopt his description of these several sand members?

A I neither refute them nor accept them. I have my personal views and I would like to think of a reservoir as a whole, I have to in my business.

Q Now, in thinking of this reservoir as a whole, have you been able to establish to your complete satisfaction that communication exists between these several members throughout the reservoir?

A I think the core analysis substantiates that statement.

Q Does the core analysis show a marked uniformity or non-uniformity of permeability and porosity?

A Now which way are you directing the uniformity?

Q I'm directing it to the way that you have testified it exists.

A Yes. When we consider one condition similar to the next condition, in other words, we compare similar conditions, we get evidence of similar rock properties. But when we cross similar

conditions or have conditions that are dissimilar, why then we are not making a fair comparison.

Q Is it your opinion that on the basis of these 15, or was it 21 cores? A Twenty-six cores.

Q Twenty-six cores that you have examined, that you can testify with certainty that there is communication between these various members so that if a particular well failed to penetrate one of the members, the other members would nonetheless be drained by that well?

A Let me direct your attention that core analysis themselves do not define interference or continuity. You have to establish that from pressure interference.

Q You have not made a pressure interference study except upon the four wells as to which you testified?

A That is all the available information, yes.

Q In that case you would not be able to testify with certainty that communication does exist so that various members might be drained, whether they were penetrated or not?

A The best information we have, I would say they would be drained.

Q It is your opinion they will? A That is correc

Q That is your opinion as to the entire area in the proposed pool?

A Based on my experience, I find that would be a reasonable

opinion.

Q I want to be sure we have clear the basis and not be repetitious, it is the interference test on the four wells that you have testified to plus the 26 cores that you have examined?

A Let's take about one thing at a time. Are we talking about interference or core analysis?

Q I am talking about the basis of the opinion you just expressed. I want to be sure it's clear what you reached that conclusion on. Would you state the basis on which you reached the conclusion that vertical communication exists and that a single member would be drained by a well penetrating another member, whether or not all members were penetrated?

A That's a pretty big order. Let me answer it this way: We have defined from the core analysis that predominantly the bulk of the reserves and the bulk of the recoverable oil will be gained out of the sand we call No. 1. We have defined interference from our interference tests, which shows that a well can drain an area in excess of 80 acres. So based on that data I say that we can effectively deplete the reservoir on spacing of 80 acres.

Q You say that each well will effectively drain the 80 acres that is allocated to it as a unit?

A Yes.

Q And that is your opinion? A Yes.

Q There is a rather broad variation in the permeability

which you found in this sand section, is there not?

A Yes.

Q From one-tenth of one millidarcy up to one hundred millicarcies?

A Or greater than a hundred.

Q Or greater than one hundred?

A Yes.

Q There is no uniformity in the relationship between the areas where those variations occur? That was a bad question. I think we agree on the answer. You heard some testimony this morning as to the existence in this reservoir of oil wells which were up structure from gas wells? A Precisely.

Q Are you aware of that condition existing in the reservoir?

A I'm assuming that you are referring to the Carson No. 5 Shell Well located in Section 27?

Q Well, refer to the well that was used this morning by Mr. Nutter.

A I would like to have the well defined, so I know precisely what we are talking about.

Q I'm not going to ask you with reference to the particular well. Are you aware that condition does exist?

A No, I'm not.

Q You have not taken into consideration the possibility that it may exist, in your testimony? You are not aware it does exist?

A No, I am not. I am confused, are you talking about a well located structurally higher than the five defined gas wells?

Q Yes, which is producing oil from a point structurally higher than gas wells in the immediate vicinity.

A Let me state this, with the data we have being of a conflicting nature and without any source of additional test information that we cannot, I cannot say if it's an oil well or a gas well, and I would prefer having some complete test information. Once I get that I will be happy to make you my interpretation of what that well is.

Q Do you feel that if that situation exists, it would have some effect on your testimony as to the reservoir?

A I can't give an opinion until I check that specific well with its test data.

Q Have you in any other hearing before this or another commission, ever recommended that any field be spaced on 40 acres?

A State that again.

Q Have you ever in any hearing before this commission or any other commission recommended that a well be developed on 40 acre spacing?

A Yes.

Q Where was that?

A Well, it might be any one of several states. I don't have my list handy.

Q All right. Thank you very much.

MR. PORTER: Does anyone else have a question of the witness? Mr. Utz.

By MR. UTZ:

Q Mr. Brinkley, referring to your Exhibit No. 13, with special attention to the ultimate recovery column, I note that you have stated there that the recovery on 80 acres is exactly twice the recovery on 40 acres? A That is correct.

Q I would assume that your recovery factor is identical for both spacings? A That is correct.

Q 40 acre radius, drainage radius, is somewhat smaller than an 80 acre drainage radius, is it not?

A That is correct.

Q Is it not true that it is the pressure differential between the reservoir and the well bore that causes the oil to flow to the well bore? A That is correct.

Q Then it would follow that your testimony here would be that the pressure and the depletion at the 80 acre radius would be the same as the pressure at the 40 acre radius?

A Appreciably so.

Q Would you care to elaborate why you feel that would be true, that depletion stage?

A I'll be glad to. As I stated earlier, the problem of well spacing is one of the industry's unsolved problems. Many of the experts have done considerable research in comparing recoveries on 40 acres versus 80 acres. They find no evidence of any

appreciable difference in ultimate recoveries when they can define the rock and fluid properties. Also it might ease people's minds if I state that an 80 acre well draining a circular area, would have contained twice the energy as a circular area containing 40 acres. Yet, the radius of the 80 acre well is only 41% greater than that for a 40 acre well. Also flow is not only affected by a pressure differential, but by friction, and of course that is affected by velocity. When one computes the velocity of the liquid flowing, we find that we are advancing just few inches a day until we get very close to the producing oil well.

Hence, with low velocity you would normally assume that you would be in the streamlined flow, and your friction would be approaching zero. Those values have been computed both for an 80 acre spaced well and 40 acre spaced well with good characteristics here. We find that to be the case. Again, may I state that it is one of the unsolved problems of industry, and I have some quotations in my bag that if you would like for me to quote from I would be glad to do that, but it is one that we will be faced with for some time. It's an educational problem. But our experience, so forth, leads us to conclude that there is no appreciable difference in ultimate recovery on a 40 and an 80 acre, I mean two 40's or one 80 acre tract.

Q Thank you. I believe that you have stated in your testimony that it is your belief that we have a gas cap in the Bisti Field?

A That is correct.

Q Would you have any recommendation as to how those gas cap wells should be produced?

A Yes. I think they should be permitted to produce at a rate commensurate with the oil voidage for an oil well, incorporating the limiting gas-oil ratio.

Q Would it be your thought that 40 or even 80 acre gas well in this area would not be a commercial well?

A Are you talking about a gas well?

Q Yes.

A It would be non-commercial.

Q Do you think that more acreage should be dedicated to the gas well in this gas cap than an oil well?

A I do.

Q Let's dwell a moment on the 80 acre unit which I believe you have requested. Am I correct in my understanding that you have requested 80 acre units to run north and south the long ways, to run north and south? A No, sir.

Q You have not requested that? A No.

Q Do you have any opinion?

A I would prefer that the counsel make a statement on that. I believe he is more acquainted with the details of the content of our application than I.

Q You have made no recommendations as to where the well

should be located?

A Yes, we have made a recommendation. I think I misunderstood your question. Yes, I have made a recommendation. I stated that the location of wells to be in diagonal 40's within a Governmental 160 acre tract and no closer than 330 feet from the lease lines. There is no statement whether the tracts would run north and south or east and west, but they can be fitted in like a puzzle, like little squares or little rectangles; the way some of the wells are spaced, we will have to go north and south, and other ways east and west. We have tried to leave it flexible to the discretion of the operator for more flexible operation.

Q It is your testimony that you could run them either way?

A Yes.

Q According to the situation? A Yes.

MR. PORTER: Anyone else have a question of the witness? Mr. Cooley.

By MR. COOLEY:

Q Mr. Brinkley, you testified that you feel that the ultimate recovery will be substantially the same on the 80 acre spacing, as it would be with the two 40 acre wells?

A Correct.

Q Under what specific conditions did you recommend 40 acre spacing?

A I did not recommend 40 acre spacing.

Q I believe you, in answer to counsel's question, stated on several occasions in the past you have recommended 40 acre spacing.

A I beg your pardon. That was on another field. As I further stated that each reservoir has to stand on its own merits, and the spacing and various other things are dependent on the peculiarities of that reservoir.

Q That's what I am getting at, what are the specific conditions that make it possible or impossible, advisable or inadvisable to space 40 or 80, in your opinion?

A Well, we had more sand.

Q Thicker sand?

A Yes. One hundred feet of sand possibly.

Q That has no bearing on drainage, but economics?

A Exactly.

Q What is another one?

A That would be the important thing, the oil in place. The whole thing could be summed up as to the oil in place and recoverable oil, if we had sufficient oil to justify a reasonable profit return to carry on exploitation and things like that, why then of course we do that.

Q Then the simple underlying factor for the recommendation of 80 acres rather than 40 is the economic factor?

A Yes, that is right.

Q You feel it is not economical to drill 40 acre wells throughout the field?

A Under a competitive situation it is hardly economical on the 80, on the average conditions.

Q Would it be so, I think you continued to use the term throughout this hearing, competitive conditions?

A Yes.

Q That does not take into consideration fieldwide unitization and secondary recovery project, does it?

A That is correct.

Q And is it not contemplated by your company and the major companies and possibly all the people in this pool, for this pool to be operated effectively, there will have to be secondary recovery?

A That is right. The salvation of the pool will be through the secondary means, pressure maintenance with unitization.

Q Assuming we achieve this salvation, would it then be economical to develop the wells on 40 acre spacing?

A No, sir. It might be economical, but --

Q (Interrupting) You wouldn't make as much money?

A You wouldn't make as much money and it wouldn't be prudent operations to spend twice as much money to gain the profit. What I am getting at is unnecessary wells are a waste. We can accomplish the same thing on wider spacing.

Q Now, when a well is drilled into a reservoir like this,

isn't there immediately a low pressure area created which causes the oil to drain toward the well bore and get your production?

A When it is produced, that is correct.

Q Is not this pressure a gradiation back off into the reservoir back off into a point where the pressure is that of the original reservoir pressure?

A The gradiation phenomenon?

Q It is not a sharp drop, it is gradiation throughout on the reservoir? A That is correct.

Q While you might have a thousand pounds, what was the initial pressure of this reservoir?

A Probably of the order of 1500.

Q When a well is immediately drilled, what does it drop to?

A As it is produced, the pressure will drop.

Q What does it drop, say within a week, to make it produce?

A I can't give you the precise answer.

Q Just a rough estimation, that is to point out the gradiation factor.

A I would just guess, produce a week might get five pounds drop, ten pounds drop, just a guess.

Q This drop will be a gradiation down through the reservoir?

A Correct.

Q As you go ahead producing, what do you think that differential would be between the pressure right at the well head and out

away from the well, you don't know, you don't believe one well will drain this entire pool?

A Given enough time, yes.

Q If you drill a well right up in the middle of the 25 mile lateral area, you think the pressure of this well would ultimately drop even though that is the only well the pressure would drop to abandonment pressure?

A Yes, it would ultimately drop to abandonment pressure.

Q Do you feel that the well, when it reaches the abandonment pressure, do you feel you can go out to the other ends of the pool and still drill a producing oil well?

A We are getting into a hypothetical condition.

Q Well, let's answer it then.

A Given sufficient time, it might take a century, the well would drain the reservoir.

Q But this pressure gradiation goes off to practically original reservoir pressure, would it not?

A The gradiation?

Q From abandonment at the well head to original well head pressure at the extreme ends of the pool.

A No, I can't say that. You do get a pressure gradiation at the well bore. It is not a sharp drop.

Q When you abandoned your 80 acre well, don't you feel that the pressures out at the periphery at the edge will be something

in excess of abandonment pressure? A No.

Q At what point in the development of this well does the pressure level off instead of grade off?

A You are kind of losing me.

Q You drilled a well and you had the pressure gradiation?

A Yes.

Q Low at the well head and high away from it?

A Yes.

Q At some place in your test, instead of grading off to a higher pressure, somewhere away from the well, it levels off it is abandonment pressure through the pool?

A No, you always have that, you just don't have sufficient pressure differential to produce the production of oil in economic quantities.

Q At the outer perimeter of your drainage area of your 80 acre well, you will have somewhat higher pressure than your --

A (Interrupting) That is correct.

Q Would there not be a larger perimeter of this well if it were drilled on 40 instead of 80 since you have a shorter radius on your 40 acre drainage, it would just be half would it not?

A No, on the contrary, you could have less oil remaining on 80 acre spacing than on 40.

Q Let me ask my question again, see if you still want to answer it the same way. This is still a gradiation?

A Yes.

Q It is lower and it's going out away from the well?

A Yes.

Q If it has to drain roughly 2,000 feet or more?

A A thousand some.

Q Twenty-two hundred feet? A For an 80 acre?

Q Yes. A 1,070 feet.

Q Draining to the other end. If it drains 1,070 feet at the 1,070 foot the pressure would be higher than it would at the 500 foot? A Yes.

Q With 40 acre wells, the outermost boundary of the drainage areawould be the 500 foot?

A No, it would be 750 feet.

Q 750 feet? A Yes.

Q Nonetheless, it would be higher?

A Yes.

Q On the 80 than the 40?

A Yes.

Q You would get more recovery on 40 acres than 80?

A No.

Q Would you care to explain in reference to your Exhibit No. 12, it seems to be another enigma, maybe you can solve this one for me. I believe you testified that the No. 4 and No. 6 wells, these are referred to as wells outlined in red, and you referred to

them as your interference wells? A Yes.

Q Your 6 and 4 wells are in what you referred to as in the superior sand? A Yes.

Q The 4 and 6 were produced intermittently or just once?

A Each of them produced roughly a thousand barrels some time during that year period.

Q And neither the C-18 nor the C-2 was produced at any time?

A That is correct.

Q Can you tell me why the C-18 and C-2, which are in the inferior sand, I believe you testified?

A That's right.

Q Were less permeable and less porous, why did they get more pressure drop than the 4?

A They had more interference.

Q Was it a time period?

A No, they had more interference.

Q Isn't that another enigma that an area with less permeability and less porosity would show more interference than it would in an area of high permeability and high porosity?

A Interference can be any magnitude, it's a matter of degree. All I can say is that they suffered more interference.

Q Wouldn't it logically be the other way, that in the good permeability and good porosity you would get a bigger draw down?

A Not at all. No. Not at all, just the reverse of what you ar

thinking.

Q Well, I could be very well mistaken, it would seem to me that the draw down would be greater in this high permeability area.

A No. For the same quantity of oil it would be opposite to what you say.

(Discussion off the record.)

MR. PORTER: Let's go back on the record. Mr. Cooley.

Q I believe you testified in answer to a question on cross examination a short while ago, that your recommendation, or the advisability of 80 acre spacing in this pool, would be directly dependent on the injectivity of your injection wells in this pool?

A Yes, the injection well would have to qualify for the wider spacing.

Q Are you prepared to state unqualifiedly at this time that the injectivity of the wells in the Bisti-Lower Gallup Oil Pool are adaptable to 80 acre spacing? A Yes, they are.

MR. COOLEY: That's all.

MR. SULLIVAN: Mr. Chairman, my name is Sullivan, representing British American Oil Producing Company.

By MR. SULLIVAN:

Q Mr. Cooley was questioning you a moment ago with regard to the reasons why the two wells in what you have referred to as the inferior sand area, did not have as great a pressure drop as the two wells in the superior sand area?

A You have them reversed.

Q Very well. Would a simple explanation of that be the fact that the wells in the area of the inferior sand simply had lesser area from which to rebuild the pressure while shutin?

A You can't give, in my opinion, you can't give a simple explanation like that because what we measure is the compounding effects of not only reservoir depletion, but interference from offset wells which we cannot precisely define. All we measure is the composite effect.

Q I thought perhaps there might be a simple or elementary answer to this enigma. I was puzzled also during Mr. Seth's cross examination of you, Mr. Brinkley, about this factor. With regard to the quantity of LPG products necessary to carry out a successful flood program -- A Yes.

Q Assume that your pilot program there proves to be successful to a practicable degree. A Yes.

Q Assume that the well spacing in the field stays on an 80 acre basis, would you not be able to carry out your missible slug program with about the same quantity of LPG products on an 80 acre spacing that would be required if the field were developed on 40 acre spacing?

A Comparing an 80 tract with two 40 acre tracts?

Q Yes. A Correct.

Q Then, in other words, with an 80 acre spacing as compared

with 40 acre spacing, at least you would make a greater or more efficient use of your LPG products in sweeping through the field?

A Precisely.

MR. PORTER: Anyone else have a question of the witness? The witness may be excused.

(Witness excused.)

I believe it's apparent that this case will not be concluded today at least during daylight hours. There are some parties who entered an appearance this morning who have indicated that they cannot be here beyond today and would like to make a statement, so we will entertain those statements at this time, and if you have a copy of the statement written out, I would appreciate it if you would leave it with the reporter.

MR. MALONE: I thought maybe in view of the time, if we might not be able to file written statements, say within a ten-day period.

MR. PORTER: In lieu of the oral statements, the written statements from the interested parties will be acceptable within a period of ten days.

MR. MALONE: May I be certain that Gulf's Exhibit 1 is admitted in evidence? It was identified but not offered.

MR. PORTER: Without objection, Gulf's Exhibit No. 1 will be received.

(Discussion off the record.)

MR. PORTER: Will the next witness come forward, whoever that may be? Is that all of your witnesses?

MR. ERREBO: That concludes the applicant's case.

MR. BUSHNELL: Did I understand correctly the conclusion of this discussion that statements may be mailed in and that those statements will be incorporated in this record?

MR. PORTER: They will be put in the record, yes, sir, within ten days.

MR. SETH: We are prepared to proceed, if the Commission would like. I was just hesitating, I thought some of the other people would like to put on some other witnesses.

MR. PORTER: Before proceeding with any further testimony, I would like to make a brief announcement. This hearing will not continue in this auditorium in the morning. We have arranged to meet in the Highway Commission Building on Cerrillos Road. We will take about a five minute break.

(Recess.)

MR. PORTER: The meeting will come to order. Mr. Seth, will you proceed with your first witness, please?

DONALD R. LINDSAY

called as a witness, having been first duly sworn, testified as follows:

DIRECT EXAMINATION

By MR. SETH:

Q Would you state your name, please?

A Donald R. Lindsay.

Q Were you sworn earlier during the course of this hearing?

A Yes, I was.

Q Would you state briefly your educational qualifications, your experience?

A I received the degree of Bachelor of Science and Mechanical Engineer from Stanford University in 1948, and degree of Master of Arts in Geology from the University of California at Los Angeles in 1952.

Q What has been your experience and by whom have you been employeed?

A I have been employed by Shell Oil Company for the past six years in the capacity of exploitation engineer.

Q Have you made a study and are you familiar with the geology in the Bisti Pool? A Yes, I am.

MR. SETH: May he testify as a geologist?

MR. PORTER: He may. His qualifications are accepted.

Q Now, have you made a structure contour map of the Bisti Field?

A I have. That is Exhibit No. 1.

Q Would you point it out, please?

A Yes.

Q Would you please state to the Commission what it shows,

Mr. Lindsay?

A This is a structure contour map on the top of the Gallup formation. The map includes the western two-thirds of Range 11 West, Township 25 North, and the eastern five-sixths of Range 12 West, Township 25 North, San Juan County, New Mexico. This is a portion of the Bisti Field and is located about in the central part of the field. The map shows the property lines within this area and the locations of the wells which have been drilled within the boundaries of the map.

Contours which have been drawn with respect to sea level at a contour interval of twenty foot show a northerly dip of about eighty feet to the mile. This map has been submitted at this time primarily to show the geographical locations of some forthcoming exhibits. We have indicated with red arrows Shell Carson No. 1 an Shell Carson 33-24, which are located in Section 24, Range 12 West, Township 25 North. These wells were cored through the productive portion of the Gallup formation, and on this map we also show the lines of Section A-B, C-D and E-F which will be referred to later in the testimony.

Q Now, would you proceed to your next exhibit, you have a stratigraphic section, do you not? A Yes.

Q We'll refer to this as Exhibit No. 2.

A Yes.

Q Was this prepared under your supervision and direction?

A Yes, it was.

Q Would you please describe what it shows?

A This section illustrates the subsurface data which we obtained from Shell Carson No. 1 and Shell Carson 33-24, which were cored through the Gallup formation. The wells are located about 2950 feet apart, slightly more than a half mile, and are shown at a vertical scale of four feet to the inch. They are hung on a datum of electric log marker GC which occurs at the top of the uppermost oil productive sand in the field.

Q The following information is provided for each well: The self potential and resistivity curves have been traced from the electric log. We show with heavy black lines the interval in each well which exhibits microlog separation. Porosity values are shown with open circles and have been connected with lines to show a porosity profile for each well. The porosity scale on the chart is zero to fifteen percent, and those values which are more than ten percent have been shaded with green.

We show permeability values with solid circles, which have also been connected in this case to show a permeability profile for each well, and the scale for permeability is a logarithmic scale from one-tenth of a millidarcy or less to a hundred millidarcies, and we have shaded each portion of each well showing more than one millidarcy in red.

The chart shows correlation lines between the wells which

connect correlative electric log markers in the two wells. These markers are identified as used by Shell, from top to bottom, GC, GD, GE, GF and GG. Two intervals contain the majority of permeable sands which supply most of the production from the field. The upper one is between marker GC and GD, and I'll refer to that as the GC sand. This is the same interval as was discussed by Sunray witnesses as the best sand, the one that was referred to as essentially a sand bar deposit.

The lower sands are between marker GD and GE and I will refer to this interval as the GD sands. This chart represents the differences in the location of permeable sands in various wells in the field. For example, in Shell Carson Unit No. 1, the GC sands exhibit very favorable reservoir characteristics. There is considerable microlog pay permeables ranging up to one hundred millidarcies, and the porosities are generally of ten to fifteen range. In the GD interval there is virtually no sand, the section appears to be almost entirely at this time impermeable silt zone.

Carson 33-24, the converse is true. The GC interval has almost entirely silted out, there is only a short interval showing microlog separation. On the other hand, the GD sands in this well possess favorable reservoir characteristics inasmuch as they have permeability characteristics which range up to over a hundred millidarcies, and have about ten feet of net microlog pay. This section, I think, illustrates the fact that sands in the Gallup

formation are not continuous and that permeability sands within the Gallup occur at different stratigraphic positions in different wells in the field.

Q Now, would you tell the Commission the source of the data that appears on this Exhibit No. 2?

A This chart contains data which were obtained from electric logs, micrologs and core information, core analysis.

Q Now, would you say that the variation in permeability in each of those sections is great or is in small or how would you care to describe it?

A I would say that these sands in the Gallup formation in Bisti Field are characterized by a very wide range of porosity and permeability values.

Q You would say then that they were greater than you would ordinarily expect in a sand reservoir or that are usually encountered in a sand reservoir?

A They are greater than any I have seen in sand reservoirs prior to this.

Q Now, does this section also represent the wide variation from well to well? What is the distance between those two wells?

A The distance is a little over a half a mile.

Q What other conclusion do you draw from Exhibit No. 2, if any?

A I would say that the petrophysical data and the core

analysis data that we have from these wells indicates a considerable amount of discontinuity in the permeable sands between these wells. The sands which show microlog pay are separated by intervals of very dense silt stone and tightly cemented sandstone, which I would say would be impermeable to the passage of oil.

Q This section, would you say this is consistent with or confirms the microlog surveys which you have used and will use in the subsequent exhibits?

A I think that this section illustrates a remarkable correspondence between microlog pay and porosity and permeability values. This is in each case where we have core data available where we have microlog separation, we also have correspondingly high values of porosity and permeability, and where we do not have microlog separation in other portions of the well, we have fairly consistently low values of porosity and permeability.

Q Would you explain, please, what is microlog separation and how useful is the data obtained?

A Well, the microlog is an instrument for detecting the presence of mud cake in the well bore and that is produced when the liquid portions, the liquid phase of the drilling fluid filters into the formation and deposits a mud cake. It is thus an indication of permeable sand and also a porous sand.

Q Do you consider it a good or reliable indication?

A I think it is a very reliable source of information in the

Bisti Field, and I believe that most of the operators in the Bisti Field evaluate it because virtually all the operators in the Bisti Field run micrologs in their wells.

Q Could you say whether or not these two wells are pretty much typical of what you find in the field as far as a unit?

A I would say that no one well is typical of what you find in the Bisti Field because there are such extreme variations from well to well. However, I think that these wells are fairly representative of what you would find in an average well.

Q Now, have you prepared an isopach map from the data you collected? Would you point out again on your contour map the location of the stratigraphic section again?

A The stratigraphic section shows these two wells, Carson No. 1 and 33-24.

Q Go ahead with the isopach.

A Exhibit No. 3 is an isopach map of the net microlog pay in the Bisti Field. That is the portion of the Bisti Field which is included by the map, and the Exhibit 3 includes the same area as is covered by Exhibit No. 1. The map illustrates the distribution of net microlog pay in the Gallup sands by the use of isopach lines drawn to an isopach interval of five feet.

Q What do you mean by that, what is an isopach interval of five feet?

A Isopach line connects points of equal thickness of net

microlog pay. For example, a closed curved line labelled 20 feet situated in Section 20 of Range 11 West, Township 25 North, means that every point on that line represents a location where approximately twenty feet of net microlog pay would be encountered in a well, and since the values decreased away from that, this implies that a well within the closed line would probably encounter more than twenty feet of net pay.

Q When you say twenty feet, referring back to Exhibit 2, would that be the total of the black, what you labeled there in black? A Yes, it would.

Q Regardless of where it occurs vertically?

A The map does not represent one large continuous sand body, but it is actually a composite map of the sum totals of many streaks of thinner pay.

For example, in Carson 33-24, there are intervals of 5 feet, 3 feet and 1 foot and half a foot, another half a foot, which adds up to 10 feet of net microlog pay, and those several intervals are combined, that gives you the 10 foot isopach value on the map.

Q That means just the total at that point, there could be a large number of stringers, is that correct?

A That's right. Actually the map illustrates that there are considerable variations in net microlog pay thickness through the field. For example, in the upper portion of Section 16 in Range 12 West, 25 North, there is a region of twenty feet of net microlog

pay and less than half a mile there is a region of five feet which to me illustrates a very rapid change in the sedimentary characteristics from one region to the other.

Q Do you have any further comments on the isopach Exhibit 3?

A Not now.

Q Would you go ahead to your cross sections, please?

A We have constructed two sections which were selected in a relatively densely drilled area, Section AB, which is Exhibit No. 4, which is located in Sections 10, 15, and 16, Range 12 West and Township 25 North. The well shown on this section are from southwest to northeast El Paso Kelley State 8. State 3, Shell Government 12-15, Shell Government 21-15, Shell Government 34-10 and Shell Government 43-10: The wells are ranged vertically with respect to sea level as a datum and are shown at proper relative horizontal positions according to the scale of the section, and the wells are an average of about 1800 feet apart.

Again we have shown with correlation lines, the correlative electric markers from well to well as we did on Exhibit No. 2. We have made schematic and interpretive correlations of net micrologpay from well to well.

We have indicated these intervals in green on each section. These correlations indicate the changes from well to well in the stratigraphic location of the interval, showing microlog pay. In other words, they show that the permeability sands, the most

permeable sands in the Bisti Field are irregular and discontinuous. For example, in Shell Government 34-10 the GC sand has a considerable microlog pay thickness which rapidly pinches out to the southwest, and is gone by the time Shell Government 12-15 is reached. This well exhibits no microlog pay in the GC sand.

Continuing in a southwesterly direction, El Paso Kelley State 3 does have some microlog pay in it, and this I interpret as a discontinuity in the permeable sand in the GC interval in this portion of the field. The degree of discontinuity of these sands is fairly well controled, suggests to me that there is probably a much greater degree of discontinuity and lenticularity of sands and permeable sands than we can possible know about.

These correlations have been made in as simple and continuous a manner as possible, and probably denser well control would reveal a much greater degree of discontinuity and lenticularity that can now be demonstrated.

Q You consider that a reasonable interpretation of the data?

A I would consider it a reasonable interpretation of the data available.

Q Of course, between wells, where it is noncontinuous, those could be terminated, but you don't know where they terminate?

A We don't know exactly where they terminate. No one knows that.

Q There could be certainly some variation from what you have

shown there?

A Yes, there could be, but I think that it is correct in principle. This also, I think, is suggestive of the fact there may be other permeable sand streaks existing between the wells which are on this particular section, which are not penetrated by any well. For example, in the GE sands in Shell Government 12-15, there is good microlog development in the GE sands which is not present in either El Paso Skelley State C or Shell Government 2315 to the southwest and northeast. It seems to me very likely that had by chance these wells been spaced at the alternate positions at which they are, this sand may have been missed completely, or it may just have been penetrated on the edge. At least it may have been inadequately penetrated by these wells.

Q Then it's possible then for wells on relatively wide spacing to miss these stringers entirely, is that correct?

A I believe that is true.

Q Are the chances of encountering them greater by reason of a number of wells than are drilled?

A Yes, they are greater. Incidently, I would like to say also that it is not to be inferred from these sections that we believe that the only production from the field is from these permeable streaks of sand and, contrary, we know that we obtain some production from the remainder of the sands where they are oil saturated, but that the permeability is so low in these sands that we feel that

wells completed in those sands without microlog pay alone would be very poor producers. In attempting to define the limits of the field, we completed Shell Carson No. 2 in Section 25, which did not exhibit any microlog pay at all. Although it did have, according to the electric log, some SP development, and therefore it did contain a sandy interval that well was completed for only an allowable of 21 barrels a day and has declined from that.

Q On your Exhibit No. 4 you have shown perforations, have you not, in addition to the microlog?

A Yes, I did. That illustrates, I think, the perforated interval does not show microlog pay because we have obtained enough oil from the intervals.

Q Now, Exhibit 4 is the cross section across the narrow dimension of the field, is that right?

A Exhibit 4 is a southwest northeast cross section which is across the main trend of the Gallup sand.

Q Do you have another cross section longitudinally?

A Yes, Exhibit No. 5.

MR. PORTER: The hearing will be recessed until tomorrow morning at nine o'clock when we will reconvene in the Auditorium of the State Highway Commission Building on Cerrillos Road.

Mr. Seth, could you have your exhibits posted there at nine o'clock?

MR. SETH: Yes.

(Whereupon, the hearing was recessed until 9:00 A. M., on Friday, September 20, 1957.)

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(Whereupon, on Friday, September 20, 1957, the hearing was continued in the Auditorium of the State Highway Commission Building on Cerrillos Road in Santa Fe, New Mexico.

MR. PORTER: The meeting will come to order, please. I would like to announce that the Governor has said he will be a little late on account of some previous commitments. He will be here later in the morning. We will resume Case 1308. Mr. Seth, would you continue with your witness, please?

DONALD R. LINDSAY

called as a witness, testified further as follows:

DIRECT EXAMINATION (Continued)

By MR. SETH:

Q Mr. Lindsay, when we concluded yesterday, you had testified concerning the cross section Exhibit 4, I believe. Would you mind going up to the exhibits, please, and indicate again where Exhibit 4 is located, the cross section Exhibit 4 on your contour map there?

A Exhibit No. 4 is cross section AB which is located in portions of Section 10, 15, 16 in Range 12 West and Township 25 North. It has been drawn in a southwest, northeast direction, and therefore is across the trend of the sands.

Q Now, do you have a section, longitudinal section through a

portion of the field?

A Yes. Exhibit No. 5 is a longitudinal section CD which is located in portions of Sections 9, 15 and 16 in Range 12 West, Township 25 North.

Q Would you point it out on there so we can see where it is?

A (Indicating.)

Q Okay.

A This longitudinal section includes the following wells, Amerada Joan White 2, Amerada Joan White 1, Phillips Mayre F-5, El Paso Kelly State 1, Shell Government 12-15 and Shell Government 23-15. This section has been constructed similarly to the cross section AB. The following information is provided for each well, a tracing of the SP and resistivity curves on the electric log, the interval showing microlog pay has been shown with a heavy black line and perforations and completion data are shown where applicable. Similarly to section AB, I have made correlations of microlog pay intervals from well to well. Again, we find that the permeable sands as indicated by the microlog occur at different stratigraphic positions in different wells. In comparing the longitudinal section with the cross section we can see that the sands are somewhat more persistent down the Gallup sand as compared with across it, but again we find that the sands occur in discontinuous streaks.

That is the permeable sands, for example, in the left four wells the sands are well developed, the GG sands are well developed, and

pinch out toward the southeast and are not present in Shell Government 12-15 in sufficient permeability to exhibit microlog separation, and that they again resume to the southeast appearing in Government 23-15. The GD sands indicate an opposite trend in that they are well developed as a series of permeable sands in the southeastern part of the section and gradually pinch out, grading laterally into silt stones and tightly cemented sand stones toward the northwest and apparently begin to resume development at the northwestern end of the section in Amerada Joan White, 2.

Q You colored this Exhibit 5 in green on the basis of the microlog separation, is that correct?

A That is correct. I have shown in green only those portions of the section which I interpret to be permeable sands, permeable enough to exhibit microlog separation, and again this section is not meant to imply that the remainder of the Gallup sands are not oil-bearing, and it does not imply that they are not productive of oil. Certainly we have seen that we do get some production from them, and therefore we perforate the Gallup sands wherever they are oil-bearing and wherever they show SP development on the electric log.

I think that we can expect these tighter sands to contribute production throughout the life of the field mainly through migration of oil flow, those sands into the adjacent permeable sands and thence through those more permeable paths to the well bore.

Therefore I would conclude from this that the efficient

drainage of this field will depend on the adequate penetration and development of the more permeable sands.

Q Which then, in your opinion, more wells would be preferable rather than fewer?

A I would say that the more wells we drill in this field the more of these discontinuous sands we will drain. I feel quite certain in my opinion wells on 80 acre spacing will miss a good deal of the permeable sands in the field, and that wells on which closer spacing, I would say that wells on one acre spacing or even ten wells to an acre would still probably miss some of the smaller sand stringers.

Q Now, Exhibit 5, as Exhibit 4, you have colored it on the basis of a reasonable interpretation, have you not, that's generally accepted by geologists?

A As I mentioned earlier, I think that the microlog is a very effective tool for detecting permeable sands in these wells where we don't have core data. I think if you will run your little eye up and down these wells shown on Exhibit 2, that at least you can't help but be impressed by the general core of microlog pay with intervals showing high porosity and high permeability.

Q Now, I was thinking take this first microlog section in Shell Government 23-15, you colored that and it is finally pinched out before reaching 12-15? A That is correct.

Q In your opinion is that a reasonable delineation of that

condition there?

A I think so, to be consistent I was not able to show micro-log pay going through Shell Government 12-15 in the GC sand because there is no microlog separation there.

Q But it was in 23-15, not in 12-15, so we assume that it stopped somewhere in between. Now, exactly where we don't know, do we?

A No, that is an interpretive problem.

Q You saw the applicant's exhibits as far as the cross section concerned the lower sands, do those exhibits actually show some discontinuity also?

A Yes. On examination of the longitudinal section, I noticed that in the lower sands which we referred to as the GC sands, there were discontinuities apparent on that section which I did not hear brought out in testimony.

Q Now, would you expect in this longitudinal section for these stringers to be longer than you would in Exhibit No. 4, which is across the section, and if that is the case, would you explain why that occurs?

A I would expect the permeable sands to be more continuous and longer in the longitudinal section than I would in the cross section since the longitudinal section is drawn parallel with the depositional grain of the Gallup sand in the Bisti Field.

I would agree with many of the points that were brought out

in the geological testimony of a previous witness, that the Gallup sand is a sand bar type deposit which was deposited in fairly shallow water, and that the sands are best developed in the vicinity of the core of the central part of the bar, and that they pinch out away from the bar in both directions.

Q Tell us a little bit more about this deposition, was it at a beach or how?

A We believe that the Gallup sands were deposited as an off-shore sand bar, probably in very shallow water very possibly, in fact, very probably during most of its deposition, I would say that the sand bar was within wave base and therefore suffered considerable disturbance by the action of waves while the sediments were being deposited, and that it was probably deposited on a fairly flat sea bottom with very low slope.

Q Do you have any other comments concerning Exhibits 4 or 5?

A I think that for the moment I have said what I wanted to about them.

Q Do you have some further data on the detailed situation in the well bores? A Yes, I do.

Q Would you tell us first a little about the coring and how you handled the cores?

A We have cored to date three wells through the Gallup sand. We attempted to core continuously through the productive portion of the Gallup sand and to best examine these cores we saw them

down the middle and photograph them.

Exhibit 6 is a photograph of a portion of the continuous core taken in Carson 33-24, and in the exhibit the core extends from the depth of 4893 to 4911, and this portion of the Gallup sand is within the productive GD zone in this well.

Q Could you point the well out on the map and on the stratigraphic section?

A The well is located in Section 24, Range 12 West in Township 25 North. The portions which are shown on the photograph is in 4893 to 4911, about in there.

Q That is the entire photograph covers that portion, does it?

A That is correct.

Q Do you consider that fairly representative section of a core and of the wells that were cored?

A Yes, I do. I have examined the cores from Carson No. 1 and Carson 33-24 and in both of these cores I find conditions similar to this throughout the Gallup in both wells. The cores I think exhibit very typically the absence of smooth, even bedding planes and exhibit the disturbed sedimentary structure which are characteristic of these sands. To augment this photograph I would like to produce core samples from this interval.

Q Yes, do you have them there?

A I regret that I don't have several copies of these. Exhibits 7 and 8 are respectively core samples from depths of

4894 and 4909 in Carson 33-24, and their positions are indicated by the left red arrows on the photograph respectively. These particular examples show that we interpret to be a result of reworking of the sediments by marine organisms, resulting in very irregular pods and tube lenses of permeable sand, which are closely associated with very tight, tightly sedimented sand stones, and I think exemplify the limited continuity of the permeability in these sands on a microscopic scale.

Exhibits 9 and 10 are core samples from Carson Unit No. 1 for which I do not have a photograph present. Exhibit 9 is from the GC zone in this well. It was taken from the interval 4878 to 94 and Exhibit 10 is from 4964. Exhibit No. 9 is from the GC sand in this well and it also exhibits very irregular and disturbed bedding, and Exhibit 10 is from the lower portion of the Gallup sand below the GD sand, and this is an example of a core which exhibits SP development on the electric log, but no microlog separation. And again I believe that the evidence of disturbance of bedding planes is extreme.

I would conclude from examination of cores and the cores that I have seen in the Bisti Field, that the permeable paths in these sands are very irregular, very torturous and very, very limited continuity.

Q Now, there was some testimony yesterday concerning some gas wells in the area. Do you have anything further on the cores

before we can discuss that matter?

A Nothing at the present.

Q Do you have an exhibit prepared showing the relative location of the gas wells to the oil wells?

A Yes. Exhibit No. 11 is a presentation chart showing the wells in the southeastern part of the field, the portion of the field that we have studied. It is referred to as Penetration Chart EF and extends from the eastern portion of Range 12 West, Township 25 North, to the eastern portion of Range 11 West, Township 25 North, and includes the following wells: Shell Carson No. 2, Shell Carson 33-24, Shell Carson No. 1. Let me start this order over again. Shell Carson No. 2, Shell Carson 33-24, Shell Carson 1, Shell Carson 4, Gulf Gle-Na-Nup-Nah No. 1, Sunray Es-Ka-Nel-E-Wood 2, Sunray or Anderson Prichard To Sah 1, and Anderson Prichard Harold Begay 1. These wells are not spaced at their respective relative distances, but the total distance from the left well to the right well is six miles, approximately. They are, however, ranged vertically with respect to sea level. On the section we have colored with red opposite the perforation intervals, those wells which produce gas, and with green those wells which produce oil. The significance of this is that gas wells have been completed in the field at comparable and even lower structural positions to oil wells in the Gallup formation.

As an example, Gulf Gle-Na-Nup-Nah No. 1 was completed with an

initial production of 1515 MCF a day dry gas and no oil. Shell Carson 33-24 to the west is 21 feet structurally higher than the other well, and completed for an initial flowing production of 470 barrels a day of oil, the GOR of 620, which is about in the average range for the field. The westernmost well, Shell Carson 2, was completed at a structural elevation 64 feet higher than Gle-Ha-Nup-Nah No. 1 and as pointed out previously in the testimony, this well does not have microlog pay, but does have SP development, and was completed for an initial production 21 barrels a day of oil with a very small amount of gas.

I would conclude from this situation that the existence of gas wells down structure from oil wells in the reservoir of this type and an unfaulted reservoir, that there must be some sort of discontinuity in the sediments themselves. I can arrive at no other conclusion at the present.

Q You agree, do you not, generally with the dip of the field as testified to by the proponents? A I do.

Q Was this existence of the gas referred to by the proponents as a gas cap, is this the same matter you are referring to now?

A I believe these gas wells were referred to by the proponents of 80 acre spacing as being in a gas cap.

Q Do you have any further conclusions or statements you would like to make, Mr. Lindsay?

A Yes. I would like to briefly summarize the results of my investigation of the Gallup sand stone reservoir of the Bisti Field

as follows: Isopach maps of the net microlog pay in the field reveal that the permeable sands are irregularly distributed and of variable thickness throughout the field. Cross section and longitudinal sections, both which show detailed correlation of microlog pay intervals, reveal that the permeable sands are located in different stratigraphic positions from well to well, and that they are discontinuous and grade laterally into tight silt stone and tightly cemented sand stones.

Correlation of core data between continuously cored wells also reveal with core analysis data that the permeable sands are variable in their stratigraphic position and that there is a very wide range of porosity and permeability within the Gallup sand stone.

Examination of cores indicates that the Gallup sands are not evenly bedded, but that they exhibit evidence of severe disturbance during deposition, with the result that permeability paths are very irregular on a small scale as wells on a large scale. Production anomalies occur in the southeastern part of the field where gas wells have been completed down structure from oil wells, which to me is virtually positive evidence of discontinuity in the sediments. Inasmuch as every avenue of investigation has indicated that the Gallup is a very heterogenous reservoir, the possibility that the field can be efficiently drained on a spacing as wide as 80 acres appears to me to be very unlikely. And that if drilling is not carried out on a denser spacing pattern, that it is probable that

much of the primary recoverable oil will remain in the ground.

Q Now if I may just make a statement, and the data you have presented concerns a large segment of the field, but is it, in your opinion, fairly representative of the entire area?

A I think that it was brought out by the proponents of 80 acre spacing that the field is fairly, conditions in the field are fairly continuous from one end to the other, and I feel that our approach of sampling about a third of the field is what we have done; on a very detailed examination has revealed a good deal more than a very broad view of the field as a whole. I do feel that our sampling is adequate and representative of the field as a whole.

MR. SETH: That's all the direct we have. We would like to move the admission of exhibits, Shell Exhibits 1 through 11 at this time, if the Commission please.

MR. PORTER: If no objections, the exhibits will be admitted in the record. Does anyone have a question of Mr. Lindsay? Mr. Campbell.

CROSS EXAMINATION

By MR. CAMPBELL:

Q Mr. Lindsay, I believe you stated that you had been employed by Shell Oil Company for six years?

A Correct.

Q As exploitation engineer? A Correct.

Q That is not exploration, is it?

A No.

Q Where has most of your work been done?

A Most of it has been in California in sand stone reservoirs. About fifteen months of that were in the Rocky Mountains in oil fields in Utah, I have to qualify that, it was a dry hole.

Q (Interrupting) I consider that experience -- Beg your pardon.

A All right, I'm through.

Q Do you feel that the sands that are encountered in this particular reservoir are reasonably comparable with those that you have encountered and studied generally in the State of California?

A I would say that these are not typical of the sand stone reservoirs in California. Although I believe that our method of geological investigation would apply in either case.

Q Isn't it not generally true that the sands encountered in the area in which you have worked have contained considerably greater pay and net pay than these sands? A That's true.

Q Does that not, in your opinion, have some bearing upon the density with which you develop these reservoirs, or recommend to your management that they be developed? A Yes, it does.

Q Now, Mr. Lindsay, you have stated that you have taken your information as to these wells from a certain area of the reservoir which you agree is of approximately the lateral extent that the proponents have testified here. Is that area generally in the

vicinity of the Carson Unit that you operate?

A Yes.

Q How many wells have you actually studied in that area?

A I would say approx --

MR. SEAY: (Interrupting) What do you mean studied?

A Excuse me.

Q I mean which one have you conducted detailed geological studies on, all of them in the area, all of them in the field, or how many?

A I would say approximately twenty-five to thirty.

Q How many wells have been drilled in this reservoir so far?

A I don't have the count.

Q If you have studied only the wells, twenty-five or thirty wells in this area, how can you make the statement that they are fairly representative of all the wells in the area in the reservoir?

A I believe that portion of the testimony which was brought out by the proponents of 80 acre spacing in which it was stated that the reservoir conditions are, and geological conditions are fairly uniform throughout the field.

Q Do you believe that it is an adequate study of a reservoir twenty to twenty-five miles in length with 134 wells, to geologically study twenty-four or twenty-five of the wells?

A I think it is an adequate sampling of the field. If you are worried about how representative this is, then you must be

concerned about the possibility of discontinuities in the field?

Q I'm asking you to satisfy me at least that your conclusions with regard to this entire reservoir which we are studying here, your conclusions are predicated upon an adequate sampling of the reservoir. Now, you have indicated that you base your conclusions as to the lack of uniformity in this reservoir principally upon the study of microlog separation?

A I think that is one of our most powerful tools.

Q Am I correct that is what you are using principally?

A No, we have used the electric log, microlog and core data and production characteristics of the wells.

Q These Exhibits 4 and 5 are predicated on microlog separations, are they not?

A The manner in which the shaded green portions are drawn are predicated upon the microlog.

Q You have admitted, as I understand you, that you will concede there is some continuity of sand, but you will not concede there is a uniformity of sand, is that correct, uniform condition of sand characteristics, permeability?

A I will concede there is a certain amount of continuity, yes.

Q So then it becomes a matter of the degree of movement rather than the movement itself, is that not true?

A Not necessarily, I don't believe. I think that a considerable portion of this reservoir is so impermeable that oil will not

move through it.

Q And you base that upon the absence of microlog separation principally, do you not?

A No, there's no need to compare microlog with an interval which the electric log shows obviously is a silt stone or shale.

Q Well, this green differential is based on microlog separation?

A That is based primarily on microlog separation.

Q Now, Shell has completed some of its wells in zones that you show that don't have any microlog separation, haven't they?

A Yes

Q How have they done that? A How?

Q Yes.

A By perforating the sands as shown by the SP curve of the electric log.

Q They have obtained production in that manner?

A Non-commercial production.

Q Have they fracted any of those wells?

A I think they have.

Q Well, now, Mr. Lindsay, this may be a production question, but it has a bearing upon your conclusion of lack of permeability, isn't it true that it is not uncommon in a reservoir of this nature where you do not show absence of microlog separation, that by perforating and fracting you may induce sufficient permeability to

create a rather satisfactory production situation, isn't that the purpose of fracturing?

A The purpose of fracturing is to increase the permeability around the well bore of the formation you are attempting to produce, but I'm not sure just how far these fractures extend into the reservoir, and I would like to refer to cross section AB where there is considerable distance as I have interpreted it from, for example, Government 12-15 in the CC sands to where I believe the permeability sands pinch out, and I would state that I doubt that fractures would reach that far.

Q Of course, you have admitted, Mr. Lindsay, that you are just guessing after you leave the well bore in any of those situations where that pinches out?

A As has been testified, geology is an inexact science.

Q I become more aware of that constantly.

A So do I.

Q As a matter of fact, if you carry your argument to its logical conclusion, which apparently is done in California, you might have some of these streaks of permeability extending immediately adjacent to the well bore, mighten you?

A I would say that is very unlikely.

Q And the only way that you could actually be assured on primary methods of recovering the oil, all of the oil in the reservoir, would be to mine it out, wouldn't it?

A I don't think any operator ever will make the claim that he will get all the oil out of a reservoir.

Q The greatest ultimate recovery of oil, I'll put it that way.

A I think that the amount of oil that you will recover from any reservoir will increase with the density of the development and that, well oil has been mined as a matter of fact.

Q Your company recommends that in this instance, would it?

A No, because it would be a very non-commercial enterprise.

Q Exactly. So it becomes a question of where you reach the point of no return, does it not, as far as economics is concerned?

A That is true, yes.

Q Have you made your analysis and your conclusion that you stated at the end of your testimony with reference that primarily recoverable oil may be lost by 60 acre spacing with any consideration of the possibility of pressure maintenance in this reservoir during the stages of primary recovery?

A I am not an expert by any means on secondary recovery or pressure maintenance, or for that matter reservoir engineering.

Q Then you have not made that statement in consideration of the possibilities of any such approach?

A As I was about to say, however, I would say that no matter how continuously you attempted to maintain the pressure in this reservoir throughout its productive life, there are sufficient discontinuities that you will never efficiently flush this well on a

wide acre, or flush this field on a wide spacing.

Q Of course you are making that in the light of your previous statement that you don't have any understanding of pressure maintenance or secondary recovery?

A I didn't say I had no understanding of it. I said I was not an expert.

Q With regard to the photograph of the core that you presented in evidence here, which is Exhibit 6, that core is taken from one of the lower zones in this sand formation, is it not?

A Correct.

Q Do you agree with the witnesses for the proponents that the most likely producing zone in an economic sense in this reservoir lies at the top of the sand formation?

A I agree that there are probably more reserves in the upper portion of the reservoir, that is what we call the OC sand, than there are in the lower.

Q Then the photograph of the core which you have taken represents a portion of the formation which is in what we would consider a poorer sand?

A In this particular well this sand is better developed on the electric log as regards microlog pay and as regards core data, than is the uppersand.

Q Do you think that this Exhibit No. 6 represents a poorer sand zone?

A No, I would say it is a fairly good sand zone.

Q What is the point of this, what are you trying to establish that the colors aren't the same, or would you explain it a little further to me?

A I was attempting primarily to illustrate the very irregular bedding planes and the evidence that we have of disturbance during deposition of the sands to point out that we are not dealing with long, continuously even bedded sands, but sands which are disturbed and irregular on a very small scale as well as on a large scale. I think this supplements, on a microscopic scale, what we show with our cross sections on a microscopic scale.

Q Did this reflect any unusual condition in this sand reservoir that is not present in other sand reservoirs in this area that you have studied?

A I have not studied other sand reservoirs in this area.

Q Now, with regard to your Exhibit No. 11, as I understand it, none of the gas wells which have been completed in this pool have ever been produced, is that right?

A I don't know of the production history of those gas wells.

Q And it is also true, is it not, that there has been limited production history with regard to the oil wells because of lack of market, isn't that also true?

A I have heard that that is true.

Q Do you know how much oil those wells on your exhibit have

produced? A No, I don't.

MR. SETH: This is a geological witness. We'll have other witnesses who are production people.

Q Have you had experience in examining the geological characteristics of a sand reservoir containing a possible gas cap?

A Yes.

Q Where was that? What reservoir?

A That was in the Ventura Field in California.

Q Does that definitely contain a gas cap?

A We believe that it did not contain a primary gas cap, but that at its present stage of depletion some of the zones have increased. Again, I'm not a reservoir engineer, but they have been depleted to the stage where considerable gas has come out of solution and that the high structural wells have extremely high gas-oil ratios, and we feel that this is evidence that a gas cap is probably forming in the stage of development of those pools.

Q You have recognized, I believe, that the rock characteristics in this particular reservoir are in some instances rather poor and variable, have you not? A Yes, I have.

Q Well, now, as a geologist, can't you say that it is true that it is not uncommon in a reservoir with non-uniform rock characteristics, to have a transition zone between oil and the gas cap that may establish anomalies over vertical distances of considerably more than 21 feet and still not eliminate the

possibility of a gas cap?

A I would say that under the geological conditions of this field that there has almost certainly been enough geologic time for equilibrium to be attained in the reservoir, and that if this were one continuous reservoir I would expect the gas cap to occur only at a higher structural position than at relatively down-structure position to oil-bearing sands.

Q Do you mean to say that in a reservoir of this type that there should be a positive distinguishing cleavage between the oil reservoir and the gas reservoir in order for you to consider there is a gas cap?

A I would not consider myself qualified to say just how sharp that cleavage would be.

MR. CAMPBELL: I believe that's all.

MR. PORTER: Anyone else have a question of the witness?

MR. SULLIVAN: Just a minute, please.

By MR. SULLIVAN:

Q Mr. Lindsay, unfortunately I was sitting down here today and yesterday I wasn't furnished with copies of your exhibits, but I believe they're all marked so that I can see them up here now. I was going to ask you to read, refresh my memory on a number of them, but I see it wouldn't be necessary.

A All right.

Q Now, have you ever appeared, Mr. Lindsay, as an expert

witness for Shell or any other company before in a hearing of this type? A No.

Q I thought I detected a nervousness or, I want to explain something very briefly. The role of the lawyer in a thing of this kind, and I consider it my role, is to elucidate, we are not here to spar with you. My client, the British American Oil Producing Company, is as eager to make known the facts in this case as is Shell. So that I don't want to approach this now, Mr. Lindsay, in the spirit of sparring with you. A Suits me.

Q Good. But I want to start off, let's reduce this thing to elementals and we will take a hypothetical question. Let's assume that this was your oil field, or that these interests in this field were yours individually and not Shell's or British American's or Sunray's or some other relatively large company. Now, if that were the case, how would you classify the oil field as to quality, just generally let's say three general classifications, real good, fair, below fair? A On what basis?

Q Just generally overall, is it a really good oil field, is it a fair oil field, or is it a below fair oil field?

A Are you referring to the amount of oil that I might expect to recover from this field?

Q Yes, on that basis, real good, fair or less than fair.

A I would put it some in the middle.

Q It's either fair or less than fair?

A I would call it fair. Better than some and not as good as some others.

Q Now, we have picked out some standard, it's in the middle here. It's kind of an average oil field. Look at it again from your personal viewpoint, your overall satisfaction with the performance of this field is going to be governed by how much money you make on it, off it, isn't it? A Oh, definitely.

Q And secondly on the basis of whether or not you have in effect recovered all of the oil that is recoverable within practical economic limits, is that correct?

A Yes.

Q Now, I think we now have established what your aim, what probably your employer's aim, and what the other people involved in this hearing, their general aim is with regard to this field, if we can consider that their attitude would be much the same as yours, is that probably a correct deduction?

A I think we have.

Q Now, I believe that you testified in effect that from the viewpoint of establishing, tapping, let's put it --

A What is that?

Q From the viewpoint of tapping each of these individual sands, the best method of making certain that you recovered all of the recoverable oil in each of those sands would be to mine it, but of course, that is preposterous, isn't it?

A Yes.

Q We depart from that degree of preposterousness. You wouldn't drill it on one acre spacing would you?

A No.

Q You would drill it on 40's I infer. I don't believe you ever made that recommendation directly, but I infer that you suggest that the field should be developed on 40 acre spacing?

A That seems to me to be a reasonable spacing for this field.

Q Do you think that at some time in the future you might recommend 20 acres, if 40 is proved to be less satisfactory than you now think they would be?

A I'm not prepared to say. I think that would depend entirely on what we found on 40 acre spacing. I am not in a position to recommend what we do in the future.

Q I am not asking that you recommend. I am asking if it may be shown that if you develop it on 40 that subsequently in order to tap each one of the disconnected sand bodies, it might be necessary to drill it on 20's?

A I would say that it is very improbable. This is only an opinion that I think that is improbable that we would want to drill 20 acre wells to attempt to recover more of the primarily recoverable oil in this field.

Q Is there any condition attached to that?

A No.

Q If it were profitable to do so?

A There would have to be a very thorough profitability investigation made of that. I am not, that is not my particular specialty.

Q Now, one point in your direct testimony, or either upon cross examination by Mr. Campbell, I'm not sure which, but I'm certain that you said something to this effect, that you felt that the type of sampling that you have done here with minute study was of a better grade than a general sample taken throughout the field?

A I think that information gained this way is more pertinent for a spacing study, that is for a general ruling for an entire field, than would a more superficial examination.

Q Well, but do I understand correctly that your study was confined to a relatively, I won't say relatively, absolutely, this series of diagrams here represents these two lines, does it not?

A It does.

Q And what is the distance of each of those lines?

A Oh, about two miles each.

Q You were present in the hearing room yesterday all day, were you not? A Definitely.

Q You heard Mr. Finfrock testify, did you not, the first witness yesterday morning? A I did.

Q Did you see the charts that he exhibited to the Commission

which were his Exhibits, I recall 6, with subletters down through F?

A Yes.

MR. SETH: We'll stipulate that the proponents Exhibits were longer than ours and covered more territory.

MR. SULLIVAN: Mr. Seth, I don't want to spar with you either.

MR. SETH: We just want to get to the point here.

MR. SULLIVAN: The point is, this young man testified Exhibit 6, this young man testified that he thought his examples were better than general examples. I assume that he referred to Mr. Finfrocks exhibits. I'm not going to refer to the length.

MR. SETH: I don't believe he characterized the proponent's exhibits at all.

A No.

MR. SETH: I don't think it is fair to put him in that position.

A You are putting words in my mouth. I did not say mine are better than his. I think his are admirable.

Q Let's go at it another way. All I want to establish was, would a study of logs extending the entire longitudinal length of the field, or as nearly along its entire axis as those logs are available, give a good picture of the entire sand bar?

A It would depend on what information is shown, what geologic tool we employ in interpreting those wells. I would say

that --

Q (Interrupting) Suppose that we employ a good geologist, an experienced geologist, to examine those logs. That's an important tool, isn't it, an experienced, competent examiner of the data? A Yes.

Q And then in addition to that examination he also makes studies of cross sections, the entire longitudinal length of that field comparable in length to your AE line, and he does five of them, would that give a more complete picture of conditions in the field than taking that same study in an isolated area?

A Only if he used all the tools which were available to him, including the micrologs.

Q Let's assume that he does use all of those tools, core analysis, microlog, anything else that has been made available to him, then we get a more truly representative picture of the entire structure, would we not? A Yes, you would.

Q Let's get around to this problem of whether or not there is any other possible set of physical circumstances which could lead to the discovery in this structure of oil above gas. That is simply stated, but a good deal of your testimony was directed to that situation, was it not?

A A very small part of it.

Q Are there any other conditions other than the non-connection of the oil and the gas bearing sands that could possibly count in this

particular instance for production of oil above the production of gas in two fairly adjacent wells?

A There is nothing that I can think of for a reservoir of this type.

Q Now, you are down here close, or on the gas cap of this structure, are you not, in this situation where the two wells, the two wells that you have referred to and which were fairly adjacent wells in which gas is produced at one in a lower elevation than the oil is produced in the adjacent well, is that on or near what has been referred to in this hearing as the gas cap?

A Yes.

Q Let's find out, one, is it not possible, let's start out this way: I believe that you stated that assuming equilibrium of the fluids in this reservoir, that that was the only conclusion that you could arrive at was the lack of connection between the sands?

A That is correct.

Q Assuming equilibrium. Well, now, if those fluids in the reservoir were not in equilibrium, would your conclusion necessarily be, would it be an inexhorible conclusion?

A No.

Q Is it possible that the fluids in this reservoir are not in equilibrium?

MR. SETH: I think he should answer the question first. Were you going to answer the first question there?

MR. SULLIVAN: I'm sorry if I interrupted. Would you read back one question, please?

REPORTER: Reading: Assuming equilibrium. Well, now, if those fluids in the reservoir were not in equilibrium, would your conclusion necessarily be, would it be an inexhoribie conclusion?

A May I answer your first question?

MR. SULLIVAN: Yes, go ahead.

MR. SETH: Yes, do.

A I think that that is a question pertaining to reservoir engineering and I think that one of the subsequent witnesses will be better qualified to testify upon that than I am.

Q Would a tilted gas, the general tilt result here in a possibility of a gas cap?

A I don't think there would be a tilted gas cap in this case if the testimony of the geological witness yesterday were correct, because as I remember on this big three-dimensional illustration there was shown a definite line, a horizontal line, showing the base of the gas cap.

Q But if the gas cap were tilted, if the gas cap were tilted, we could state this as a hypothetical question if you like, but if the gas cap were tilted, then it is possible to produce gas at a lower level than oil is produced, is it not, even with inter-connecting sands?

A Again I would like to remind you that these questions involve the field of reservoir engineering, which I think one of our subsequent witnesses would be better qualified to testify.

MR. SULLIVAN: I will take it up with him, Mr. Lindsay.

Q Are you prepared to qualify as to whether or not you believe there's any vertical permeability? I think it was referred to as vertical permeability by Mr. Brinkley.

A Is there any?

Q Yes, any. A Yes, there is some.

Q To what degree, in your opinion, does it have any substance or importance in this reservoir?

A I would say it has an importance in that I believe that vertical migration of oil may take place from the very low permeability oil-bearing sands into the very permeable streaks of sand in a vertical direction where they are adjacent to them, and then I would expect them to travel more or less horizontally there to the well bore.

Q Do we have any modern method other than in your cores, of determining the extent of vertical permeability? Is there any method of determining vertical permeability except from the study of the cores? A I don't know.

Q Did your cores there show any signs of vertical permeability in any of these sands? A Yes.

Q Of which they were illustrative?

A As a matter of fact, the core sample No. 7 shows some vertically distributed sand streaks which I would assume to have some vertical permeability.

Q I had one other thought too, Mr. Lindsay, which maybe we shouldn't pass by in connection with this gas above the oil, or oil above the gas situation. Are you familiar with the term relative permeability? A Yes.

Q In a tight sand, does the relative permeability of the sand to gas as compared to oil make it possible that an oil-bearing sand will produce gas when it does not produce oil?

A I believe that is possible.

MR. SULLIVAN: I think that's all, Mr. Chairman.

MR. PORTER: Anyone else have a question of the witness?

MR. SELINGER: I have a few questions to ask. Would you care to have a short intermission before I embark on my series?

By MR. SELINGER:

Q Mr. Lindsay, I represent Skelly Oil Company, so you may know who I am. I want to direct your attention to the exhibits that you yourself have made and presented to the Commission, and in order to avoid any misunderstanding of questions and answers to be forthcoming, I want to get it clear as to the extent of your study. Is your study confined to the one-third of the area of the field, or do you have any knowledge at all of the entire field?

A My study has been concentrated in the approximately

one-third of the field which I have described in my exhibits.

Q Do I take that answer to mean that you know nothing about the entire field as a whole? A No.

Q Then to what extent is your knowledge for the entire field? Do you have knowledge, for example, as to the aerial extent of the field? A Not precisely.

Q Do you have any idea then as to the approximate amount of productive acreage as disclosed by presently drilled wells?

A I cannot give you a figure.

Q Do you have any knowledge of that? I didn't ask for any specific figure.

MR. SETH: I think that is a reservoir question.

MR. SELINGER: I am not asking him about any reservoir data whatsoever. I am asking geologically, the productive limits of the field, if he knows.

A All right. I would say that the presently proven productive limits are a little more than twenty miles long and a little more than two miles wide.

Q Does it extend beyond Ranges 11 and 12 West?

A Yes.

Q And by your answer then, I assume that you have made detailed study of the area in Ranges 11 and 12 West, but a study of a great deal minor detail in Ranges 13 and 14 West, is that correct?

A That is correct.

Q Now, within the area that you have made a detailed study, particularly Ranges 11 and 12 West, are there any areas of undeveloped acreage lying in those ranges?

A Yes.

Q Would you mind pointing it out to the Commission as well as indicating for the record the approximate four or five, six, sections that have little or no producing wells?

A I would say that portions of Sections 11, possibly 12, 13, 14, 23 and 24, 15, you say little or no? I'm pointing to the ones for which there are remaining locations to be drilled.

Q Thank you. That is what I had in mind.

A Those are in Range 12 West, in Range 11 West. I would consider remaining locations to be drilled in Section 16, little or no you say, 18, 19, 20, 21, 16, we're getting into the gas area. I have no idea how densely that will ever be.

Q That is sufficient, you have answered my question. In answering that question, you have referred to Exhibit No. 3?

A Yes.

Q Now, on that exhibit, have you determined geologically the limits of production in that particular area?

A We have defined the approximate limits of production in that area.

Q Both on the northeast and southwest along its entire line?

A Yes. You said along its entire line?

Q Along its entire line northeast and southeast.

A I think from the drilling that has been carried out in that area that we have a pretty good idea of where the productive limits are in the northeast and southwesterly direction.

Q So that as a geologist, you can say to the Commission that you have determined for all practical purposes the productive limits of the Gallup zones in Ranges 11 and 12 West?

A I think we have.

Q Now, on that Exhibit 3, which is an isopach map of the net microlog, is that correct? A Correct.

Q Can you trace, for example, across the entire area delineated on that particular exhibit for example, a line oh, ten foot along the south line and then along the north line?

A Shall I describe where it is?

Q No, I ask you first can you do so?

A Yes.

Q Will you do so by merely pointing and we'll let the record be silent in that respect, but the Commission can get it from your pointing? A All right.

Q Now, along the north line can you similarly do so?

A I think I can. I thought I could.

Q Thank you, Mr. Lindsay. Would you be able to continue the tracing of the ten foot line, which is not exhibited on Exhibit 3 in Ranges 11 and 12 West, but could you similarly trace that, a

continuation on through Ranges 14, to the northwest and Ranges 15 to the southeast?

A I think I could if you were to draw one.

Q Thank you. I want to refer your attention particularly to your Exhibit 2 which is styled stratigraphic section in which you have depicted there on two wells, the Shell Carson No. 1 and the Shell Carson 33-24, and you have indicated on this exhibit the distance between these two wells as being 2950 feet?

A Correct.

Q You have indicated on your Carson No. 1 your permeability, which is depicted in millidarcies in red, is that correct?

A Correct.

Q Do you have any of whatever nature on your Carson 33-24?

A Any what?

Q Any permeability in the so-called GC sand which the proponents have indicated as the upper, do you have any permeability of whatever nature on that well?

A Yes.

Q How many feet?

A Of permeability?

Q Yes.

A Permeability of what magnitude?

Q Of any kind. Do you have any, I said, and you said, yes, and I'm asking you how much.

A How many feet?

Q Yes.

A Or magnitude?

Q Any magnitude, I am.

A I cannot give you a figure at the moment because on this chart, since we have a logrithmetic scale for permeability, there is no zero in a logrithmetic scale, so I do not know how many of those marked one-tenth of a millidarcies include the zero or less, which may include some intervals of zero permeability.

Q Do you have any coloring of red on that?

A No, I do not.

Q Will you kindly step to the exhibit and see whether or not there is any red appearing on that?

A In the GC sand you say?

Q In the GC sand.

A I'm sorry, I am mistaken, there is a small amount.

Q Would you care to correct your answer? We started out by saying, and you agreed, there was some degree of permeability, you didn't know how much. Now will you kindly, since you have stepped to the board and looked at Exhibit 2 closely, indicate whether or not there is any degree of permeability in that well, referring to the Carson 33-24.

MR. SETH: He already testified there was.

A There is some degree of permeability in that sand.

Q Do you know how much, to what degree?

A Do I know what is the magnitude of the permeability?

Q Yes.

A I know of over the portion of the zone, but unfortunately

when we cored the well there is no recovery over the interval which shows the microlog pay.

Q Can you give us any figures as to the red color that you have there?

A Yes, I have a small interval which shows slightly more than a millidarcy.

Q Is it possible to correlate the permeability from the Carson No. 1 to the Carson No. 33-24 in the 3C sand or upper sand from this exhibit?

A I can only say that those intervals of permeability may or may not be connected.

Q If there is additional permeability which is not shown on this exhibit because of what reason —

A There was no core recovery in that interval.

Q Because of the lack of core recovery, then would it be possible to show your correlation through there?

A That would depend upon what well control you had in between those two wells.

Q Are there any other wells in between those two wells?

A No.

Q So that it's a matter of speculation as to the extent of the permeability and the correlation between those two wells, is that correct?

A I believe it is.

Q That speculation is due primarily to the lack of additional

wells between those two wells? A That is correct.

Q And if there were additional wells between these two particular wells depicted on Exhibit 2, you would be in a better position to give a more clarified answer?

A I think you would be in a better position.

Q Thank you. Now, I want to ask you about this Exhibit 4. In this well known as the Shell 13-15, you have depicted on this Exhibit 3 major green lines, is that correct?

A Green intervals.

Q Green intervals? A Yes.

Q Do you show these three green intervals separated from each other? A I do.

Q Do you show these three green intervals separated from the respective wells on each side? A I do.

Q Is it your view as a geologist only that these three green intervals are separated from each other and that they each bear oil or gas?

A I think that they are separated with either no, or very little, permeability between them.

Q Is it your view as a geologist that they are not connected, that they are separated? A It is.

Q Is that well perforated in all three of these separate lenses?

A It has perforations in all three of them.

Q From that, then, you would assume that the well is

producing from all three of those intervals?

A I would.

Q Now, I might ask you in the interval between the Shell, what is that, 21-15 and 12-15, how far apart are those wells?

A Those are about 1800 feet apart.

Q Would you have any opinion as a geologist if a well was drilled in between those two wells we have mentioned, and which I am pointing to, whether or not that well would find production in the zone of production in Well 21-15 and in the zone, one of the zones of Well 12-15?

A I think that I can only say that it may or may not do so.

Q And your answer is given on the basis of lack of additional drilling in between those two wells, is that correct?

A That is correct.

MR. SPILLER: I believe that's all. Thank you.

MR. PORTER: Anyone else have a question of the witness? Mr. Rushnell.

MR. RUSHNELL: I just have one or two quick questions.

BY MR. RUSHNELL:

Q Mr. Lindsay, as a geologist, is it your opinion that the oil in this Bisti Field originally originated these sands, or would you say in your opinion that it migrated to these sands?

A I would say that probably the oil was supplied from both sources.

Q From both sources? A Yes.

Q Did I understand you to say from both sources?

A You did, yes.

Q So that part of it could have been formed elsewhere and then migrated into the sands now known here as the Bisti Field?

A I'm not prepared to say how far.

Q No, I wasn't asking how far. I was trying to repeat what you had said that in your opinion, am I correct, you just said that in your opinion part of the oil here now migrated from some other source, is that correct? A That's correct.

Q If that is true, then, Mr. Lindsay, would it not follow that the oil in the Bisti Field would be all one common source as to that portion that migrated at least?

A I can't say at the moment whether that's true or not.

Q Does that sound logical?

A I would say it's not impossible.

Q Does that mean the same as it sounds logical? Let me ask you one other question, then, you have used the word discontinuity several times here. A Yes.

Q Were you using that to mean that you are denying communication? A No, I am not.

Q In other words, you can have discontinuity and still have communication, is that correct?

A You can have all degrees of communication.

Q So that you could have discontinuity and still have communication, is that correct?

A Not where you had discontinuity, no. I would say what I'm referring to is the Gallup sand as a whole, I would say that there is a limited amount of continuity in it, but where there is discontinuity there is just discontinuity.

Q You are not denying that there could not be communication by use of that word, are you?

A Communication from where?

Q To these terms that have been used between these intervals in the Gallup sand.

A Up and down?

Q Yes.

A I don't believe there is communication up and down between these two intervals, these two main groups of sands that I have referred to, since there appears to be fairly persistent silt and shale bodies existing between them, which I would say is impermeable to migration of oil.

Q I thought I had you saying what I wanted you to say, but I lost you. Let me repeat once more, Mr. Lindsay. You have used the word several times here this morning, discontinuity, is that correct?

A That's right.

Q Are you using that word to mean that when you have that condition you cannot have communication? You are not using one opposite the other, are you?

A One what?

Q Opposite of the other. One is not to the exclusion of the other, is it?

A I would say in some places discontinuity.

Q This is a general principle. I'm not a geologist. I am a lawyer with Amoreda, I forgot to introduce myself.

A How do you do. Could you restate the question, please?

Q The word you are using, the word discontinuity, is not to the exclusion of communication is it? I'm not referring to any particular piece of testimony, I'm just using it to define in my mind the word discontinuity.

A I used discontinuity to refer to a portion of the reservoir where I think oil will not migrate. I use communication to refer to a portion of the reservoir where I think oil can pass through, to a certain degree.

Q Let me put it this way, in an oil pool that is a common source, you could have parts of it where there exists what you used the term discontinuity, but in other parts of that field there could be communication? A Yes.

MR. [illegible]: That is all the questions I have.

MR. PORTER: Mr. Cooley.

By MR. COOLEY:

Q Mr. Lindsay, does your general geologic picture here look more favorable or less favorable from the standpoint of recovery of oil than Mr. Finfrock's? A On what spacing?

Q Any spacing. It doesn't make any difference. Does it look like there is more oil to you in the reservoir from the pictures you have drawn than it did from the pictures that Mr. Finfrock drew?

A His pictures, no. I would say that his look better than mine.

Q That's what I thought. Then yesterday the argument developed between the proponents and protestants as to how much oil there was in the reservoir. In that argument, Shell was on the other side. Now I can't understand how there can be more oil by Mr. Finfrock's picture, which is put in terms of barrels at 210 feet per 10 acre tract, I don't see how this is consistent with the geologic picture you drew.

A What I meant by better, that is that Mr. Finfrock's pictures looked better, was that they showed more continuity than mine do.

Q Didn't they also show more oil?

A I don't think he specifically showed where the oil existed in his pictures.

Q No, but if the conditions that he portrayed exist, there would be more oil than if the conditions you portrayed existed, would there not?

A Not entirely, because he had an isopach map of net microlog pay which would compare pretty much with ours. If they base their estimate on how much oil there is in the field on that

net isopach map, then our pictures I think would be quite comparable.

Q Thank you.

MR. PORTER: Mr. Utz, did you have a question?

MR. UTZ: Yes, sir.

By MR. UTZ:

Q Mr. Lindsay, through all of this gas well discussion here, I still haven't determined in my own mind as to whether or not you have an opinion as to whether there is a gas cap in this pool or not.

A I don't know whether there is a gas cap or not. There certainly is some gas production, and I would, in my opinion, those gas wells produce from sands which are not connected with sands which produce oil in upstructure positions. Whether or not you would call that a gas cap, I don't know.

Q Is there a possibility that it could be a local gas cap condition?

A I think there is a possibility, but I don't know how continuous that gas cap would be from gas well to gas well.

Q I see. On these four different cores that you have submitted here as exhibits, would you have any permeability information as to those individual cores? Would you be in a position to say what the permeability was in each core?

A You are including these?

Q Yes, I'm referring specifically to these rock cores that you have brought in.

A Well, the situation is that permeabilities within these cores, Exhibits 7 and 8, would probably range from zero to some considerable number of millidarcies of permeability, depending upon which part of the core I sampled.

Q By considerable, you mean what, hundred millidarcies?

A These streaks may or may not contain a hundred millidarcies. I think they could.

Q I'm trying to establish in my mind what the relationship between flow of oil and permeability would be, referring specifically to the type of oil we have in the Bisti Pool. How low a permeability can we have, if this is an engineering question please say so. How low a permeability can we have and still have a movement of oil through it?

A It is an engineering question, however, I would estimate that the range of permeabilities through which oil would flow might be on the order of a tenth of a millidarcy to a millidarcy. Actually I would say that it might be actually less than that through which oil could flow at all. I would certainly say that sand showing zero permeability oil would not certainly flow with any ease through that type of sand, but as to the break-off point, as to where oil will flow and oil will not flow, I am not prepared to say.

Q But you don't think that at a tenth of a millidarcy oil would flow through it?

A I can only give an opinion on that, and I would say that oil would probably flow through a tenth of the millidarcy sand, but probably very, very slowly.

Q It would flow better through one millidarcy?

A Certainly.

MR. UTZ: That's all I have.

MR. PORTER: Does anyone else have a question? Mr. Kellahin.

By MR. KELLAHIN:

Q Mr. Lindsay, I'm representing Phillips Petroleum Company. I just wanted to ask you, you just have the two cores, is that correct? A Pardon me.

Q Two cores which you brought here?

A Four.

Q About what are the sizes of the cores, about three inches?

A Yes.

Q Then you are taking about a twelve-inch section of the pool to relate the twelve miles, is that right?

A Twleve inches?

Q Well, you have four cores three inches across, that is about twelve inches.

A No, these are not the extent of our reservoir information about the reservoir rock.

Q Those are the only ones that you have presented to the Commission? A That's right.

Q You are relating that, and by inference saying it covers twelve miles.

A I am prepared to testify that these cores are representative of the Gallup sand, the entire Gallup sand, which was cored in these two wells.

Q Those four cores are from two wells?

A That's correct.

MR. KELLAHIN: That's all.

MR. PORTER: Anyone else have a question? Mr. Cooley.

By MR. COOLEY:

Q Mr. Lindsay, you are familiar with the term common source of supply?

A I have heard it, but I have never used it, and I do not know its definition.

Q Do you feel that questions concerning common source of supply should be better directed to an engineering witness rather than a geological witness? A Yes.

MR. COOLEY: No further questions.

MR. COOLEY: Mr. Nutter.

By MR. NUTTER:

Q Mr. Lindsay, I believe it has been stated at this hearing that the length of this pool is some twenty miles, is that correct?

A I think I heard that figure, twenty or perhaps a little more.

Q What is the overall length of the entire study which you have made as depicted on Exhibits 1 and 2 by the red lines, the general overall length of your study?

A About, I would say, between nine and ten miles. I would say nine miles as a figure.

Q And that lengthwise study has been made, or that nine or ten mile study has been made along the longitudinal axis of the pool, is that correct?

A No, both along the longitudinal and across the axis of the trend.

Q How many miles of study have you made along the longitudinal axis of the pool?

A You are right, about nine.

Q In other words, that nine or ten miles of study that you have made along the longitudinal axis of the pool represents a study of some half of the length of the pool?

A Approximately. Slightly less, I would say.

Q And I think that you stated, correct me if I am not correct, you stated that you believe that the general reservoir conditions along the longitudinal axis of the pool are similar from one end to the other?

A I would say that I have stated many times that this is a very hetergenous reservoir, and I think that the heterganity that we would find in these nine miles would probably exist throughout the

entire reservoir.

Q Did you hear the testimony yesterday, Mr. Lindsay?

A Yes.

Q Was the general tone of the testimony yesterday such that would indicate that the generalconditions of the reservoir would prevail from the northwest to the southeast end of the reservoir?

A Yes, they do.

Q Do you feel that your nine or ten mile study therefore, along the longitudinal axis of the pool is typical of the entire length of the pool?

A I believe that it is.

Q What length are the crosswise studies that you have made across the pool? A About two miles.

Q What is the general width of the pool throughout the length of the pool?

A I would say about two and a half miles.

Q So you have pretty adequately studied the cross section of the pool, do you feel that is true?

A I feel that I have.

Q Mr. Lindsay, in response to a question by Mr. Selinger, you pointed out certain areas where the acreage had not been completely developed? A Yes, I did.

Q Has Section 5 of Township 25, 12, been fully developed in your opinion?

A It has been fully developed on 80 acre spacing.

Q Has Section 8 been fully developed?

A On 80 acre spacing, yes.

Q Are there several other sections there that haven't been developed on 40 acre but they have been fully developed on 80 acre spacing? A Yes, there are others.

Q So that no part of the pool has been fully developed insofar as 40 acre spacing is concerned? A That is correct.

Q In response to another question by Mr. Selinger, he was mentioning a hypothetical well that could be drilled between, referring to your exhibit of cross section AB, a hypothetical well which could be drilled between the third well and the fourth well on that exhibit reading from the left?

A Yes.

Q Where would that well be located on your red line on the exhibit showing the plat of the area? A Here.

Q Would that be a standard location for a 40 acre well?

A No.

Q So that even on 40 acre spacing it would be impossible to know what would prevail between those two wells as depicted on cross section AB? A Correct.

Q In response to another question, Mr. Lindsay, I believe this question was directed by Mr. Bushnell, he asked the origin of the oil which is in Bisti-Lower Gallup Pool?

A Yes.

Q Whether the oil had occurred somewhere else and migrated into the pool, or whether it occurred in the pool, you stated that you believed it could possibly have occurred in both places?

A Yes.

Q If the oil had occurred somewhere else, would it have been possible for the oil to have found its way through geological time into any zones which may be permeable but are surrounded by relatively impermeable sections?

A That would depend partly on when the oil was formed and what the geological conditions were when oil migration took place. Have I evaded your question?

Q No, I think you have answered it. Do you think that the oil, if the oil was formed someplace else throughout geological time, would it have a better chance of getting into the, now you say, I believe that there are isolated permeable sections, isolated sections of permeability and porosity? A Right.

Q Would the oil have a better opportunity or lesser opportunity of getting into that isolated section of permeability and porosity in geological time or of getting out of the isolated section of permeability and porosity during the normal life of an oil well?

A I would say the oil would have a much better chance of getting in than getting out.

MR. HUTTER: Thank you. That's all.

A Unless we drilled enough wells.

MR. PORTER: Are there any further questions? The witness may be excused. We will take a short recess.

(Witness excused.)

(Recess.)

MR. PORTER: The hearing will come to order. Mr. Seth, will you call your next witness?

MR. SETH: I want to call Mr. Norbert E. Methven.

NORBERT E. METHVEN

called as a witness, having been first duly sworn, testified as follows:

DIRECT EXAMINATION

By MR. SETH:

Q Mr. Methven, were you sworn during the course of this hearing?

A I was.

Q Will you state your name and position with Shell and your educational experience, please?

A My name is Norbert E. Methven. I was granted a Bachelor of Science degree in electrical engineering from Oregon State College in 1953. I have been with Shell four years, specializing in reservoir engineering.

Q Where do you live at the present time?

A I'm living in Farmington, New Mexico.

Q Have you made a study of the Bisti Field in this connection?

A I have.

Q Are you generally familiar with the reservoir characteristics in that field? A Yes, I am.

MR. SETH: May he testify as an engineer?

MR. PORTER: Yes, sir, his qualifications are acceptable.

Q Mr. Methven, will you please proceed and describe the reservoir characteristics and the source of your data and how you arrived at your various figures and computations?

A Yes, I will.

I'm employing the geologic interpretations as presented by our previous witness, also employing the petriphysical analysis and the study of the reservoir data. We find in general that wells spaced in accordance with the rules and regulations of the New Mexico Oil Conservation Commission, firstly will recover more oil than wider spaced wells, secondly will run a sufficient profit, and thirdly will pay out the cost of this development within a reasonable length of time. These findings are based on calculations of the total oil in place and an estimate of the amount of recoverable oil. These calculations involve the use of the average reservoir porosity, in the region we are discussing this value is 15%, we are using an average water saturation of 25% as determined by electric log interpretation, core analysis, mercury capillary pressure curves, we are using a shrinkage factor of .7% as determined

by PET analysis and permeabies with ranges as previously testified to in this hearing of one to two hundred, and averages of ten and thereabouts millidarcies.

We also are basing this on a drive mechanism of solution gas drive receded by gas expansion while the reservoir is above the bubble pressure. Using these data, the total oil in place as calculated, is 680 barrels per acre foot.

I want to point out that this is in the microlog pay interval. Now, we think that the primary recovery efficiency, or I think, that the primary recovery efficiency will be about 20% of the oil in the microlog pay regions as described in its Exhibit 3 as previously mentioned. Now, this 20% would be of the 680 which is 135 barrels per acre foot. We also want to point out that I believe that this value is applicable only to wells spaced at 40 acre intervals and it will not hold 80 acre spaced wells due to these previously testified to discontinuities. These have been exemplified by Exhibits 2 through 11. I would like to present an Exhibit No. 12.

(Marked Shell's Exhibit No. 12, for identification.)

This Exhibit No. 12 constitutes well data in the Bisti Field of properties operated by Shell Oil Company, and generally in the region as depicted by the Exhibits 2 through 11.

Column 1 are the well numbers as we have them on our exhibits.

Column 2 is the location of that well. Column 3 are the perforated intervals. Column 4 is the microlog pay pick or thickness, and we also have tabulated what we term poor pay in that same column. The next column, 5, are the amounts of fluid used in fract treatment wherever applicable. The sixth column is the total depth of the well. The seventh column is the elevation in feet measured from the Kelly Burk, the next column is the initial rate and barrels per day of these wells where applicable. The next column is the initial pressures of these respective wells. The next column is the most recent pressure data of these wells, and the eleventh column is the cumulative oil in barrels. These numbers are up to 8157 unless otherwise noted.

I want to qualify especially Column 10 which are the recent pressure data, and these data were obtained by Amerada type RPG pressure bomb which was hung in the perforated interval of the respective well and these data in Column 10 represent shutin pressure of wells, these wells having been shut in for periods of 19 to over 180 days.

These, therefore, represent average reservoir pressures in the region of the particular well.

I would like to point out some of these wells on one of our exhibits. I would like to make the general statement that in the interior region of the Shell operated properties, in the region of the central portion of the Shell operated properties, and I might

qualify that by giving some specific wells, Carson Unit No. 1 which is in Section 24.

Q Mr. Nethven, why don't you stand over on this side, and I think everybody can see.

A Carson No. 1 in Section 24, 12 West is this well right here. This well as of 9-2-57 had a pressure, static pressure of 1546. Another well in that region would be Carson 4 of Section 20, which is right here. This well had a pressure of 1580, 1,504 on PSI. Another one is Carson 14-13 in Section 13, which would be right here, had a pressure value of 1539, which as I said the evidence is very near original pressures in that region, primarily because of the lack of withdrawals in there. To the west in Sections 10 and 15, significant withdrawals have been made. I think the discontinuities become evident from these data.

Now, specifically 14, 15 in Section 15, which would be this well right here, had a value of 1177 PSI after withdrawals of 6,355 barrels. Now, Well No. 12-15 had a pressure of 1154 PSI, which is the next well up here, after withdrawals of 22,309 barrels. Now, the next well to the north, 14-10, this one right here, had a reservoir pressure or average static pressure of 1454 PSI after withdrawals of 15,152 barrels.

I would like to qualify this data as I neglected to do before, the pressure data, these have been corrected to a common elevation of 1500 feet, common datum. My point here is that this well 14-15,

12-13 and 14-10, these are in Township 25 North and Range 12 West, have values of only in the region of a little over 1100 PSI, while the well to the north has 1454 PSI. In accordance with the testimony the other day, I do not have the specific example, but they had a similar situation where the pressures were the same in general on locations like that, but here it does not occur. But there is a significant difference and yet withdrawals have been appreciable here. I think it's a kind of a comparable example, and yet it points to or suggests a different conclusion. It suggests another discontinuity, or at least a hetergeneous type of reservoir in view of the fact these wells have been static for quite some time, or shut in.

Now, based on the previous reservoir perimiters that I have listed, and based on the isopach map of the microlog pay which is Exhibit 3, and based on an average microlog pay of 12 feet, based on 40 acre spaced wells and the previous recovery factor of 20% and the 135 barrels per acre foot recovery average, I have calculated that there would be 65,000 barrels per well from this sand. This I want to repeat again is the isopach, from the isopach of the net microlog pay. Now, in addition to that we have what we term poor pay. These are sands that are within these major microlog pay intervals and others, and we think that there will be some oil from there, in fact this is based on the fact that we have wells that have been exemplified that. My estimate of that oil per well

will be on the order of 10,000 barrels. Thus there should be about 75,000 barrels per 40 acre well. This figure of 75,000, of course, disagrees with the previous testimony. Economics of this recovery of 75,000 barrels and an estimated drilling and development and completion cost of $48,000 will render adequate profit, the pay-out on the basis of this cost and this recovery will be less than two years, assuming existing New Mexico allowables.

Now, in conclusion, I feel that 40 acre spaced wells will recover a greater percentage of the oil in place. I also feel that 40 acre spaced wells will be profitable and will have favorable and acceptable pay-outs. Therefore, I think it's imperative for us to recover this additional oil in the interest of all concerned and in accordance with the rules and regulations of the New Mexico Oil Conservation Commission.

MR. SETH: I believe that's all the direct. We would like to have the exhibit introduced into evidence.

MR. PORTER: Exhibit No. 12?

MR. SETH: No. 12, yes, sir.

MR. PORTER: Without objection it will be admitted in the record.

CROSS EXAMINATION

By MR. CAMPBELL:

Q Mr. Mathven, Shell, up-to-date at least, has generally confined its operation in this area to the Carson Unit area, has it

not?

A With the exceptions to the west of one or more sections.

Q Has Shell followed a practice in this area of drilling wells and delaying the actual completion of these wells, in other words, not actually been producing them? Have you done that?

A That is true. Exhibit 12 exemplifies that some of these wells have not been completed.

Q Just how much production history do you have from the wells you have drilled in this reservoir?

A I do not have the cumulative number, but it is only a matter of several thousand barrels. You may be able to add that up if you would care to be more specific.

Q I have noted that a number of the wells in the Carson Unit with which your company has been principally concerned, contain a number of blanks in your well data exhibit.

A Yes, sir.

Q I assume that is due to the fact that you have not completed those wells? A Yes, sir.

Q Do you think that you have enough data upon the basis of Shell's experience in this pool, to reach a firm conclusion that permanent 40 acre spacing is justified in this whole reservoir?

A In my opinion it was sufficient to recommend this spacing.

Q Do you feel that there would be any disadvantage of retaining the present 80 acre well density in this pool for a period of

one year to obtain additional production data upon which you could base firmer conclusions?

A As will be brought out in subsequent testimony, it will be disadvantageous in some respects to delay the more dense spacing program.

Q You have stated that in your opinion wells should be drilled now in this reservoir upon a 40 acre spacing pattern. Do you make that recommendation with regard to all of the areas in this reservoir or just to the more prolific areas in the center strip that you, I believe, or the other witness have referred to?

A I believe I testified to this, was on the average of the microlog pay region as depicted by Exhibit 3.

Q Yes. My question now is when you leave the areas of thicker microlog pay and move to the boundaries of the reservoir on the exterior edges of it, would you recommend to your company drilling wells on 40 acre spacing in those areas?

A No, I wouldn't and, because these are unprofitable ventures as testified by one of Sunray's witnesses.

Q All right. Then assuming that you are correct in your analysis that this reservoir lacks uniformity and that there are areas on the edge that are not as prolific of oil or profitable financially, would not your proposal result in the loss of oil from those areas if you drilled your best areas on 40 acre spacing and recognize that you cannot drill the other areas on 40 acre spacing?

A There will be some of that oil left behind, of course. In fact, there might be quite a bit of it. However, I don't think any industrial organization would want to go, would want to go there and drill these wells because they are uneconomical.

Q Your recommendation is based on the belief that you can, by 40 acre drilling at the apex of this reservoir --

A (Interrupting) Would you repeat?

Q Your conclusion on 40 acre spacing, as I understand you, is based upon your belief that because of the thickness of the sands in the better areas of this reservoir, you can recover more oil than if you drill on 80 acre spacing throughout the entire reservoir, am I right in that? Do you believe that you can do that?

A I want to be sure I understand the question.

Q Perhaps it was vague. Do you believe that if this reservoir is developed by drilling on 40 acre spacing in the areas of the reservoir, that contain the thickness of the sand which you say will pay these wells out rather than drilling 80 acre wells throughout the entire reservoir, in which system would you get the most ultimate recovery of oil?

A As stated, I don't believe that I could give an opinion because as stated, the question infers that if you develop on an 80 acre spacing pattern that you will drill wells out in the non-profitable region.

Q Well, don't you believe as a matter of practical economics

and mathematics that you are more likely to do it under those circumstances than if you are called upon to drill it on 40 acres where it is only half the investment?

A If it's a loss, I don't think that anybody would care to put their money into a losing venture.

Q That would depend too upon the rate of withdrawal, would it not?

A Excuse me.

Q That too would depend to some extent upon the rate of withdrawal permitted from the 80 acre well just as your --

A (Interrupting) I said a loss. I mean if it constitutes a loss in dollars.

Q Is your conclusion as to the advisability of 40 acre spacing from an economic point of view for your company, predicated to any degree upon the desire of your company to acquire oil from this reservoir for its pipeline and refining and marketing purposes?

A Sir, I'm in the Production Department, and as you know, our job is to produce and develop these fields. I am not qualified to speak as far as the other phases of the company are concerned.

Q Have you made any study of the proposed effort to establish a pressure maintenance program in this reservoir?

A Yes, I have.

Q Have you in connection with your studies of proposed spacing in this reservoir at this time taken into consideration the possibilities of that effort?

A Yes, we have.

Q Is it your opinion that if wells are immediately drilled on a 40 acre basis and withdrawals take place at the assumed rate that you used of the present allowable, that there will be a pressure decline in the entire field somewhat equivalent to the pressure declines you pointed out in Sections 10 and 9?

A I believe that you have stated that if wells are drilled immediately. I don't think that's a practical consideration. I don't think it's a practical question.

Q All right. If wells are not to be drilled immediately upon that basis, what objection can you have to an order of 80 acre spacing for one year?

A I just testified previously that that would be brought out in future testimony.

Q You don't have any views or ideas on that at all?

A Would you state a question?

Q If you do not believe it is feasible, and it obviously isn't, to drill wells on a 40 acre basis in the next year, what objection do you have to continuing the field on the 80 acre basis until at least the pressure maintenance program is tested?

MR. SETH: I don't believe the witness so testified. He didn't testify it was not practical to drill wells on a 40 acre spacing during the next year.

Q Do you think that you can drill enough wells in the next year to develop the Carson Unit on a 40 acre basis?

A That is quite probable.

Q How many wells would that take?

A Oh, estimating in the next year?

Q Yes.

A Probably -- Carson Unit?

Q Well, on your acreage.

A Well, something like fifty wells, I believe.

Q And how many do you believe it would take to develop this field on a 40 acre basis entirely during the next year?

A Are you speaking of the same area now?

Q I'm speaking of the entire Eisti-Lower Gallup Oil Pool as we presently know it.

A The entire Eisti Pool. I believe that's brought out in the testimony the other day of a very great number of wells.

Q Approximately 300 wells, was it not?

A Something like that.

Q Now, do you think it's practical to drill that many wells in a year?

A I think I already said that it wasn't.

Q That it wasn't? A No.

Q What do you consider to be the bubble point pressure in this reservoir?

A My figure is very close to that figure as testified to yesterday.

Q That I believe was 12 --  A 1207.

Q 1207.

A 1207 I believe it was, yes.

Q I notice that with the limited production that has taken place in the field, that two of the wells to which you referred as having some production in Section 15, that the recent pressures are already below the bubble point, am I correct?

A That is correct.

Q As a reservoir engineer, does that have any significance to you insofar as ultimate recovery from this reservoir is concerned?

A Significant of this pressure?

Q Pressure decline to below the bubble point with the amount of oil that has been produced.

A Would you restate the question?

Q Does that have any significance to you, the decline of reservoir pressure in the short production history of these wells below the bubble point have any significance?

A Very definitely. It's a very normal reaction.

Q Doesn't it indicate to you that this is a reservoir that requires a rather conservative approach as far as spacing and withdrawal is concerned?

A That's why we have given it a very thorough study.

Q Do you think that the overall production history is

sufficient to justify the risk that you think must exist, the caution that must be used in the development of this reservoir?

A Yes, I do. I think that it justifies the risk in my recommendation I wouldn't have recommended it.

MR. CAMPBELL: That's all.

MR. PORTER: The hearing will recess until one-fifteen.

AFTERNOON SESSION

September 20, 1957.

MR. PORTER: The meeting will come to order, please. Anyone have any further questions of Mr. Methven?

MR. SETH: We have a few more exhibits we would like to offer at this time. They only relate to the general study that Shell has made of the field and we wanted a complete picture. We would like to offer Exhibits 14, 15, 16, 17 and 18 at this time.

MR. PORTER: Are those studies by Mr. Methven?

MR. SETH: No, they are by other personnel in the company who occupy similar capacities to Mr. Methven.

MR. CAMPBELL: I would like to take a look at those.

MR. PORTER: Surely.

MR. SELIGSON: While Mr. Campbell looks those over, may I interrogate the witness?

MR. SETH: I might explain those are copies of letters that have been sent out to the people interested in the Carson Unit and the United States Geological Survey. I think most

everybody here has copies. Excuse me, Mr. Selinger.

MR. CAMPBELL: What are the marks appearing on them? There are some red marks.

MR. SETH: No particular significance.

MR. CAMPBELL: Are any of those people going to be present to testify? Is Mr. MacAlister going to testify?

MR. SETH: Yes.

MR. CAMPBELL: Mr. Robison, I assume, is not?

MR. SETH: Mr. Robison is here. Mr. MacAlister will be prepared to discuss the letters, Mr. Campbell.

MR. CAMPBELL: Mr. Pickell?

MR. SETH: No, he is not here.

MR. CAMPBELL: I won't offer any objection. If you desire, as far as I'm concerned, offer them at this time. Is that all of the letters that have been sent to the participants in the Carson Unit by Shell as operator?

MR. SETH: I doubt that very much. These are the regular geological reports. There have been innumerable letters written on the Carson Unit, I'm sure.

MR. CAMPBELL: Are these all the geological reports?

MR. SETH: Mr. MacAlister can answer that. Is that right?

MR. MacALISTER: Yes, that's right.

MR. CAMPBELL: Do you have extra copies of these?

MR. SETH: No, we don't.

MR. CAMPBELL: I don't mean to be arbitrary, if the Commission please, but this is quite a number of geological conclusions, without even an opportunity to read the letters I hate to accept them in evidence, particularly in view of the fact that the witness is not here to testify. I don't mean to be arbitrary. If I could have a little time while the cross examination is going on to look them over, perhaps I can accept them.

MR. SETH: We are not in any hurry.

MR. PORTER: Then it would be agreeable to you to wait until the other witnesses have been accepted before you offer these exhibits?

MR. SETH: Yes, certainly.

MR. SULLIVAN: Could you lay your foundation for the introduction of those through a subsequent witness like Mr. MacAlister?

MR. SETH: Perhaps we could if that would be --

MR. SULLIVAN: (Interrupting) Then you can identify them and they would come in in a more regular fashion, would that be praferable, Mr. Campbell, from your viewpoint?

MR. CAMPBELL: It would be acceptable.

MR. SETH: That's right, I would like the record to show that we offered them, but we will defer urging their admission until Mr. MacAlister has had an opportunity to testify and to further identify them.

MR. PORTER: Well, the Commission will delay the acceptance or any consideration of acceptance of these exhibits until after your other witnesses have appeared. Mr. Selinger.

CROSS EXAMINATION

BY MR. SELINGER:

Q Mr. Methven, as an engineer do you likewise have the opinion that the previous geological witness had that, particularly with reference to Exhibit 11, that there are some oil wells producing structurally higher than gas wells?

A If that's as the exhibit presents, yes, I believe it.

Q Is your testimony, is your opinion based on that Exhibit 11?

A Well, it's based on Sunray's exhibit as presented yesterday also. It shows the same structural relationship.

Q And referring to Exhibit 11, are you familiar with Shell's completion methods of your wells in this field?

A Somewhat, yes.

Q You are somewhat? A Yes.

Q Which of the oil wells produce structurally higher than the gas wells? Just name them.

A Could I refer --

Q (Interrupting) Surely. If you want to refer to the exhibit. It's all right to.

A Yes. Would you repeat the question again?

Q Which of the oil wells produce structurally higher than the

gas wells on that exhibit, or any other information that you may have?

A Which of the oil wells produce structurally higher than the gas wells?

Q Yes.

A It appears that most of these oil wells on this exhibit produce structurally lower than the gas wells. I believe there's an exception here. Yes, Shell Carson 2 produces higher structurally, I believe.

Q Then that's the only well on this exhibit that produces oil structurally higher than the gas well, is that correct, on this exhibit? A On the exhibit.

Q Do you know whether or not Shell individually tested the various perforations to determine whether or not those particular perforations were productive of oil?

A I do not know if they tested those individually.

Q In the event that the well was tested through all of the perforations simultaneously, how can you ascertain whether or not the particular, the uppermost perforations produced oil?

A We can't testify to.

Q Now, look at the log, are you familiar in reading logs?

A Somewhat.

Q Does that indicate that it might be productive of oil itself?

A The log doesn't tell you whether it's gas or oil.

Q Does the indenture lines on the left-hand column, the left-hand side of the well bore column indicate, what does that indicate?

A You mean this line over here?

Q Yes, on the left-hand side.

A I believe that our geologist said that depicted sand development.

Q Then I'll ask you does the sand development, as indicated by this particular log, indicate the ability of the well to produce oil from that particular perforation?

A Certainly not. Just a minute. Your question was does this --

Q (Interrupting) Yes. A Does this what?

Q Then I'll ask you does the sand development, as indicated by this particular log, indicate the ability of the well to produce oil from that particular perforation? You will have to speak so the Court Reporter can hear your answer also.

A Okay.

Q My question is whether or not this Exhibit 11 indicates that the sand development on the Carson No. 2 shows the ability of a well to produce oil? A No, it doesn't.

Q Do you have an explanation, I didn't mean to cut you off, Mr. Witness, do you have an explanation?

A No, that will be all.

Q Now, I want to call your attention to Exhibit 12, this morning you referred to your Exhibit 12 and in pencil indicated on Exhibit 1 in red, three wells, two of which are located in Section 15, Township 25 North, Range 12 West, and one located in Section 10, Township 25 North, Range 12 West.

Do you recall your testimony on direct and cross examination in which you put those figures in red?

A Yes.

Q Do you have your Exhibit 12 in front of you?

A I have.

Q I note that a number of wells were fracted and a number of wells were not fracted, is that correct?

A That is.

Q A number of those wells were fracted with 30,000 gallons of acid, is that right, or treatment?

A Oil and --

Q Treatment? A Treatment.

Q You indicated on this morning's session that the two wells in Section 15 had quite a rapid drop or decline in bottomhole pressure as compared to the well in Section 10, did you not?

A The wells are specifically --

Q (Interrupting) The wells are specifically 12-15 and 14-15?

A Yes.

Q Are those two wells at the present time from your exhibit

the lowest pressures in the field that you have measured?

A In accordance with the exhibit I believe they are.

Q Are they both below the bubble point?

A We have established that they were.

Q Your answer is yes? A Yes.

Q How many gallons of treatment was used in fracting the well in Section 10, Well 14-10?

A That well has not been fracted.

Q How many gallons of treatment were used in fracting the Well 12-15?

A That was 117,450 gallons.

Q How many gallons of treatment were used in fracting Well 14-15? A 115,280 gallons.

Q Did you, in any completion of your wells, use that fracting in any of the other wells from your Exhibit 12?

A No, those are the largest ones.

Q From an eyeball survey of Exhibit 12, would you say that the average gallonage used in fracting the wells in this field were approximately from thirty to fifty thousand gallon?

A That may be, yes, the most of them are in the thirty to fifty thousand gallon region, yes.

Q As an engineer, would you likely expect a more rapid decline in pressure after an unusually large fracting?

A If you had two completely similar wells the objective,

of course, of fracting is to improve their productivity, and therefore the larger fract may not decline as rapidly as the other.

Q Have you had experience in fracting in the completion of oil wells generally in your career?

A I've been involved in a few cases.

Q In those few cases do you generally find it true the heavier the fracting the more of a pressure decline in those few cases that you are familiar with?

A I don't recall the answer.

Q Very well, would you have an answer then for the explanation of the rapid decline of these two wells in Section 15, 25 North, 12 West, being due to the extremely high gallonage of treatment used for fracting, would that be an explanation for that decline?

A No, I think the reason that these wells have had an abnormally great decline is due to the fact that their drainage area is not large. They have a relatively small drainage area.

Q By a relatively small drainage area, you take into consideration for your answer the thinness of the pay compared to the well in Section 10?

A Of course, the amount of initial oil in place that this well drains very definitely has a definite effect.

Q Does pay thickness have an effect on the original oil in place?

A By all means.

Q Then your answer is that you did take into consideration the

thinness of the pay of these two wells in explaining the rapid decline in pressure for these two wells?

A I didn't mention it specifically.

Q You may not have mentioned it directly, but you did after three questions. You said that would depend on the small drainage area, and by the small drainage area you meant the oil in place.

A The drainage volume.

Q Drainage volume, which was in turn controled by your thickness of pay? A Yes.

MR. SELINGER: That's all. Thank you.

MR. PORTER: Does anyone else have a question of the witness? Mr. Utz.

By MR. UTZ:

Q Mr. Mathven, I'm still trying to arrive at some conclusion as to whether or not there is a gas cap in the Bisti Pool or not. Do you have an opinion on that subject?

A Yes, I have. I don't think I have the answer to it. In the last cross examination the inference was that we didn't know in the case of the oil wells, where the oil was coming from. Now, in the case of the gas wells, the same will hold. However, there were pressure measurements made in those gas wells while producing, and the drawdown was several hundred PSI. I cannot recall the exact number, I don't have the data with me, but it was several hundred PSI, and assuming the pays in the field which are

relatively general, let us assume they are one-tenth BB for PSI, then there should have been a considerable amount of oil with that gas, assuming this rapid drawdown.

Now, then, I believe the figures and the initial production of those wells do not show any oil. Therefore, I can only conclude that gas is coming from all those sands and that oil is not coming from them. Further, to further the explanation, I might go back and say that, let's see, I believe in yesterday's testimony Mr. Brinkley stated that you can have gas occurring, you can have a gas cap, I don't remember his exact words, but this was the thought, that you could have a gas cap in the presence of undersaturated oil. Well, he not only said you can, but he says, I believe his words, that it happens all the time. There are, of course, many cases where it does not happen. Therefore, that is not true.

Also I don't see how it's possible to have a gas cap in conjunction with undersaturated oil just based on the theory of fluid mechanics. So, assuming that you cannot have those two in the presence of one or another, then there has to be some other explanation. I think that in view of the discontinuities that have been placed or are pointed out in our previous testimony, I think you could draw a very logical conclusion that there is another discontinuity in that area which could account for it, but a gas cap existing where you have undersaturated oil, I can't explain that any other way.

Q Then I take it from your explanation that you would gather, or your opinion is, that these gas wells are in a common source of supply of their own and gas only? In other words, a gas reservoir?

A I'm not completely familiar with the exact definition of common source of supply.

Q Well, gas only and no oil?

A Oh, well, the wells have exhibited no oil in their production history, several have exhibited that, so if there was not a discontinuity and, as brought out by the geologist, if there was not a discontinuity, this thing couldn't occur because over the millions of years that this thing took to get there, it will have to be separated some way. There haven't been appreciable withdrawals here so there hasn't been much movement there in many years according to the geologist.

Q Then, do you feel that if these gas wells were allowed to produce unrestrictedly, it would have no effect on the reservoir energy in the Bisti Oil Pool?

A If it was a separate pool, why then it wouldn't, but I do not know what the answer is to their occurrence.

Q You don't know at this time whether it is a separate gas pool?

A No, I do not.

MR. UTZ: That's all I have.

MR. PORTER: Anyone else have a question of the witness? Mr. Kellahin.

By MR. KELLAHIN:

Q Mr. Methvan, I understand that the initial reservoir pressure in this pool were on the order of 1580 pounds?

A Yes.

Q Is that correct? A In that region, yes.

Q I notice on your Exhibit No. 12 you have the Government 12-15 and the Government 14-15 wells, on the first you show an initial pressure of 1330 pounds, and on the second, 1314 pounds, is that correct? A Yes, it is.

Q Does that not indicate that those wells, prior to the taking of initial pressure tests, had suffered some drainage then?

A Yes, and this drainage, I believe, was pointed out by our geologist. He did not make the contention that you had specific 40 acre blocks of oil that you will have some communication, and therefore I should think that that pressure drop would be caused by some communication from other wells.

Q From other wells in that area? A I should think so.

Q I notice too on the Government 14-15 that shows no microlog pay? A That is correct.

Q And yet it was completed for the production of oil?

A That is correct.

Q And it also suffered this drainage?

A It infers that, yes.

MR. KELLAHIN: Thank you very much.

MR. PORTER: Mr. Sullivan.

By MR. SULLIVAN:

Q Mr. Methven, has Shell conducted, in any of the gas wells, any bottomhole pressure surveys?

A Yes, I just reiterated one, but I do not have the data with me.

Q How did the bottomhole pressures in the gas wells compare with the bottomhole pressures that you discovered in the adjacent oil wells on bottomhole pressure survey?

A I don't remember the specific values, however, if there was an appreciable difference there I may have read it, but I don't remember what those values were.

Q Now, if there had been an appreciable difference, you think you would have remembered that there was an appreciable difference?

A Pardon me.

MR. SULLIVAN: Well, would you go back and read his last answer?

REPORTER: Reading: I don't remember the specific values, however, if there was an appreciable difference there I may have remembered it, but I don't remember what those values were.

Q Do I take that answer to mean that if there had been an appreciable difference in the bottomhole pressures between the gas wells and the oil wells adjacent, that you would have remembered that there was an appreciable difference?

A I said I may have. I also said that I do not remember those values.

Q Well, if the pressures shown in the gas wells and in the oil wells were about the same, certainly upon initial completion, would that be indicative that the gas-producing stratum was a separate stratum from the oil-producing strata in the vicinity?

A It would not tell you that it was or wasn't.

Q Is it likely that if they are one continuous stratum through there between the gas and the oil-producing sands, that the pressures will be identical or substantially so?

A They should be, but if they are of the higher values, we have just previously stated that this case should not exist in view of the laws of fluid mechanics.

Q Do I remember correctly that your testimony was that you anticipated that you could drill and complete the remaining wells on the Shell property in the field at about an average cost of $48,000? A Now --

Q (Interrupting) Feel free to correct me.

A Will you state it over again?

Q Do I remember correctly that your testimony was that it would cost about an average of $48,000 for Shell to drill and complete each well that remains to be drilled on your property?

A That is correct. That would be the cost for each additional well.

Q Would a cost of $48,000 include a figure for a sand fract job?

A They did. However --

Q (Interrupting) A sand fract job of the magnitude of the two that Mr. Selinger asked you about in one case, you used 115,000 gallons of treatment and in the other case I think it was 117,000 gallons of treatment. Now, if you conduct a fract job of that magnitude, can you do it and complete the well for $48,000?

A We have a subsequent witness that is going to testify to the specific values, and therefore, I would rather not.

Q Well, Mr. Methven, I assumed that when you testified that the cost of a well was $48,000, that you knew the component parts that went into making up that total cost.

MR. SETH: That is not the correct understanding, it has been furnished, that cost, by Mr. Robison, who will be the later witness.

Q You did not testify --

MR. SETH: He is prepared to discuss the cost in full.

Q You did not testify to the $48,000 then, of your own knowledge?

A I base my profitabilities on that $48,000.

Q But you did not arrive at that figure of your own knowledge or your own figure as to what the wells will cost?

A I did not make that calculation.

MR. SULLIVAN: That is all, Mr. Chairman.

MR. PORTER: Does anyone else have a question of the witness? Mr. Cooley, did you have a question.

MR. COOLEY: Yes.

By MR. COOLEY:

Q Mr. Methven, you testified under cross examination a short while ago, I believe, that you would not advise your company to drill wells out on 40 acre spacing outside the profitable area shown here on Exhibit 3 or Exhibit 1 I believe it is.

A It would be Exhibit 3, which is the microlog.

Q Exhibit 3, that's right.

A Any wells drilled out there would be of an exploratory nature.

Q What area was it that you testified to in answer to Mr. Campbell, that you would not advise your company to drill?

A In the region of only a very few feet of micro pay and there out beyond the zero line. And I also contend that you would not drill 80 acre wells out there as admitted in other testimony.

Q That's my next question. Does it make any difference what spacing it is, the purpose for not drilling the well is the fact it wouldn't produce oil? A That's right.

Q If it had a thousand barrel allowable it wouldn't be any different than if it had a ten barrel? A No, it wouldn't.

MR. COOLEY: That's all.

MR. PORTER: Any further questions?

MR. SELINGER: I want to ask the witness one more question that Mr. Cooley brought out.

By MR. SELINGER:

Q You said a few feet of micrelog. What do you mean by a few feet, five, six, seven, eight?

A Certainly not beyond the zero line or the five foot.

Q Would you drill any wells between five and ten feet?

A Yes, you would.

Q Where in between those two points would you have your line of demarkation?

A I couldn't say because this well assumed you place it, let's assume that you place it on the five foot line, will drain some towards the zero and some toward the thicker pay.

Q Having in mind the exhibit that Mr. Seth was attempting to introduce before and which he graciously withheld, would you say that you would recommend the drilling of a well on ten feet on 40 acre basis? A Yes, I believe I would.

MR. SELINGER: Thank you. That's all.

MR. PORTER: Any further questions? Mr. Utz.

By MR. UTZ:

Q Mr. Methven, can you tell me from your personal knowledge whether or not Shell has completed any gas wells in this trend or not?

A I do not have data on any specific gas wells, with me that is.

Q Then in your opinion you haven't completed any gas wells?

A I don't know.

Q You're not sure? A That's right.

Q Do you have another witness who could answer this question?

A Possibly, I don't know.

MR. UTZ: That's all I have.

MR. PORTER: Are there any further questions of Mr. Methven?

MR. COOLEY: Did you have something to say in answer to Mr. Utz' question, Mr. Methven?

A I just ran across one of the numbers I have here. It is Shell Carson Unit No. 32-20, that it did produce on an initial test of 1250 MCF per day of gas. Therefore, I believe that one would be it.

MR. UTZ: Did it produce any oil?

A We have a figure of something like three barrels.

MR. PORTER: Was that a twenty-four hour test?

A I'm not sure what it is. I cannot attest to the fact that this is oil or what type of fluid it is.

By MR. UTZ:

Q Do you know what Shell's policy is going to be in regard to producing that well?

A No, I do not. I should think that it would be in agreement with the New Mexico Oil Conservation Commission Rules and Regulations.

Q In the absence of any regulations, do you think they would produce it for whatever it would produce or whatever the market was?

A If under the state regulations they were permitted to produce that.

MR. UTZ: That's all.

MR. PORTER: Mr. Cooley, did you have any more questions?

By MR. COOLEY:

Q Mr. Methven, is there a line or point of demarkation from which you can tell from your engineering experience what is dry gas and what is casinghead gas as those terms are commonly understood?

A There's not a fine line, that I'm aware of.

Q But ordinarily your casinghead gas would contain much more liquids, would it not?

A Yes, yes. The fact is, it is generally referred to as wet gas.

Q Would a gas cap be wet gas? A A gas cap?

Q That is in commonly understood sense a true gas cap, would it be wet gas or dry gas?

A It should have some liquid constituents, I believe.

Q To your knowledge has there been any gas analysis on the gas being produced from the Bisti-Lower Gallup Oil Field?

A There have been gas samples taken, but I do not know which wells these were taken from.

Q Are you aware of the results of those tests?

A No, I'm not and I don't have them with me.

Q I wonder if anyone with your company does.

MR. SETH: We can furnish it to the Commission, I'm sure, if you would like to have it.

Q In your opinion would the properties of this gas, and particularly the amount of liquids contained therein, have any bearing on whether or not this is a gas cap or is not a gas cap?

A It could, yes.

MR. COOLEY: In view of that answer I would like to have the results of those analyses if possible.

MR. SETH: Be glad to get them.

MR. PORTER: Anyone else have a question of Mr. Methven? The witness may be excused.

(Witness excused.)

ROBERT S. MacALISTER, JR.

called as a witness, having been first duly sworn, testified as follows:

DIRECT EXAMINATION

By MR. SETH:

Q Have you been sworn previously during the course of this hearing?

A Yes, I have.

Q Would you state your name please, and your position with Shell?

A Robert S. MacAlister, Jr., Division Exploitation Engineer,

located in Farmington, New Mexico.

Q How long have you been with Shell?

A Ten years.

Q What have been your duties during that time?

A I have been an Exploitation Engineer with the company during that entire time. Three years was spent as a specialist in secondary recovery operations.

Q What are your educational qualifications?

A I graduated from the California Institute of Technology in 1947 with a Bachelor of Science degree in mechanical engineering.

Q Have you made a study and become familiar with the Bisti Field in New Mexico?

A I would say that I was familiar with the field. I haven't studied it myself as a full-time project, but I have had a number of people working under me who have studied it, and I'm familiar with their work.

MR. SETH: Are his qualifications acceptable?

MR. PORTER: Yes, they are.

Q Would you proceed, Mr. MacAlister, please, and give us a brief statement, perhaps, of Shell's position with regard to this LPG pilot program?

A I would like to state at the outset that Shell is very much interested in secondary recovery in any field where it can be done profitably, and we can improve the recovery of reserves and, in

particular at Bisti, we're very hopeful that some sort of secondary recovery in one form or another will be found applicable there and it has been testified that we are actively supporting the present LPG injection test.

I would also like to state that I believe that wells drilled on closer than 80 acre spacing will be required for secondary recovery operations in this field, and I see no reason why 40 acre drilling needs to be postponed on account of the secondary recovery prospects. I would like to mention four reasons why I make this statement. First, is that I believe it would be impossible to fit any efficient injection well production well pattern to the present random spacing of wells in the field on 80 acre density. The second reason, I believe that while the current, the form of the current pilot injection test is the best that could have been devised considering all the conditions with which we had to contend, I could not recommend to my management that we extrapolate the hurried results which we must obtain from this pilot project to a project that would be based on 160 acre five spots in that field, and if only 80 acre wells were drilled, then 160 acre five spots would necessarily obtain, if we went to such a pattern. I might say that a five spot is a five-well arrangement in the form of a square, with four wells at the corners, one well in the center, and this is the arrangement that is being used in the pilot injection project at Bisti. In that particular project the injection well is at the

center and the producing wells are at the corners.

The third reason, I believe why 40 acre spacing will be necessary, is that in view of the demonstrated discontinuities and irregularities in this reservoir, an efficient sweep out of the reservoir cannot be done on wide spacing. I might interject here that during the testimony yesterday I heard it said that in one field the recovery efficiency was the same on 40's and on 80's. I found that a little difficult to reconcile with another statement that said if you went from close spacing to wide spacing at Bisti you would get better efficiency. I think it was also mentioned that at sacroc they found that wide spacing was better than close spacing, and while I'm not familiar with all the details of sacroc, I do know that is a reef limestone field with over something in the neighborhood of 200 pay, of pay at a depth of 7,000 feet, and I don't believe that anything that happened there could be said to be relevant to the Bisti situation.

The fourth reason that I believe that closer spacing would be desireable is that the pay-out of a secondary recovery project would be unattractively long with wide spacing. One of the more unattractive features of secondary recovery operations is that you have to make a considerable investment, and your pay-out on your investment doesn't begin for one or more years, doesn't begin for one or more years after you make that investment. I believe that in an LPG injection project, which we all hope will be found

feasible here, that that situation will be even more critical because of the large investment that will have to be made in LPG. Perhaps as much as fifteen to twenty million dollars alone for LPG in this field. Therefore, I believe that spacing on closer than 80 acres would be required to gain an acceptable pay-out in this field. The pay-out time varies roughly with the spacing in secondary recovery operation. It seems to me I had something more to say, but maybe we had better get on with it.

Q What is the arrangement of the initial injection project here, what spacing would that be?

A The four producing wells are on 40 acre spacing, and the injection well is drilled between them would be called a 40 acre five spot, but the actual spacing between injector and producer is 20 acres.

Q You mentioned the importance of the time factor in secondary recovery. Do you mean that once you inject this large investment in LPG gas, it could be a year or several years before you even get the injected gas LPG back, is that what your testimony is?

A Well, the injected LPG in gas would be the last thing you would expect to come out. What I meant to convey was that in order to get additional recovery over and above what you would get by primary operations sufficient to pay out the investment, it takes a number of, well, it takes a year or more for that to begin in most secondary recovery projects.

Q There has been some testimony about pressure changes that have resulted from drilling in the pool. Are those pressure changes a function or related to spacing, or is the pressure change more a function of withdrawals?

A I think pressure drop is related both to withdrawals and the drainage volume from which you are taking those withdrawals. A well with small volume of reservoir attached or being drained by the well would have a relatively higher pressure drop with a small withdrawal.

Q But the overall field pressure would be controlled more by the overall field withdrawals than any other factor, is that correct? A Yes.

Q Do you have any other comments you would like to make relative to this secondary recovery matter?

A I don't believe so at the moment.

Q Have you written a number of letters to the parties participating in the Carson Unit relative to the geology and engineering in the area?

A We have. As one of our obligations as operator of the Carson Unit, we have to present plans of development for the unit and recommendations as to participating area within the unit. To accompany our recommendation, we have from time to time presented our tentative engineering interpretations.

Q I hand you what has been marked for identification as

Exhibits 15, 16 and 17. Would you describe please, to the Commission what those are?

A These are entitled "Geologic and Engineering Report, Gallup (Upper Cretaceous) Pool - Carson Unit, San Juan County, New Mexico", and the first one is to accompany the proposed first revision of the participating area. That's Exhibit 15.

Exhibit 16 was to accompany the proposed second revision of the participating area. Exhibit 17 to accompany the proposed third revision of the participating area.

Q Now, do these three exhibits represent the opinions and the thinking of Shell at the time that they were written?

A They do.

Q I will also hand you No. 14 that is signed by Mr. Pickell.

A J. J. Pickell.

Q Who is he?

A He was an Exploitation Engineer who was for a time in charge of the Exploitation Engineering Section in this area.

Q Would you examine 14 and can you state whether or not that is a report similar to 15, 16 and 17?

A It is. It has the same title as the previous reports except that this one is to accompany the proposed initial participating area.

Q Now, do these reports also reflect the development of the study and the thinking of Shell over this period of time?

A Yes, they do.

Q Could you tell the Commission whether or not that shows any slight change in Shell's thinking and approach to this problem during this period?

A I don't believe these letters or reports show the present thinking of Shell. The last one.

Q I meant do they show the position as of the time they were written, each one individually? A Yes.

Q Does that show any change in position?

A Yes, there is some change.

Q Would you describe that to the Commission, just in general terms is sufficient?

A At the time that the first report was written I believe we made statements as to our belief of the general continuity of the sands in this field, especially true along the central portion of the productive test where a good pay development has been observed. I think as we go along in these reports will indicate that we become less and less convinced of the continuity of the sands.

MR. SETH: We would like to offer these in evidence at this time.

MR. CAMPBELL: I have no objection as far as we're concerned.

MR. PORTER: Any objection to the admission of the exhibits?

MR. SULLIVAN: In regard to that, may I ask one

question which may establish whether I want to object to their admission?

CROSS EXAMINATION

By MR. SULLIVAN:

Q What has happened to Mr. Pickell? You have testified that he was in such and such a position. Where is he now?

A Mr. Pickell is in Denver.

Q Still in the employ of the Shell Oil Company?

A Yes, he is.

MR. SULLIVAN: Thank you. I have no objection.

MR. SETH: If the Commission please, I might perhaps make an explanation in order for offering these. We wanted to show the trend in the study and thinking of Shell in this connection over this period of time. We thought the letters, we're a little disappointed, we thought they would be more interesting to the proponent than they are. We think they are a part of the story and the Commission has a picture on them.

MR. CAMPBELL: We haven't had an opportunity to view them yet.

A I believe the Commission has obtained copies of these. They were sent to the Commission as well as the other parties in the unit, and the United States Geological Survey.

MR. PORTER: The Commission rules that Exhibits 14, 15, 16 and 17, Shell Exhibits, will be admitted to the record.

MR. SETH: That's all the direct we have.

MR. PORTER: Anyone have a question of Mr. MacAlister?

By MR. CAMPBELL:

Q First a few questions with regard to your position on the pressure maintenance program in this area. Have you had an experience with a pressure maintenance program of this nature?

A No, sir, I have not.

Q Then the reasons that you give for disagreeing with Mr. Brinkley's conclusion on the effectiveness of the program under 40 acre or 80 acre spacing, are based upon what assumptions or general knowledge of secondary recovery, or what?

A Based on some general knowledge of secondary recovery plus the fact that it will be a fluid drive project, and as are all secondary recovery operations, I think it differs by degree only from say water flood project in that the physics of controling the drive are not greatly different from one project to another.

Q You will agree, will you not, Mr. MacAlister, that in any fluid pressure maintenance or secondary recovery program, that the determination of the pattern of injection has to be determined by experimentation, does it not?

A I would say that that could be part of the answer, it's also based on experience I believe.

Q Well, isn't it conceivable here that continuing study of this pilot program and initial phases of the program itself could,

for example, result in flooding this reservoir from one end to the other or from the gas area toward one end or the other.

I mean isn't that a matter to be determined as the program progresses?

A I believe that a line drive project might be possible, but I think it is probably even more dangerous to try and extrapolate a five spot plug on close spacing to a line drive on wide spacing.

Q But in any event, that is a matter of disagreement of approach between you and Mr. Brinkley, isn't it?

A Yes.

Q And either one of you may be wrong, is that right?

A In my opinion he is more likely to be wrong than I am.

Q I'm sure if he had an opportunity to testify he would express the same views. Now, since that is true, and assuming that he may be right, since there's an honest difference of opinion between you in this engineering matter, what objection can you have to delaying this thing at least a year until that difference at least has a chance to be reconciled?

A I believe that the discontinuity and irregularity within the reservoir is going to require closer spacing for both primary and secondary recovery operations no matter what form the secondary recovery operation takes.

Q That matter can be determined within the early stages, I assume, of the program, can it not, say during the next year?

A In my own mind, why I believe that we have already shown that it has to be. You can't drive oil out of these dead end things.

Q Now, with regard to your statements concerning the pay-out of the secondary recovery or pressure maintenance program, you were referring to the pay-out of the program, it's not the pay-out of the entire investment of the operators in the field, were you not?

A It's the pay-out of the secondary recovery investment.

Q Of course, if wells are drilled on 80 acres instead of 40, and assuming the effectiveness of the LPG program, you will have twice the cost to work against, will you not, on the pay-out for the entire investment?

A The cost would be not twice, but it would be considerably more than on 40, but you have to inject for twice as long to get your oil out.

Q Mr. MacAlister, with regard to the reports of your company as operator of the Carson Unit to the other operators in the unit, and the U.S.G.S. and the Oil Commission, I would like to ask you whether in addition to these, indicating your continuing belief, that there is what I prefer to call a lack of uniformity in this reservoir that these do not also indicate your continuing belief that you cannot determine the pressure declines and other information in the reservoir due to the lack of production history?

A Certainly we're missing some important information by not having some production information. However, we've made these

detailed studies which have been presented here today by previous witnesses since the last of those reports was written. Our ideas are considerably different now than they were at the time that the last of those reports was written as regards the continuity of the sands and the ability to drain on wide spacing.

Q Throughout these letters you refer to wells which Shell has drilled but not completed, is that correct?

A That's correct.

Q How many such wells are there now?

A Oh, there are probably half a dozen, maybe as many as ten now. We have recently embarked on a large completion program in which we perforated some sixteen to twenty wells, I believe, and those wells are undergoing production tests at the present time.

Q I want to ask you one final question which hasn't yet seemed to me to be answered. What disadvantage is there to Shell Oil Company in the light of the circumstances that you present forgetting our testimony, what disadvantage is there to you to space this field on an 80 acre program for a period of one year?

A I think it will be brought out in subsequent testimony. It's going to cost more money to do it that way. That consideration aside, my feeling is that from the standpoint of engineering work we would be better able to concentrate on this development program in a single continuous program rather than an interrupted one. I believe that from the standpoint of efficient utilization of the

primary reservoir energy, it's better to complete your wells on a uniform spacing pattern to begin with rather than get oil going in one direction at one time and then go in and drill more wells and start it going in another direction. I believe that from the standpoint of efficient completion work, the earlier you drill and complete your wells, the better off you are.

Q The better off you are? A Yes.

Q Is that irrespective of the reservoir condition?

A No, that's not irrespective of the reservoir condition.

Q That will depend on each reservoir, will it not?

A In general I think it can be said to be true of almost any reservoir.

Q One last question. I know you don't like to do this, but you pointed out, and I have too, there is a difference of opinion between you and Mr. Brinkley about the effectiveness of this pressure maintenance program. If Mr. Brinkley is right, would you then still feel that this field should be developed at this stage on 40 acre spacing?

A I can't agree that Mr. Brinkley is right.

Q All right.

MR. CAMPBELL: That's all I have.

MR. PORTER: Anyone else have a question of Mr. MacAlister? Mr. Sullivan.

MR. SULLIVAN: Is this the witness that will be able to

testify as to well costs?

MR. SMITH: You have to wait one more witness.

MR. SELINGER: May I ask Mr. MacAlister a few questions?

By MR. SELINGER:

Q You talk about the Carson Unit, and your counsel in having you identify Exhibits 15, 16 and 17 and the explanation that it would tell the entire picture of your consistency of your views as operator of the unit, will you kindly tell the Commission the size of the Carson Unit in acreage and who are the owners of the Carson Unit, if you know?

A The Carson Unit is four sections wide by six sections north and south, that is twenty-four sections, 150,000 acres plus or minus, not all, am I wrong, that's too big, 15,000 acres, excuse me. Not all of the leases within that area are participants in the unit, but substantially all of them are, I believe.

Q Will you kindly tell the Commission the owners of the, or the participants of the unit, and if you have it available, the percentage owned by each?

A I can't tell you the exact percentage, but Shell is the largest participant with something in the neighborhood of eight, oh, eighty-five percent of the acreage. Phillips Oil Company and Skelly Oil Company each have in the neighborhood of --

Q (Interrupting) Seven and a half percent?

A Seven and a half percent. El Paso and Humble each have

minor interests.

Q Now, in furtherance of your counsel's explanation for Exhibit 15, 16 and 17, and in order to coincide with his wishes to give the Commission the complete picture, do you have correspondence between you and the U.S.G.S. and you and the other participants or owners of the Carson Unit with respect to bringing Exhibits 15, 16 and 17 up-to-date?

A I'm not sure I understand.

Q Did you have any further correspondence outside of Exhibits 15, 16 and 17 with any other operator in the Carson Unit?

A Oh, yes.

Q Do you have that available here?

A Not all of it, no.

Q Did you get any correspondence from Phillips about the unit?

A Yes, sir.

Q Did you get any correspondence from Skelly about the unit?

A Yes, sir.

Q Did you get any correspondence from any of the others, and if so, from whom? A From Humble and El Paso.

Q Now, can you, since you are familiar with that, can you indicate to the Commission the desires of the other participants in the Carson Unit since you have gone into great detail as to the desires of Shell with respect to this matter?

MR. SETH: I believe the letters would be the best evidence.

Perhaps you have them, Mr. Selinger.

MR. SELINGER: No, I haven't. You are putting in the testimony and the exhibits, I would like for you to put the rest of the exhibits in.

MR. SETH: If you have them we will be glad to put them in if the Commission would like to receive them.

MR. SELINGER: I don't have the correspondence from Rumble or Phillips.

MR. SETH: I am thinking that you object to the spacing in the --

MR. SELINGER: (Interrupting) Let the exhibits speak for them.

MR. SETH: There is a lot of correspondence.

MR. SELINGER: Let the exhibits speak for them. This witness said he has the correspondence here.

A No, sir, I do not.

MR. SETH: He does not.

A I do not have all of them.

MR. SETH: If you will identify them more particularly, we will be glad to get copies and submit them to the Commission.

Q On examination you stated that you had correspondence from these various companies. Tell the Commission the correspondence you had with Skelly with respect to the Carson Unit.

A We have had more than one series of letters with Skelly.

When we first suggested a plan for spacing in this area, I believe Skelly indicated that they might, that they would be happy to drill some, to have some 40 acre wells drilled on their lease. Subsequently we have had letters from them that indicate they have changed their mind on that subject.

Q Did they say why they changed their mind?

MR. SETH: If the Commission please, I think the letters are the best evidence. You must have your letter. You are asking about what you wrote.

MR. SELINGER: I am going to ask about Humble and the rest which Skelly has no possession of.

MR. SETH: Do you have your letter with you?

MR. SELINGER: No.

MR. SETH: We would like for you to produce it.

MR. SELINGER: We would like to have Shell furnish the Commission with the correspondence from the other interested parties in the Carson Unit which will indicate likewise the desires of those other participants as well as Shell in their Exhibits 15, 16 and 17 so that the Commission can get the complete picture. They have presented only one, Shell's position. Now my purpose in asking for the additional information to be supplied, is to show all the participants.

MR. SETH: I believe we told you we got them once and we must distinguish between these exhibits, these are reports by the

operators to the participants in that capacity. This other is just extraneous correspondence, but we'll be glad to furnish it to the Commission, of course, if they would like them.

MR. COOLEY: Mr. Selinger, for what purpose is the correspondence sought?

MR. SELINGER: The same purpose that Exhibits 15, 16 and 17 as explained by Mr. Seth, to show the full picture, it's for the same purpose.

MR. COOLEY: As I understand it, it could not be for the same purpose because I believe the purpose of 14, 15, 16 and 17 was to show the change in policy of Shell Oil Company, and I can see how no correspondence from any other company could indicate that change.

MR. SELINGER: Well, we have no —

MR. COOLEY: (Interrupting) Is that the purpose of 14, 15, 16 and 17?

MR. SETH: That's right.

MR. SELINGER: We have no control over Shell's viewpoint, but they are speaking now on behalf of the Carson Unit. I want the Commission to understand that the consistency or inconsistency of their view in operating the Carson Unit can likewise be indicated by the inconsistency of the views of the other participants.

MR. SETH: I think the record, we speak for Shell Oil Company as Shell Oil Company, we are not speaking for the Carson

Unit. It is not involved in this hearing.

MR. PORTER: In the interest of time, Mr. Seth, the counsel for Shell, has agreed to supply the Commission with copies of this correspondence, which the Commission will accept.

MR. MECHEM: You can include that too in your statements to the Commission.

MR. SELINGER: Yes, sir, we shall.

Q Mr. MacAlister, you said that you had sent copies of Exhibit 15, 16 and 17 to the U.S.G.S.?

A Yes.

Q What was your latest correspondence with relation to those exhibits, Exhibits 15, 16 and 17 to the U.S.G.S. with respect to the development plan?

A We sent them a plan of development suggesting development of the Carson Unit on 40 acre spacing, and we recommended the drilling of 53 wells.

Q Was that subsequent to those exhibits?

A Yes, it was.

Q Was that your latest word to the U.S.G.S., was there any later correspondence you had with the U.S.G.S. with respect to the plan of development? A Yes, there was.

Q What was the date of that later correspondence, in effect, the gist of it, to the U.S.G.S. as to the plan of development in the Carson Unit?

MR. SETH: If the Commission please, I believe the Commission has copies of that correspondence, do they not, Mr. MacAlister?

A I'm not certain.

MR. SETH: Or the Commissioner of Public Lands, in any event. We will get copies of that.

A Ordinarily the correspondence is handled by our Land Department. I'm not familiar with the dates of the correspondence.

Q You mean it will be covered by a subsequent witness?

A No, I'm afraid we don't have one here.

Q You said you were familiar with the later correspondence of the U.S.G.S. as to the latest plan of development as submitted by Shell. Will you tell this Commission in gist form what was that later plan of development?

A We requested the U.S.G.S. to approve certain wells within that plan of development in order to continue our operations in the field while this discussion of spacing in the field was being settled.

Q And that basis was 80 acres for the present, is that correct?

A No. We didn't say that, anything as to spacing as I recall it.

Q You did not say it would be on 80 acre density?

A No, I don't believe so.

MR. SELINGER: That's all I have.

MR. PORTER: Mr. Utz, did you have a question?

By MR. UTZ:

Q Mr. MacAlister, are you familiar with the economics of the Sunray pilot flood which they are beginning to operate now?

A Generally.

Q Do you know what the estimated cost per barrel of oil recovered by secondary means is to be?

A No, I don't believe I can answer your question directly.

Q Do you have that information available that you can furnish the Commission with it?

A Let me try and answer it. Maybe I can satisfy you and maybe I can't. The cost of the project is going to be, I believe, somewhere in the neighborhood of one hundred fifty to two hundred thousand dollars, including the cost of LPG and gas. That's the capital investment, of which I think we can reasonably expect to recover substantially a large part of the LPG and gas eventually, so maybe the total investment would boil down to one hundred thousand, one hundred twenty-five thousand dollars. If the project works as well as they have predicted it will, they will recover something like 136,000 barrels of secondary oil.

Q Did your one hundred twenty-five thousand include the cost of drilling the injection well?

A Yes, but it doesn't include operating costs. I'm not familiar with what the operating costs might be.

Q Roughly it would be about a dollar a barrel?

A I would think that would be reasonable.

MR. UTZ: That is all.

By MR. CAMPBELL:

Q You and Mr. Utz are only referring to the pilot phase of this project, are you not?

MR. UTZ: I am, yes, sir.

Q I wasn't sure he was, I wanted to be clear.

A Of course they won't recover 136,000 barrels in time necessary to recover the pilot and extrapolate it to a full scale flood, if that becomes desireable it comes over the life of the injection project.

MR. PORTER: Anyone else have a question? Mr. Kellahin.

By MR. KELLAHIN:

Q Mr. MacAlister, as I understand it, Exhibits 14 through 17 have been offered for purposes of showing the change of position on the part of Shell, is that correct?

A Yes, sir.

Q Yet, based solely on these exhibits, they reflect no change in Shell's opinion that there is a continuity of the sands in the northwest, southeast direction, is that not right?

A I think you'll have to say that that statement was rather qualified in the letter.

Q Well, I would assume that Exhibit 17 is the last report,

is that right? A Yes.

Q I believe on Page 2 of Page 2 of Exhibit 17 your statement is to the effect that "In previous proposals for participating areas (see Geological and Engineering Reports supporting the proposals of Initial Participating Area and First Revision of the Participating Area, January 16, 1957 and April 26, 1957 respectively) data were presented suggesting fair continuity of sand development along the northwest-southeast pay trend, and poor continuity in the transverse direction." Is that the qualification you refer to? A Yes, I believe that was.

Q Yet you support that by a reference to the two preceding reports which do not in anywise qualify your statement.

A Can I elaborate on the context of that?

Q I am referring to the contents of the exhibit, if your attorney wants to bring out the explanation.

MR. SETH: You can explain your answer. Go ahead and explain your answer.

A That was written to explain why we had extended the participating area in the direction and meetings that we had, and it was an extension along the grain of deposition of the sands, and it was meant to convey that we felt that we could extend the participating area in that direction with more confidence than we could across the grain, simply because the general deposition indicates that commercial production can be obtained laterally along the

grain, I mean from commercial wells more readily than you can predict a transverse extension of commercial production.

Q But on the basis of these exhibits alone, you request no change in your opinion as to the continuity of the sands aside from the qualification which you state?

A I don't think it reflects a change in our ideas as to the gross picture of the sand deposition.

MR. KELLAHIN: Thank you.

MR. PORTER: Are there any further questions of Mr. MacAlister? Mr. Cooley.

By MR. COOLEY:

Q One of the major factors, Mr. MacAlister, you said in secondary recovery, was to get a quicker pay-out and make it attractive to the company since there was such a large expenditure of monies? A Yes.

Q You felt that you would get this quicker pay-out on 40 acre spacing, you would get a quicker pay-out on 40 than you would on 80?

A Yes, sir.

Q My only question is was that based on well potentials, you can just produce more out of twice as many wells, or was this based on greater allowables assigned?

A Usually the life of a secondary recovery project depends on the average injection rate that you can maintain in the injection wells. The more injection wells you have, the faster you can inject

and flood out the reservoir.

Q Then it's actual potential of the well and not the allowable? The statewide allowable has nothing to do with your discussion on that point? A No, injectivity.

MR. PORTER: Anyone else have a question? The witness may be excused. We will take a short recess.

(Witness excused.)

(Recess.)

MR. PORTER: The meeting will come to order, please. Mr. Seth, will you call your next witness?

MR. SETH: We would like to call our subsequent witness now.

R. R. ROBISON

called as a witness, having been first duly sworn, testified as follows:

DIRECT EXAMINATION

By MR. SETH:

Q Would you state your name, please, Mr. Robison?

A My name is R. R. Robison.

Q By whom are you employed?

A I'm employed by the Shell Oil Company as Division Production Manager, Farmington.

Q How long have you been employed by the Shell Oil Company?

A Going on thirty-four years.

Q During that time what experience have you had, Mr. Robison?

A Well, back up to the beginning, I graduated from Stanford University in 1924 and majored in mechanical engineering. I went to work first in our Gas Department for a year or two, and then in mechanical engineering as mechanical engineering work, and later as Division Mechanical Engineer, and then Engineer of the Drilling Department, later Drilling Foreman, Division Superintendent, and since 1953, Production Manager. That is a hurried rundown.

Q At the present time you are in Farmington, is that correct?

A Yes, I came to Farmington when the so-called Farmington Division was organized, April 1st, of this year.

Q Have you, during your work in Farmington, had occasion to become familiar with the costs of wells in the Bisti Area?

A I have.

MR. SETH: Are his qualifications acceptable?

MR. PORTER: They are.

Q Would you please state, Mr. Robison, the experience of Shell with well costs in the Bisti Pool?

A Yes, in that connection I have two tabulations here of costs, one labeled Exhibit 13-A, the other Exhibit 13-B. I might pass these out. Referring to the tabulation labeled Exhibit 13-A, you will note that it includes six wells which were completed this year during the month of July. These costs are not down to the dollar, but serve as representative costs, days drilling cost of Shell's in the Bisti Field. These costs range from $40,800 to a low of

$35,200. The average being $38,000. This $38,000 includes a well completed as a flowing producer including everything from the roads, the drill site, the actual drilling, testing, the casing, casing services, cementing, perforating, the tubing, the wellhead, the flow line as well as the cost of the formation fracturing that we commonly do. Then if you will refer to the tabulation shown as Exhibit 13-B, we go back to the first well that we drilled in the Bisti Field, after a tabulation of total cost for the 37 wells that had been completed the middle of August. You will note that there is a wide variance there in cost, our first wells being, first well being $88,000, that well was drilled in the early part of 1956. The average cost of the, on a per well basis for the 37 listed, is $46,500. The logical question would be why such a marked reduction.

There is nothing in my opinion that's mysterious about it. It is largely due to concentrated efforts, what we now know how to drill, but even more important the cost began to come down mainly because of a development program. This reduction from $46,500 to $38,000 in current cost is rather sizeable, I doubt that we can do as well in the next year and a half, but the downward trend is still with us. Again largely because of the continued development program in the field.

We, as I said earlier, started the, organized the Farmington Division the first of April. Since that time we've in addition

to the two strings that we are now running here, we got up to a maximum of thirteen currently drilling eleven, with eleven strings of tools, two of which are Bisti. The cost of moving the outfits into the Bisti Field is quite sizeable, but that has been, has paid off, so-to-speak, amortized over the wells that have been drilled and are being drilled.

The next group of wells which we have contracted for will be two bits a foot less than we are presently paying, that means roughly a saving of $1250 a well. Again that downward trend is with us. I might right here clear up the figure of $48,000 that a previous witness used. That has been arrived at from these figures, taking into account the reduction that we contemplated in the next group of wells, namely $37,000 complete with fracture treatment, completed as a flowing producer, add $6,000 as being the future cost of pumping equipment, plus $3,000 as each well's share of the field facilities from here on out.

Q What are these field facilities, Mr. Robison?

A Share of the gas and oil separators, the manifolds, and main roads.

Q Now, how, what effect does it have on the cost of field facilities if you initially plan for an 80 acre spacing and then have to go back to a 40 acre spacing?

A Unless the program were continuous, it would add materially to the cost. It is, as I tried to explain, a reduction in our

drilling costs is largely because of the continuity of operation and we get that for several reasons, we have been able to maintain the same contractor in the field, and I might add too that we had a string of tools of our own, our own crew in there to drill six wells, but mainly it's been contract work. The crews become familiar with the operation and that is quite important in this country, you find it necessary not only, the contractors find it not only necessary to tell us to weed out the crews to get good help, and secondly if we were to have a shutdown in operations, someone has to pay to move this equipment out and move it back in. That pay comes to us or any operator in the field. That runs into rather sizeable figures, and the two together, well, it depends on the number of wells, the amounts to, I had better just say a sizeable figure, several thousand dollars per well.

Q The well costs, you expect them, they would be less ultimately, if you can maintain a continuous program, and they would be less too if you did not have to start on an 80 acre spacing and then go back to a 40, is that right? A Correct.

Q Now, what is your drilling program for the balance of this year?

A The balance of this year we have planned, and our budget approved and calls for the drilling of 29 additional wells in addition to the 37 listed on the exhibit shown as 13-B. For next year under 40 acre spacing, we have tentatively planned in our budget,

and incidentally, our budget is on a calendar year basis, so we are right in the preparation of it now, but we are planning on 58 wells in the Bisti Field for next year. We would like to drill them.

Q Are you prepared to drill them?

A We are prepared to drill them.

Q Is the money budgeted to drill them?

A Only tentatively, but we have had a preliminary budget hearing and top management appears to be in agreement. That was, I might mention this number of wells was originally included in our tentative budget when the Farmington Division was organized. So I look for no problem as far as obtaining the funds.

Q Then Shell is prepared, if the Commission permits it, to go ahead on a 40 acre basis, is that correct?

A Correct.

Q And would you have a rough approximation of the acreage of Shell leases within the proposed pool, just roughly?

A Yes, roughly 25% of the area that's been discussed here previously.

Q As by the other witnesses? A Yes.

MR. SETH: We would like to offer these two Exhibits, if the Commission please, 13-A and B, at this time.

MR. PORTER: Any objection to the admission of these exhibits? They will be admitted.

Q Do you have any further statements you would like to make,

Mr. Robison? A No, I believe not.

MR. SETH: That's all the direct we have then.

MR. PORTER: Does anyone have a question of Mr. Robison? Mr. Campbell.

CROSS EXAMINATION

By MR. CAMPBELL:

Q Mr. Robison, just a few questions about your exhibits relating to well costs. The reason, as I understand you, that you have been able to reduce your well costs from your first wells to your latest wells is by virtue of the size of your drilling operations, am I correct in that, and the information you have obtained?

A Not so much the size because we are not conducting a large operation now, you might say we only run two strings of tools, but by size I would interpret that to mean, I would rather say it as to continuity of operation. First we went in as sort of an exploratory operation, we drilled a few wells and then there would be a period when there was no development, we would have to go back in again and in turn pay for getting the contractor's equipment into the field.

Q Have you estimated the number of wells that you would be drilling if the 80 acre density were maintained during the next year?

A Yes, I have.

Q How many would that be?

A To what we consider proven now, there would be enough 80

acre wells, for the remainder of 1957 there would be 29 wells to keep us going through the balance of the year the same as the 40, but next year there would be 11 wells.

Q But you could maintain a continuous program for the balance of this year at least with the present operation that you contemplate?

A That's right.

Q Are there, to your knowledge, operators in this field who do not have the amount of undeveloped acreage that you do?

A I couldn't speak with very much authority on that, but I would say that there are probably some that do not have the acreage because I just mentioned that we have 25%.

Q Your plans with relation to the development of your acreage in this field have assumed that you would be permitted to drill it immediately upon 40 acre basis?

A We have gone on the assumption all the time up until the filing of this petition, that we would have 40 acre spacing.

Q That is the sole disadvantage to the delay of 40 acres, assuming that it were later put into operation, that your company sees in this application?

A No, I can't say that is the only objection. I'm merely citing one part of the objection. One objection.

Q What others, that you know of?

A Well, I was listening to a previous witness who thought there might be some inefficient use of reservoir energy through postponing

of drilling of all the wells.

Q Do you feel that the economic loss to your company that you say that would exist for the balance, for 1948 if this were drilled on 80 acres to that time justifies the drilling of additional wells by other operators is a sole reason?

A I don't quite follow you how the other --

Q You mean that your economic loss -

A (Interrupting) Because we would force other operators to drill unwanted 40 acre wells?

Q Yes, sir.

A Well, basically we are sold on the 40 acre spacing, so we don't think that even the other operators would suffer.

Q Well, that of course, is the essence of this discussion, for the last two days, but my reference was whether you thought that was a sufficient sole basis for your feeling you shouldn't go along on a one-year 80 acre spacing program?

A Well, again, I'll just have to say we would like to abide by the present regulation, one well to 40.

Q Would you, if that remained in effect, be able to drill all your 40 acre locations in the next year?

A I'm not positive of that, but I'm sure that we would get the majority of them drilled.

MR. CAMPBELL: I believe that's all.

MR. PORTER: Does anyone else have a question of Mr.

Robison? Mr. Cooley.

By MR. COOLEY:

Q Mr. Robison, has Shell completed as of this date, or commenced, rather, as of this date, any well which could not have 80 acres dedicated to it? Plain words, have you started any 40 acre locations?

A We have not started, or did not start, any 40 acre well after the date of the filing of the petition, but we have, I believe, one well, maybe two, that are on a 40 acre basis, at least I would call them that. Now, I don't know whether we can add another 40 to them. They're not uniformly spaced 80, put it that way.

Q I'm aware of that that there would be several exceptions to the attempted uniform spacing plan in here, but you do have an additional 40 acres that you could dedicate to any existing well?

A That I'm not sure of. If there is any, there's only one or two. If I can leave it as general as that.

Q You stated that Shell has not commenced any 40 acre wells since filing this application. Would you be in a position to state whether they anticipate commencing any until there is a final decision in this case?

A I think that is right, that we will defer, we will like to and probably will defer drilling until there is a decision in this case.

Q You cannot state as an absolute fact that you will not drill any?

A Well, we would advise you people, we would have to get your concurrence to do so and would like to, in preference to discontinuing our present operations. We will attempt to, but we will not do it on our own.

By MR. PORTER:

Q Mr. Robison, I believe you stated that you hadn't started any wells since the application was filed. Do you know whether or not you had completed any prior to that time on 40 acres?

A Yes, that was the one that I was referring to. We did not spud a well on a 40 acre location, at least to which it couldn't be called an 80, we did not spud any 40 acre locations after the petition was filed, but just prior to that we were ready to go and were drilling on one well, the name of which I think was -- was this 44-10.

MR. MacALISTER: I believe Government 31-15 is the well which could not have 80 acres dedicated to it.

A There appears to be one.

MR. MacALISTER: I also believe that Government 44-10 probably could not have 80 acres dedicated to it either because subsequent to the completion of that well we've drilled 14-15, I believe it is. Carson Unit.

A Yes. 44-10 is right in the corner.

Q What section?

MR. MacALISTER: We have drilled this one. I was mistaken in the number. 14-11 has been drilled also.

Q What is the location of the section and township?

MR. MacALISTER: It is in the southwest of the southwest of Section 11, Township 25 North, Range 12 West.

MR. COOLEY: Just a minute, that is not the location of the well which could not have 80 dedicated to it?

A No. That is Government 44-10 in the southeast of the southeast of Section 10, the same township and range that could not have 80 dedicated to it.

Q The other well?

MR. MacALISTER: Government 31-15, which is in the northwest of the northeast of Section 15, Township 25 North, Range 12 West.

Q Those are the only two wells that you know of?

MR. MacALISTER: Yes.

A Yes.

MR. PORTER: Does anyone else have a question of Mr. Robison? Mr. Sullivan.

By MR. SULLIVAN:

Q Mr. Robison, I have before me Shell's Exhibit 13-E from which you have been testifying. I notice that in your tabulation of all of the 37 wells that Shell has drilled in this field, you have two there with double asterisks.

A Yes. I neglected to mention that.

Q The explanation for the double asterisk that I read is "costs include above single asterisks plus artificial lift equipment".

A Yes.

Q Do I take it that these are the only two wells then in your entire 37 on which you had to set pumping equipment?

A Correct.

Q Are there any of those wells which will necessitate the installation of pumping equipment to put them on production?

A Quite likely.

Q You have several wells over there which have never actually been completed as producers? A Correct.

Q Now, out of those you expect that there will be some that will require pumping equipment? A It's possible.

Q Have you installed flow lines on those wells that are in that situation?

A We are in the process now of dividing our oil gathering system as part of the automatic custody transfer system that was approved a few months ago, and flow lines are in part of that and we are even putting them in for other locations that we expect to drill and feel assured of getting production, and until we put the field under production we will use a gathering system as a water system. We will economize.

Q What I'm asking is are there some of these figures in the

right-hand column on your Exhibit 1)-A which do not include, one, the cost of pumping equipment?

A The two wells are the only ones that include pumping equipment.

Q Are some of these wells the figures in the right-hand column, do not include the cost of flow lines?

A Right.

Q As they exist on this page?

A I think you are probably right, probably the flow lines are not in.

Q Are you in a position to make an estimate as to the per well cost --

A (Interrupting) Of a flow line?

Q No, sir, of the installation of your automatic lease --

A (Interrupting) Automatic custody transfer? A.C.T.?

Q Automatic custody transfer equipment. Can you estimate what that will cost per well? Just average it out, you know, take a total figure and divide it by the total number of wells.

A Oh, $3,000.

Q Well, now, that figure is not included in any of this, is it?

A That's right. This figure --

MR. SETH: Just let the witness answer.

Q Excuse me.

A This is not a complete analysis by any means, and the fact

that two wells here have included that cost of pumping equipment, the average of $46,500 is slightly distorted, possibly if you take out $16,000 I doubt if you could read your slide rule, however, to find it, but it does illustrate, I compared that to today's figures in the tabulation marked Exhibit 13-A. Those figures are comparable generally.

Q Mr. Robison, I'm not questioning the accuracy nor the propriety, but we are concerned about the fact that we believe that drilling of a well is completion and the entire works will cost considerably more than the figures that you have testified to here as to Shell's cost, and what we're trying to establish is one, where the discrepancy arises between what we anticipate and what you anticipate, and we think that in view of the fact that these figures have become important in the discussion with regard to the economics of drilling wells on a closer or wider spacing, that it should be brought forth that there may be additional costs other than these which eventually will be added into your well cost in the Bisti Field. Now, let's put it this way, are these the final costs that you anticipate? A To date.

Q And which you will allocate to each of those wells as of the date they start pulling oil into the new pipeline?

A Well, our well costs do not include as such, we have a completed well cost statement that does not include anything in the way of lease facilities, only for profitability of the well do we

include that.

Q Do you cut that off short after say tankage, lease tankage?

A Flow line is where we quit. That is part of the well.

Q So if your accounting methods call for the inclusion of lease tanks as part of well costs, these figures in turn would be increased? A Would be higher, yes.

MR. SULLIVAN: Thank you. That's all I have.

By MR. COOLEY:

Q Mr. Robison, did you say that the figure of $48,000 was your average well cost when you put in the cost of a pump for each well and some other items you enumerated?

A And future share of lease facilities.

Q Which was the same facilities that Mr. Sullivan was referring to?

A Yes, and which was referred to by our previous witness when Mr. Methven used $48,000.

Q The $48,000 that has been used by Mr. Methven and explained by you, all the way through includes all the facilities?

A That is the average expenditure that we expect to incur in the Bisti Field in the way of capital, put it on a per well basis, but in any of our completed well cost statements that will not show the forty-eight.

Q But your total cost allocated to all the wells in the field averages out $48,000? A From here on out.

MR. COOLEY: Thank you.

A We hope maybe to get a slight reduction. That is right.

MR. PORTER: Any further questions of Mr. Robison? The witness may be excused.

(Witness excused.)

MR. SETH: That's all the witnesses we have, if the Commission please.

MR. PORTER: Mr. Kellough.

MR. KELLOUGH: Seeth Kellough. I am a lawyer for Gulf Oil Corporation, and we have a witness we would like to present to the Commission.

MR. COOLEY: Is this the gentleman I swore the other day?

MR. KELLOUGH: Yes. You have been sworn, have you not?

MR. BAUMAN: Yes.

WILLARD BAUMAN

called as a witness, having been first duly sworn, testified as follows:

DIRECT EXAMINATION

By MR. KELLOUGH:

Q Will you please state your name to the Commission, and will you please spell it for the reporter?

A Willard B-a-u-m-a-n.

Q Where do you live, Mr. Bauman? A Denver, Colorado.

Q By whom are you employed? A Gulf Oil Corporation.

Q In what capacity?

A Zone Petroleum Engineer.

Q Are you employed by the Denver Division which has within its jurisdiction the northwest part of New Mexico?

A I am.

Q How long have you been engaged in duties as a petroleum engineer for the Gulf Oil Corporation? A Since March, 1946.

Q Do you have an engineering degree, and if so, will you please state from what college?

A I have a degree in mechanical engineering from Texas Technological College in 1941.

Q Has all of your work since that time been in connection with petroleum engineering?

A I spent approximately a year and a half on an engineering training program with Gulf upon graduation, and except for the time I served in the military service, why I have been working in petroleum engineering.

Q Have you made a study of the Gulf wells in the Bisti-Lower Gallup Pool and that portion of the pool upon which they are located? A I have.

MR. KELLOUGH: Are the qualifications of this witness acceptable?

MR. PORTER: They are, Mr. Kellough.

Q Will you please state to the Commission, Mr. Bauman,

the number of acres that Gulf has under lease in the area covered by this application?

A Well, if these are regular Governmental quarter sections, it would be 960 acres.

Q It is approximately 960 acres? A Yes.

Q Would you state for the information of the Commission the number of wells that Gulf has?

A Gulf has completed five wells and is drilling the sixth.

Q In other words, as far as this pool is concerned, Gulf is a small operator? A That is correct.

Q Have you made a study of the economics of drilling wells upon 40 acre spacing as authorized by the statewide rules?

A I have.

Q From that study is it your opinion that it is economical to drill a well under the existing statewide rules without any special 80 acre order? A It is possible.

Q Do you have an opinion as to the amount of profit to be expected to be made from the wells based upon the study of the Gulf wells?

A I would estimate the profit to be in excess of $49,000 per well for a 40 acre tract.

Q Have you prepared an exhibit that will reflect your views in that regard? A I have.

MR. KELLOUGH: Miss Reporter, will you please mark this

as Gulf Exhibit No. 2?

(Marked Gulf Oil Company's Exhibit No. 2, for identification.)

MR. KELLAHIN: Yesterday there was an exhibit identified as Gulf's Exhibit 1, and I thought to keep the record straight this could be Gulf's Exhibit 2.

Q Now, Mr. Bauman, will you please state briefly for the Commission what this exhibit shows?

A This Exhibit No. 2 shows an economic analysis of drilling a typical well on Gulf's leases in the lower flanks of the field. It shows that an estimated ultimate recovery of 60,000 barrels, gross barrels, and on the basis of two dollars and ninety cents per barrel net for the oil, the net revenue would be in excess of $152,000, which does not include any value for the casinghead gas that would be produced and sold. The total outlay to recover this oil would be 50¢ per net barrel for production expense, amounting to $26,000, production tax, a little over $6,000, and development cost including producing equipment and a proportionate amount for tankage, of $72,000. And after allowing for a small credit for salvage, the total outlay would amount to $103,000, which subtracted from the net revenue from the oil, would yield a profit of $49,000.

Q $49,230, is that the figure there?

A That is correct.

Q Was this exhibit prepared by you?

A It was.

Q Is it based on a solution drive type reservoir?

A It is based on a solution drive recovery.

Q That determines your recovery factor?

A That is correct.

MR. KELLOUGH: We offer in evidence Gulf's Exhibit No. 2.

MR. PORTER: Without objection this exhibit will be admitted.

Q Now, Mr. Bauman, are you familiar with the proposed arrangement for proration units which has been proposed by the applicants here in this case, which is that the units may run either north and south or east or west? A I am.

Q And are you also familiar with the proposed well location pattern which provides that the well may be located in either 40 acres of the 80 acre unit provided that they are diagonal with any one Governmental quarter section?

A Yes, I am.

Q That is a statement, as you understand, the proposal for this floating or flexible well location pattern proposed, is that right?

A That's the way I understand it.

Q Have you made a study of the Gulf leases with respect to whether such a proposal will protect the correlative rights of the Gulf in that case? A I have.

Q I refer you now to what will be identified as Gulf Exhibit No. 3, and ask you to please state what that is.

(Marked Gulf's Exhibit No. 3, for identification.)

A This is a plat of portions of Township 25 North and Range 10 and 11 West, and shows the acreage located within the proposed spaced area, the blue acreage shaded in blue is identified as Gulf leases.

Q Does this exhibit show the location of the presently existing wells by the solid circle, is that right?

A It does.

Q Does it show the authorized location of wells under the proposed well location pattern by crosses?

A It does.

Q Now, referring to the southwest of Section 24, what is that?

A 25 North?

Q 25 North, 11 West. How many wells are located on the Gulf lease?

A Two producing wells.

Q Under the proposed 80 acre pattern, well location pattern, could any more wells be located there?

A They could not.

Q How many wells could be located under the proposed pattern offsetting Gulf lease?

A There could be six wells, six, seven wells on offsetting

Gulf acreage that would not be owned by Gulf.

Q That would be on the authorized pattern?

A That would be on the authorized pattern.

Q And the ratio of seven to two as to that particular 160 acre tract?

A That is correct.

Q Will you please explain to the Commission what the blue circles represent?

A The blue circles merely represent an area of 80 acres at the same scale that this map is drawn.

Q That is drawn on the assumption that a well would drain 80 acres as contended for here in this case, is that correct?

A That is correct.

Q And that is prepared also on the assumption that the Commission will grant the application as it is now asked for?

A That is correct.

Q What does the area between the blue circles represent?

A The area between the blue circles merely represents the area in which there is the highest pressure or the highest oil saturation between the four permitted locations.

Q Is it not an elementary rule of petroleum engineering that oil will migrate from areas of high pressure to areas of low?

A That is generally accepted.

Q Now, in that connection then, what is the significance of your blue arrows?

A Well, the blue arrows merely indicate that from some point in the center of this area the oil under a uniform spacing pattern will move equally to the four wells that are draining that area.

Q That would be the direction of the flow of the direction of the drainage under a uniform 80 acre pattern?

A That is correct.

Q Now, Mr. Bauman, what do the red circles represent?

A The red circles represent an area of equal magnitude of a well, another well that could be drilled under the flexible pattern.

Q Will you please demonstrate to the Commission the effect of the drainage of oil if you add the two other wells which would be permitted wells under the proposed application?

A The effect of adding the other two wells would mean that in the 160 acres that those three wells would be located, you would be taking out three barrels of oil and three barrels of oil here as compared to two barrels of oil from the tract upon which the completed wells are located, and that in effect, would create a pressure somewhere in the vicinity of the three wells that would not be created under a uniform pattern, and in effect, would create additional force that would cause the oil to move toward those additional wells and would result in more oil moving to these three wells from this area right here, and this area here then would be the case under a uniform pattern, and the correlative rights of Gulf would not be protected.

Q In other words, the arrows represent the pull of the oil, and by the addition of that well, is authorized the pull of the oil would be off of the Gulf lease?

A That is correct.

Q Would that result in uncompensated drainage?

A It would.

Q And in your opinion then will the application as proposed, protect the correlative rights of Gulf Oil Corporation?

A It will not.

MR. KELLOUGH: That's all.

MR. PORTER: Does anyone have a question of Mr. Bauman? Mr. Campbell.

CROSS EXAMINATION

By MR. CAMPBELL:

Q Mr. Bauman, I believe you stated that Gulf owns 960 acres in this area? A That is correct.

Q It's approximately two percent of the present productive proven limits of the field?

A I haven't made the calculation so I presume though that you have stated it correctly.

Q Is it true that Gulf owns 20 percent of the proposed four corners pipeline?

MR. KELLOUGH: I am going to have to object to that line of questioning. It is quite apparent that the question of markets

or market demand or matters of that nature are not germane to an application for a well spacing. That's a proper and appropriate question as to the question of the allowable production for the pool, but certainly the question of what market may exist over the life of this pool should not be an issue in this case to determine the proper location of wells. Therefore, I think it's an improper cross examination to try to delve out of this witness any information with respect to the company's ownership, if it has any, in any proposed pipeline.

MR. PORTER: Mr. Kellough, your objection is sustained.

Q Mr. Bauman, I understood you to say that Gulf has completed six wells to date on their acreage?

A I believe I stated five.

Q What was the figure? Are you completing one now or drilling?

A The sixth one is drilling.

Q According to the information that was presented yesterday, three of those wells are gas wells, is that correct?

A No, sir, there's only two of those wells that are gas wells.

Q I show a well, or this exhibit shows a well in the southeast quarter of Section 21 which is a gas well, that is 25 North, 11 West.

A That is correct.

Q And it shows a well in the, that's southeast quarter of Section 21, the southwest quarter of Section 30.

A In southwest of Section 30 there is what?

Q A gas well according to this map.

A There is one gas well.

Q And the southwest -- wait a minute. The well in the additional well in the southwest quarter of Section 30, has that been drilled to total depth yet?

A Which well are you referring to?

Q The one that is now drilling apparently in the southwest of the southwest of 30.

A That is a completed well. That is a gas well that I was referring to.

Q What about the one in the northeast of the southwest of 30?

A That's an oil well.

Q Are you producing it as an oil well now?

A It is.

Q What is --

A (Interrupting) To the best of my knowledge it is being produced.

Q What is the gas-oil ratio?

A The gas-oil ratio of that well at completion was determined as 2300 cubic feet per barrel.

Q How much oil has it produced?

A I don't know how much it has recovered to date. It was only completed in July.

Q How much oil treatment was it given in fracturing, if you have

that information?

A The well was perforated from 5,085 to 92, and 5110 to 20 feet, and flowed naturally 168 barrels of oil per day through 2664 inch choke.

Q With no fracture? A No fracture treatment.

Q Do you have the cumulative amount of oil that Gulf has produced from this reservoir?

A I don't have it available.

Q Is Gulf prepared to drill wells on their acreage in Section 24 on a 40 acre pattern?

A Yes, sir. At least I would recommend it to the management.

MR. CAMPBELL: I think that's all.

MR. PORTER: Anyone else have a question of Mr. Bauman?

MR. SELINGER: I would like to ask one question.

By MR. SELINGER:

Q I couldn't quite hear your answer, what was the cost of drilling and completing a well of your five wells in the Bisti Field? I didn't get that total figure.

A The cost to drill and complete?

Q Yes, everything, complete cost.

A $72,300.00.

Q That's what I thought. Thank you.

MR. PORTER: Mr. Sullivan.

MR. SULLIVAN: I think I can confine myself to one question.

By MR. SULLIVAN:

Q Mr. Bauman, if 40 acres becomes, it stays or becomes the spacing pattern for the field, how many locations will you have offsetting this 160 acres that you were describing in your testimony, that's set forth on your Exhibit 3?

A How many --

Q How many offset locations will there be surrounding your 160 acre lease on a 40 acre pattern?

A Well, there would be, I presume you are referring to these locations off of Gulf acreage?

Q Yes.

A Well, there would be one, two, three, four, five, six, seven, eight, nine, ten, eleven.

Q As compared to how many possible offset locations under the application as submitted by Sunray Mid-Continent?

A I believe this shows one, two, three, four, five, six, seven.

Q So that your correlative rights will be better protected with eleven offset locations than with seven?

A That's correct.

MR. PORTER: Anyone else have a question of the witness?

MR. KELLOUGH: I would like to ask a question on redirect examination if there are no other questions.

MR. PORTER: Mr. Utz has some questions.

By MR. UTZ:

Q Mr. Bauman, would a rigid 80 acre spacing pattern tend to correct this situation which you state will exist under the conditions there?

A In my opinion it would not. I presume you're referring to a uniform 80 acre pattern?

Q That is correct.

A With the wells located in the same Governmental --

Q (Interrupting) Same quarter, quarter section on the 160. Your answer was that you don't think it will?

A I don't believe it will.

MR. PORTER: Mr. Nutter.

By MR. NUTTER:

Q Mr. Bauman, would you state the rate of flow at which the well which you testified the GOR was 2300 to 1, would you state the rate of flow on that test please?

A 168 barrels of oil per day.

MR. NUTTER: Thank you.

MR. PORTER: Are there any further questions? Mr. Cooley.

By MR. COOLEY:

Q There's been testimony throughout this case that the heart of this pool is highly productive, much better than the fringe areas. Does Gulf own a characteristic proportion of each or do they own more good acreage than bad, or what will be your opinion on that

matter?

A I think we are represented for the area of the southeast portion of the pools insofar as the wells that have been drilled so far.

Q You think you have your representative share of the good acreage and your representative share of the bad acreage?

A Yes, sir.

Q Did you say it would be your recommendation to your company to drill all 24 possible locations under 40 acre spacing? I believe there are twenty-four nine hundred sixty divided by forty nets twenty-four, if my arithmetic hasn't failed me.

A I would recommend that we would drill the 40 acre locations on that tract in the southwest of Section 24 at the present time, and depending upon the results of the well now drilling, that could be extended.

Q You wouldn't care to estimate how many wells Gulf will eventually end up with on the acreage shown on Exhibit 3 on 40 acre spacing?

A That is pretty hard to say without knowing the results of the well now drilling.

MR. COOLEY: That's all.

MR. PORTER: Are there any more questions on cross examination? Mr. Kellough.

RE-DIRECT EXAMINATION

By MR. KELLOUGH:

Q I would just like to ask one question, Mr. Bauman, in the event that this application is denied and the drilling is upon the statewide rules of 40 acre spacing, and if Gulf completed the drilling of wells in the southwest of 24, then in connection with Mr. Sullivan's question, would there be an offset to each of the wells on the adjoining tracts?

A There would be an offset, yes, sir.

Q Did you wish to convey the impression to this Commission that in your opinion the correlative rights of Gulf would be better protected under the proposed application than they would under the statewide rules?

A I'm not sure that I understand you. They would not be protected the way they are now, but we would be able to protect them if that tract was offset by 40 acre drilling.

Q Then, perhaps you misunderstood Mr. Sullivan's question as I understood your answer, Mr. Sullivan asked you if it was not a fact that the correlative rights of Gulf would be better protected under the proposed application than under the statewide rules and your answer, I believe, was that it would. Is that what you intended to testify?

A To the extent that there would be no drainage from our property.

Q Well, I'm trying to get you to express your opinion to this

Commission, Mr. Bauman, as to whether in your opinion, based upon your exhibit, the correlative rights of the company, Gulf Oil Corporation, would be protected under the proposed 80 acre floating well spacing pattern.

A I don't think they would be.

Q Would they under the statewide rules?

A They would.

MR. KELLOUGH: That's all. Thank you.

MR. PORTER: Does anyone else have a question of Mr. Bauman. The witness may be excused.

(Witness excused.)

You just had the one witness?

MR. KELLOUGH: That's all we have.

MR. PORTER: Does anyone else have any witness?

MR. SULLIVAN: I would like to call Mr. Thomas Hogan in this case.

MR. PORTER: He has previously been sworn?

MR. SULLIVAN: Yes, sir.

MR. KELLOUGH: I am a little late, but I would like to offer in evidence Gulf Exhibit No. 3, the map. I believe I neglected to do that.

MR. PORTER: Without objection, Gulf Exhibit No. 3 will be admitted to the record.

THOMAS HOGAN

called as a witness, having been first duly sworn, testified as follows:

DIRECT EXAMINATION

By MR. SULLIVAN:

Q Will you please state your name, your employer, your position with that employer?

A My name is Thomas Hogan, I am employed by British American Oil Producing Company, and what was the other one?

Q What is your position with that employer?

A District Superintendent for the Northwestern District.

Q Where are you located? A Denver, Colorado.

Q You say that you are District Superintendent. Would you explain to the Commission in your company what that district encompasses?

A It encompasses the producing active, the producing and drilling activities in Montana, Wyoming, Colorado, Utah, Nebraska and New Mexico, North and South Dakotas.

Q In those states, Mr. Hogan, just approximately how many oil fields do you have under your jurisdiction as far as drilling and producing is concerned?

A Quite a few, I don't know. We have four field offices with Field Superintendents over them.

Q In other words, in your organization a district is considerably

vaster area than we have heard described as being divisions in other organizations? A It is.

Q Briefly, and be as brief as possible, Tom, in this, state your professional experience.

A I received a B. S. degree in mining engineering from the University of Oklahoma in 1933. Since that time I have been employed by The Texas Company in various engineering capacities, with the Iranian-American Oil Company as Superintendent of the Abquiq District and as Chief Development Engineer, and now for the last five years with British American Oil Producing Company as District Superintendent.

Q Mr. Hogan, you have read and are familiar with the application of Sunray Mid-Continent in this case?

A I have.

Q Is the position of your employer, the British American Oil Producing Company, in support of that application?

A Yes, we are strongly in support of the application, but I would like to point out that we would like to stress the temporary nature of the order that we wish issued.

Q Now, there are two, let us say three, distinguishing parts to the application. One, they ask for 80 acre spacing, two on a temporary basis, three for the expansion of the definition of the pool. Do I take it that you are saying that your company is in support of all three facets of that application?

A It is.

Q But that you believe that there is particular emphasis to the temporary part, what do you mean by the emphasis that your company puts on the temporary feature asked for?

A We do not believe that there has been sufficient production and pressure history from the Bisti Field to enable us to determine that 40 acre spacing is economically feasible.

Q But you, on the other hand, are willing in effect to consider it when you get sufficient information?

A We are.

Q One further question, how many producing wells does British American operate in the Bisti Field? A Thirty.

Q That's approximately what percentage of the total in the field? A Twenty-five.

Q Do you recall how many of those wells, off-hand, you have cored? A Approximately twelve.

Q Do you recall the first witness put on, in Mr. Finfrock's testimony, how many core analyses of wells were involved in the diagrams which he presented, was it twenty-six?

A It was in the twenties I believe. I'm not sure.

Q With all of the producing information that you have from thirty wells, and with the core analyses from twelve wells with the additional information that you have obtained from producing those wells, I take it then that your position is that you still do not

have enough information to determine that you can successfully and economically drill on a 40 acre basis?

A No, we feel that we don't, principally because the production of the field has been restricted so drastically throughout most of its life, and as testified by Mr. Brinkley, it is still in the early stages of the producing life of the field.

MR. SULLIVAN: That's all, Mr. Hogan.

MR. PORTER: Does anyone have a question of Mr. Hogan?

By MR. SETH:

Q Just one question. How long have your wells been producing, Mr. Hogan?

A The first well was completed in January of 1956.

Q Been producing over a year? A Yes.

MR. SETH: That's all.

By MR. PORTER:

Q Mr. Hogan, do you recall about what the gas-oil ratios are on your wells?

A Oh, they are in the neighborhood of I would say 450 feet to the barrel. I wouldn't guarantee it, but that is my best recollection.

MR. PORTER: Does anyone else have a question? The witness may be excused.

(Witness excused.)

MR. SULLIVAN: I would like also to ask Mr. John Stein

to testify, Mr. Chairman.

MR. PORTER: All right. Will you take the stand, please?

MR. SULLIVAN: He was sworn yesterday.

JOHN STEIN

called as a witness, having been first duly sworn, testified as follows:

DIRECT EXAMINATION

By MR. SULLIVAN:

Q Mr. Stein, will you briefly state your name, your professional education and professional experience?

A My name is John Stein. I am a graduate of the Missouri School of Mines with a degree in mining engineering, petroleum engineer. I have been with the British American for eight years, and during the past two years have served in the capacity of District Engineer for the entire Northwestern District.

Q In your capacity as District Engineer, Mr. Stein, are you familiar with the Bisti Field? A Yes, I am.

Q Part of your duties are to study and make recommendations, generally supervise, in effect, the engineering of the Bisti Field?

A Our portion of it, that is correct.

Q You have been present during the last two days of testimony on this cause? A I have.

Q Are you generally in agreement with the conclusions reached by the witnesses for the proponent of this application?

A Yes, I am.

Q Would you like to comment upon the opinion that you have reached with regard to the economics of drilling this field according to the present stage of your knowledge on a 40 acre basis?

A Well, at the present time I don't feel that we have sufficient knowledge of how much reserves we can attribute to nine 40 acre wells. We have made some special core studies in which we have come up with a representative figure, we think, of recovery per acre foot. Now, we base most of our profitabilities on one well to 80 acres. Now, in the very heart of the field where we have the good production, we expect to obtain on 80 acre spacing roughly a hundred to ten thousand barrels of oil, which deduct royalty and lifting costs and so forth, would amount to a gross profit, or a gross revenue in the neighborhood of $190,000.

Now, it costs us around $70,000 to drill a well. So that means that on one well to 80 we could get $120,000 gross profit. That is assuming that our recovery estimates are pretty good. Now, if we drill two wells on that 80, that's going to require $140,000 expenditure, and that just cuts the gross profit right down the middle, which would leave somewhere in the neighborhood of $50,000 for that particular 80, which we are not sure we can even get, because there hasn't been enough production decline history, nor bottomhole pressure history to substantiate these initial estimates of recovery of oil per acre foot.

Q Now, I understand that these estimates were based, did you state that these estimates were based upon an average cross section or thickness of pay?

A No, this would only apply in the very best portion of the field. Now, we have some wells that have already been completed and actually indicate that they'll never pay out, and they are on 80 acres.

Q They are completed in the upper bench?

A Yes.

Q As producers. Are they also completed in the lower benches of the sand?

A They certainly are.

Q So there are wells even in your end of the field completed in the upper bench and lower benches which you do not consider economic wells at this time?

A That's right. Actually our core studies indicated that in the poorer sections of the reservoir we might expect from five to fifteen barrels of oil per acre foot. That is pretty low. We have already had a couple of wells which had considerable drop in pressure for only a small amount of oil produced. If we would just take the pressure decline that we have had on those two wells, we can only expect to get roughly 15,000 barrels of oil out of them ultimately, and that will never pay for a $70,000 well, yet they are on 80 acres.

Q Can you corroborate the gas-oil ratio that Mr. Hogan testified to with regard to your average or individual gas-oil ratios

in the section of the field which you are producing?

A Yes, they are running in the neighborhood of 400 to 450. There may be a few in the 500 range, but very few.

Q In connection with your special core studies, did you direct your attention in any respect to the possibility of communication between the upper and the lower benches, and if you did, with what purpose?

A Not particularly with core studies. However, we did note that on our core analyses that there was some minute amount of permeability even in the shalely, silty zones between the better-developed sand benches, so we conducted some communication tests.

Q Other than your core studies?

A Yes. We perforated the third bench of the Gallup sand and fractured it, and swab tested it, and then we went up and perforated the first bench of the Gallup sand, fractured it and swab tested the two together. Of course, established a rate, then we ran a packer on the tubing and set it in the blank interval between these two perforated zones and pump tested the well for, oh, I don't know, about two months, a man ran fluid level surveys on the fluid in the annulus, and the results of that test did indicate that there was communication between those two zones to some degree.

Q You were pumping it from which bench at that point?

A We were pumping from the third bench, the bottom bench, and checking the fluid level in the annulus, which is supposed to be

in the first bench if no communication existed, however, as we pumped from our third bench from the packer, our fluid level in the annulus went down the hole and finally stabilized when we shut the well in for a week to a month at a time, the fluid level in the annulus would build back up. Those are definite evidence of communication between those sand benches in that well.

Q I won't ask you whether or not you have made a deduction from that test. I would like to ask you whether or not you have a suspicion as to what this proves between the relationship as what you refer to as the upper and the third bench?

MR. KELLOUGH: We have had a lot of opinions, but I don't believe we should have a suspicion.

Q Would you state your opinion as to what may be your deduction from the test you have run?

A Actually that is only on one well. Of course both zones were fractured. Now, any time you fracture a well, a fracture is going to go in all directions, we may have caused that communication by fracturing, and again we may not. It may be due to the natural permeability in the reservoir. I don't think we can quite conclude on this test. We do wish to make more tests.

Q That is why I didn't ask you for a conclusion. I just wondered if you had a suspicion. One further question, did you earlier testify in connection with the economics of 40 as versus 80 acre spacing as to what you estimate your completed well cost will be

in that field from here through the foreseeable future?

A I don't know if I made that statement exactly, but our costs, I expect --

Q Would you make it now?

A (Continuing) -- to be between sixty-five and seventy thousand dollars per completed well.

Q Generally what will that include?

A That will include everything pertaining to a well from drilling it, setting the pipe, perforating, logging, perforating fracturing, all of the pumping, lifting facilities and lease facilities. Everything that is necessary to get this well to produce into tank battery.

MR. SULLIVAN: That's all, Mr. Chairman, that I have.

MR. PORTER: Does anyone have a question of Mr. Stein? Mr. Cooley.

CROSS EXAMINATION

By MR. COOLEY:

Q Mr. Stein, you said your company had already completed some wells that in your opinion would not pay out?

A Yes.

Q You stated that that was on 80 acre spacing with the inference at least, I thought, that possibly the payout would be less if they were on 40 acre spacing?

A Certainly we couldn't even expect to offset these wells and

get any more additional oil. I mean we have already they are on 80.

Q Offsetting is not required where the well is not economic, Mr. Stein? I want to know, if anything, an uneconomic well is drilled, the dedication of no amount of acres to that well will make it economic, will it?

A I don't quite understand.

Q If you dedicate 20 acres to that well, or 1000, it is still an uneconomic well, is it not? A I'm afraid it is.

MR. COOLEY: Thank you.

MR. PORTER: Mr. Utz, do you have a question?

MR. UTZ: Yes.

By MR. UTZ:

Q Mr. Stein, in answer to one of Mr. Sullivan's questions, I understood you to say that you were generally in favor of Sunray's application. Would that indicate that you are not wholly in favor of it, some portion of it that you don't agree with it?

A I am in favor of a temporary 80 acre spacing order, I'll put it that way. I would not be in favor, for instance, of making this a permanent spacing order. Of course, they have not asked for a permanent spacing order. I am in favor of the one well to 80 acre spacing on a temporary one year basis.

Q Are you in agreement with their so-called floating spacing pattern?

A Well, yes, I would be in agreement with that.

Q That would allow you to cluster four wells around a quarter quarter section, or quarter section?

A Yes, it would allow that in certain specific cases. However, there are some wells in the field already that are off spacing and therefore, there is going to have to be an exception made for those particular wells. You have to either give them an east-west 80 or north-south 80. There is also a possibility that a fellow sitting off out here that is maybe only got 70 acres within the zero contour, so I think if you had a little leeway as to where he could drill that well, he would still only have one well to the 80. I think there should be some leeway to that.

Q You are in favor of flexible spacing pattern then?

A To some degree.

Q Even though it would be clustering the wells?

A I think it should be either east to west or north to south. I wouldn't want to throw them on a diagonal.

MR. UTZ: That's all I have.

MR. PORTER: Any more questions? If no further questions, the witness may be excused. (Witness excused.)

MR. COOLEY: I would like to direct a question to either Mr. Errebo or Mr. Campbell. As you gentlemen know, this state as a general rule interpreted its spacing orders to permit the drilling of more than one well on a standard proration unit, whatever size it may be. As Mr. Campbell knows, there are many areas of this state

where there are two, three and four wells on 140 acre proration units. In view of the fact that this is somewhat peculiar, since an 80 acre unit will probably get just twice what a 40 acre unit will get, that anyone who desired could drill on a 40 acre spacing pattern even though the established and recognized 80 acre proration unit were established.

MR. PORTER: There is a limitation there, Mr. Cooley, in that regardless of the number of wells that the unit received the same allowable even though one well?

MR. COOLEY: That's correct, but since on a 5,000 foot well there is no depth factor, than a 40 acre well would get just exactly half of what an 80 would and vice versa, which would not occur in any other depth range.

MR. PORTER: Not under your existing rules.

MR. CAMPBELL: What is your question?

MR. COOLEY: The question being does the applicant by this application propose to prohibit the drilling of more than one well on an 80 acre?

MR. CAMPBELL: We would like to have the order so provide, if the Commission issues any order. The interpretation of the statutes we would leave up to the Courts. The section that permits drilling on one unit, if you want to, with one allowable.

MR. COOLEY: Yes. We have not ordinarily interpreted our rules, in say a 40 acre pool, to prohibit the drilling of an

additional well on the 40.

MR. CAMPBELL: You have occasionally permitted after application.

MR. COOLEY: No application, they just drill them.

MR. CAMPBELL: We would like to have the order so provide, if the order is issued, for temporary 80 acre spacing.

MR. SELINGER: May I attempt to answer that likewise? I have here a suggested order, both the findings and the order, which I would like to introduce and merely for the suggestion on the part of Skelly in which it incidentally coincides with Mr. Campbell's suggestion, but it is very short. I might read it, I would like to suggest this:

Findings: That the geological and engineering evidence presented to the Commission hearing on the matter of well spacing indicates that the Bisti Field as classified and defined in this order, should, for a period not to exceed one year from the date of this order, be developed on a pattern of one well to eighty (80) acres in order to drain efficiently the recoverable oil from said pool, assure orderly development, and prevent waste in a manner to protect correlative rights.

That temporary 80-acre spacing in this field will result in a earlier determination of the geologic and engineering characteristic of the pool, avoid the drilling of a number of unnecessary wells should a wider spacing prove to be proper after additional evidence

is obtained as will protect correlative rights.

In the order we suggest that: That effective this day temporary 80-acre spacing is hereby established for the Eisti Field.

That this order shall continue in force for a period not to exceed one year from the date hereof.

It was merely a suggestion and I might add that it is based on practice and procedure that we have in the State of North Dakota which issues temporary spacing orders for the express purpose of securing information upon which to predicate a permanent order.

MR. PORTER: Mr. Cooley, before we conclude this matter we would like to know if there are any other companies who desire to present testimony in this case.

MR. BUSHNELL: At the opening of the hearing Amerada intended to put in a four and one-half page statement at the end of the hearing, but during the course of the hearing the last several days we conclude that we would like to put that statement in in the form of testimony since it was prepared by a witness who is here. However, since it appears that this hearing may run on through the lunch hour today, I contacted Mr. Seth and we have stipulated that I may enter this statement of Amerada's, prepared by Mr. Christie, into the record as if it were given by Mr. Christie, and if there is no objections I would like to offer this into the record as Amerada's Exhibit No. 1.

MR. SETH: We have so stipulated. I don't know what

Gulf's position will be on it. We had stipulated that if Mr. Christie were called, he would testify as this statement reads.

MR. KELLOUGH: We have no objection to the admissibility of the statement.

MR. COOLEY: Do both you gentlemen waive the right to examine him?

(Marked Amerada's Exhibit No. 1, for identification.)

MR. PORTER: Under these stipulations, the statement will be accepted as testimony. Does anyone else desire to present testimony in this case?

MR. KELLOUGH: I just want to make one comment, whereas I have no objection to Mr. Christie's statement, on the other hand and quite to the contrary, I do object to any admission of Mr. Selinger's order in the record in this case. If he wishes to present it as argument on his behalf, I think that is very well and good. I certainly don't think, I think it would be a little presumptious to submit to this Commission a finding based upon all of the evidence which has been presented here for the last two days.

Now, I'm sure that Mr. Selinger intended that to be only argument, if that is the case, very well and good, but if it is intended to be admissible in some manner in this case, then I would like to object to it.

MR. SELINGER: I merely intended to give Mr. Kellough

advanced notice that I'm going to attach that to my statement to be filed within the next few days. That's why I had it read.

MR. COOLEY: It has been the practice on occasion, of this Commission and other Commissions, to accept proposed orders, but they have no evidentiary weight whatsoever.

MR. KELLOUGH: Very well.

MR. PORTER: Was this question of number of wells to the unit settled to your satisfaction?

MR. COOLEY: What, the application section? Yes.

MR. PORTER: If there are no further witnesses to appear, no further testimony to be presented, the Commission will entertain statements that you may have. However, as you remember, yesterday we indicated that written statements might be submitted within ten days, ten days from yesterday. However, you still have the privilege of presenting the statement orally if you so desire.

MR. HINKLE: If the Commission please, Clarence Hinkle of Harvey, Dow and Hinkle, Roswell, representing Humble Oil and Refining Company. I would like to present a brief statement on behalf of the Humble. The Humble Oil and Refining Company has a 4.722% interest in the Carson Unit area which covers a part of the Bisti-Lower Gallup Oil Pool and owns additional acreage within the proposed horizontal limit of the pool. The Humble desires to go on record in this case as supporting the application of the Sunray Mid-Continent Oil Company for a temporary order of one year establishing orderly de-

acre spacing in the Bisti-Lower Gallup Oil Pool.

Due to the fact that production from the Bisti-Lower Gallup Oil Pool has been relatively small because of the market outlet, the information accumulated to date with respect to well performance and bottomhole pressure data has been rather limited, and although the production data thus far accumulated indicates that one well will affectively, efficiently and economically drain more than 80 acres, a temporary order entered for a year would permit further development on an orderly 80 acre spacing pattern during such period so that additional well performance and pressure data can be accumulated to enable the Commission to more definitely determine the characteristics of the pool and as to whether at the end of the year development should properly proceed on an 80 acre or 40 acre spacing.

It is also possible after a field has been on a definite 80 acre spacing pattern, to drill the additional wells so as to complete the development on 40 acre pattern if essential to obtain the greatest ultimate recovery. But once development has started to any considerable extent on 40 acre pattern, for all practical purposes it can never be changed, and it would then be too late to prevent economic waste caused by the drilling of unnecessary walls and the unnecessary use of steel and other industry equipment.

We, therefore, urge the Commission to give favorable consideration to the Sunray Mid-Continent application.

MR. PORTER: Anyone else have a statement? Mr. Kellahin.

MR. KELLAHIN: Jason Kellahin appearing for Phillips Petroleum Company. Phillips Petroleum Company owns acreage in the Bisti-Lower Gallup Pool, participates in the Carson Unit area, and is likewise participating in the pilot LPG injection program now under way in this pool. Phillips is of the opinion that the reservoir information which has been presented in this case and is now under consideration shows that one well on 80 acres will efficiently and economically drain and develop the 80 acre unit.

In that connection we would like to call the attention of the Commission to the testimony offered by Sunray Mid-Continent as to four wells which showed an initial pressure below the original reservoir pressures, and also Exhibit 12 offered by Shell which shows on at least two of the wells the same situation, which on the testimony from both the proponents and the opponents of this application, show effective drainage over an 80 acre area. For that reason, Phillips Petroleum Company supports the application and urges the adoption by this Commission of the temporary 80 acre spacing order for a period of one year.

Also in connection with it, we would like to urge the Commission to give serious consideration to the testimony which has been offered in regard to the pilot injection program, the testimony of some of the witnesses indicates that the development of the area on closer spacing could well endanger that program and result in reduced recoveries. The money which would be spent, according to the

testimony of the witnesses, in developing this acreage on 40 acres could more profitably be used to institute this secondary or this pressure maintenance and secondary recovery program with a resulting recovery in excess of that which could be achieved by any multiple program which has been offered.

For that reason Phillips endorses the application and urges the approval by the Commission. I am also authorized to state that El Paso Natural Gas Products supports the application and urges a temporary 80 acre spacing and drilling unit program for the Eisti-Lower Gallup Pool. I am likewise authorized on behalf of Benson-Montin and Greer to state that they likewise support the program. They have an interest in this field as does El Paso Natural Gas Products Company, and urge the approval of the temporary 80 acre spacing order.

MR. SELINGER: If the Commission please, Skelly Oil Company concurs in the application for a temporary 80 acre spacing order for one year. We will file a detailed written statement later.

MR. BUSHNELL: Bushnell for Amerada. I would like the record to show that Amerada is in support of this application subject to the single qualification that Amerada would be agreeable to and would favor an order which provided for uniform spacing.

MR. JUSTICE: My name is P. S. Justice. I am Manager of the Rocky Mountain Division for the Sun Oil Company, Denver, Colorado, with jurisdiction over and responsibility for Sun's

operations in the area of the Bisti-Lower Gallup Oil Pool. I would like your permission to make a statement on behalf of Sun. I would like to make this and have it understood it is a comparatively brief and non-technical statement. Since this is the first time I have had the privilege and opportunity of attending a hearing before the New Mexico Oil and Gas Commission, I wish to express my personal and official appreciation of the impartial, patient, and efficient manner in which this hearing has been conducted by the Commission and its Staff. If at first blush this appears to be apple polishing, I can assure you that you can consider yourself unanimously polished by this attendance here.

Sun Oil Company concurs fully in the application of Sunray Mid-Continent Oil Company for an order extending the horizontal limits of the Bisti-Lower Gallup Oil Pool in San Juan County, New Mexico and temporarily establishing uniform 80 acre spacing in accordance with the details of said application.

Furthermore, in Sun's considered opinion, the evidence so lucidly, ably and intelligently presented by Sunray Mid-Continent Oil Company as applicants in this case unmistakably demonstrates the desirability, urgency and practical necessity for prompt establishment of such temporary 80 acre spacing. We believe that this is necessary in order to prevent waste, that it will aid in promoting the ultimate efficient maximum economic recovery of oil from said pool with due regard for the legal, moral, and just or relative

rights of all interested parties.

Finally, we wish respectively to state to the Commission and to the parties opposing this application, that in our opinion the adoption or the establishment of such a temporary 80 acre spacing order would not necessarily be permanently harmful to the premises or position of the opposition even if the same later should be proven to be correct or advisable. On the other hand, if lesser well spacing regulations remain in force and development on 40 acres is permitted, no later action or order could effectively prevent the waste or other inequities that have clearly been shown to result therefrom. Thank you.

MR. PORTER: Thank you, Mr. Justice. Any more statements?

MR. EHRENS: Sinclair Oil and Gas Company entered an appearance in the matter after the first day, and they have authorized me to state in their behalf that they strongly support Sunray's application for 80 acre spacing, that they equally strongly oppose 40 acre spacing, and they support our application with the exception that they would favor a permanent order and that their second choice would be a temporary order, and that they will file a written statement subsequent to this hearing.

MR. PORTER: Mr. Sullivan, did you have a statement?

MR. SULLIVAN: I think it behooves me to say one additional word in view of Mr. Cooley's question to Mr. Campbell with regard to the well locations and the way the 80 acre spacing units

would lie. I don't think the position of British American Company should be based on Mr. Stein's position, because in discussing it with him, I don't believe you were on common ground in this discussion with Mr. Utz.

Let me say we are in agreement with the position that Mr. Campbell takes, we feel there should be one authorized well to the 80 acre unit, and the Commission should establish the direction in which the units should lie, and that they should be uniform. Is that essentially correct, Mr. Campbell?

MR. CAMPBELL: The only thing I discussed with Mr. Cooley, that we did question, that if an order is entered that it provide that not more than one well be drilled upon any 80 acre unit. The present application as it stands, permits flexibility in the location of the well on the unit. And there has been some testimony or indication here that some people feel it should be a fixed pattern rather than a flexible one, but our application is for a flexible pattern.

MR. SULLIVAN: So it is within 330 feet of any place within the acre boundary?

MR. CAMPBELL: I believe that is 3330 feet from the boundary track which is a part of the 80 acre unit.

MR. COOLEY: Which could put it 330 feet anywhere around.

MR. SULLIVAN: I would go one step further and say we would like to see the present spacing pattern as it exists in the

British American portion of the field maintained.

MR. CAMPBELL: We have no objection to a fixed pattern spacing insofar as it is feasible under the present circumstances.

MR. SETH: Do you modify your application to that extent?

MR. CAMPBELL: We'll let the application stay like it is.

MR. SETH: The same thing that troubled Mr. Cooley has troubled me. Ever since the application first came to us, it's an application for prorationing units in an area where there is no prorationing. It is not really a spacing case when you get right down to it. Under the terms of the application it will be perfectly proper for anybody to drill any number of wells within the 80 acre tracts if they wish to do so. I think the application and publication and so would permit. This is not an application for spacing, it is an application for proration units.

MR.CAMPBELL: I disagree. I think it is broad enough that the Commission could deem it advisable to limit the drilling in this area of one well per 80 acres.

MR. SETH: We have treated this and tried this as a spacing case. We are prepared to go along with any spacing rule that the Commission has. I don't think the application is for spacing at all.

MR. PORTER: Anyone else have a statement? Mr. Cooley, do you have some letters?

MR. COOLEY: Yes. From Honolulu Oil Corporation:

"Honolulu Oil Corporation owns and operates one well in this field in the area included in the notice of hearing. This well is our State of New Mexico "D", Well No. 1, located 660 feet from the North and West lines of Section 36, T 26N, R 13W, NMPM.

Because of our minor percentage of production and reserves in this field, we do not plan to be represented at the hearing. However, it is our belief that the proposed temporary 80-acre well spacing is proper for this field at this time.

Honolulu Oil Corporation respectfully requests that the Commission adopt the special rules and regulations for the Bisti-Lower Gallup Oil Pool as proposed by Sunray Mid-Continent Oil Company."

From The El Dorado Refining Company: "Notice has been received in the matter of Sunray Mid-Continent Oil Company's application for the purpose of establishing spacing and special rules for the Bisti lower Gallup oil pool, San Juan County, New Mexico. It is our understanding that this matter has been scheduled for Wednesday, September 18, 1957, in Santa Fe, New Mexico.

This is to advise that as an operator in this area The El Dorado Refining Company supports Sunray Mid-Continent Oil Company in their request for 80 acre proration units and well spacing plus special rules and regulations for the subject pool."

From Anderson-Prichard Oil Corporation: "Anderson-Prichard Oil Corporation recommends that the Commission approve the

application of Sunray Mid-Continent Oil Company for an order which will (1) extend the horizontal limits of the Bisti Lower Gallup Oil Pool, (2) temporarily establish uniform 80-acre spacing for oil wells, and (3) require semiannual gas-oil ratio and bottom hole pressure tests.

Anderson-Prichard Oil Corporation further recommends that the Commission include in the field rules a volumetric withdrawal formula for computing allowables for gas wells which are completed in the gas cap portion of the Lower Gallup oil reservoir. The equities of all parties can best be preserved by permitting the operators of such wells to attribute up to 320 acres to each well for allowable purposes provided that said acreage is proven productive of gas."

From Shiprock Industries, Inc.: "It is our understanding that you are having a meeting on 9-18-57 to consider oil well spacing in the San Juan Basin, New Mexico.

We are the holders of thousands of acres, both proved and unproved, in this area and it is our studied opinion, after advice from our geologists, that it is quite improbable that more than forty acres of oil land can be drained by a well thereon. We therefore violently oppose changing of the laws of the State of New Mexico to allow for spacing greater than forty acres per oil well."

From Laurence C. Kelly Trust: "I have been notified that a meeting of your Commission will be held in Mabry Hall on September 18th, at 9 A.M. to consider among other things Case #1366,

the application of Sunray Mid-Continent Oil Company for an order extending the horizontal limits of the Bisti-Lower Gallup Oil Pool in San Juan County, New Mexico, and temporarily establishing uniform 80-acre well spacing and promulgating special rules and regulations for said pool.

The Laurence C. Kelly Trust, of which I am Trustee, holds State of New Mexico Oil and Gas Leases Nos. E-6597, E-6644, and E-7698, aggregating a total of 4,116.59 acres. All of this acreage is in Township 25 North, Ranges 12 and 13 West, and covers all of the State owned acreage in this Township and Ranges, with the exception of 1,000 acres.

You will remember no doubt that the discovery well of the Bisti Pool was on Section 16, Township 25 North, Range 12 West, which is part of our State Lease.

As Trustee for the above Trust, I would like to make formal protest against changing from the present established 40-acre spacing to 80-acre spacing, as requested by Sunray Mid-Continent Oil Company, for the following reasons:

1. The Oil Conservation Commission of the State of New Mexico has never before found it necessary to change the spacing from 40 to 80 acres as it has no doubt found 40-acre spacing satisfactory from every angle.

2. It is the considered opinion among a great many well qualified geologists that one well cannot possibly drain in excess of 40 acres, because of the nature of the Gallup Sandstone which has been established as a very tight formation with low porosity and permeability.

3. The only sound reason in the opinion of the writer that have been advanced to date, namely, lack of market for the oil, will be completely eliminated before the end of the year when the Four Corners Oil Pipeline to California will be in operation and the Refinery of the El Paso Natural Gas Products Company will be on stream.

4. It would appear to be short-sighted policy to restrict the production of oil from the Bisti Pool at a time when there is a very strong demand for it and the Refineries of California are clamoring for it. This condition might not prevail for too long and should be taken advantage of while it does.

5. A change in the established 40-acre spacing could be very detrimental to the revenue obtained from oil by the State, which undoubtedly, like nearly every other State, needs more and more revenue every year for school purposes. It is more than likely to bring about requests for wider spacing than the present 40 acres.

In view of the above facts I cannot urge you too strongly to allow the present established spacing of 40 acres to remain in effect."

MR. PORTER: Let the record show that these letters are entered in evidence.

MR. ERREBO: I have a copy of a letter from Honolulu. Did you read that?

MR. COOLEY: Yes, supporting.

MR. CAMPBELL: Are you going to make a statement, Mr. Seth?

MR. SETH: Mr. Carroll will make the summation. You go ahead, you are the applicant.

MR. CAMPBELL: Normally they close. I don't want to be contentious about it.

MR. CARROLL: I appreciate this has been a long hearing. I do not want to labor the evidence, but I would like to summarize

the principal issues that have been brought out in this case. In particular to review very generally the nature of the spacing order that has been requested, the economic consideration involved, the relationship of the spacing to secondary recovery, and the effect of the spacing on correlative rights. Insofar as the nature of this spacing order itself is concerned, as I am sure the Commission is well aware, this represents what is an unprecedented request for 80 acre fieldwide spacing at 500 foot depth. Previous spacing orders have been eight to nine thousand feet or greater depth.

The Commission would have every reason to believe and expect that where applicants come forth requesting exceptions from statewide rules which have been established and followed, they would present evidence of some unusual circumstances or conditions existent in this reservoir which would justify a variation from the rules. However, the applicants have utterly failed to do this, and as a matter of fact, as I think their evidence has shown, they have testified that the conditions in this reservoir do not vary materially in any other respect from other reservoirs in the state.

The next point I would like to present, the correspondence in connection with the application itself, is in regard to the so-called density pattern. It is obvious from examination of the petition itself as well as from a review of the testimony, they avoided the use of the word spacing pattern. This is easy to understand

because this so-called strategy of arbitrarily dedicating acreage to a well to achieve an 80 acre unit is contrary to the practices of the Commission and contrary to the ordinary spacing pattern.

Furthermore as has been emphasized by some of the early discussion, what has been requested is a floating pattern with diagonal 80 east-south or north. It is to produce an indefinite spacing pattern rather than a fixed orderly pattern which is normally fixed by the Commission. Other considerations in connection with the order, and one in which the applicant has placed great emphasis, that a temporary order cannot possibly hurt anyone or do damage to present development in the field. We firmly believe this is not true. If, in fact, an 80 acre order is given and 80 acre wells are actually drilled, although we are firmly convinced they will not by any means effectively or adequately drain an 80 acre area, they may yet take enough oil out of the area so that later on it will be uneconomical to drill the area on 40 acre basis.

Furthermore, we have demonstrated if you drill on 80 and try to drill on 40 again, you will have waste and dissipation of reservoir energy. Next, having briefly considered the petition, I would like to go into economic conditions involved. In this connection I think it quite significant that if you take the figures with regard to potential reserves, figures that have been established in the prior LPG hearing by the applicant, figures that have been established by

virtue of correspondence which the applicant wrote to various operators trying to interest them in LPG operation, and finally evidence of reserves as presented by their testimony in this case, I think it can be firmly established that drilling on a 40 acre basis is economically practical and feasible.

Furthermore, there are other considerations in this case that I feel that perhaps hasn't been too adequately emphasized, I think for obvious reasons, that is namely in addition to the interest of the State of New Mexico in the lands affected by the petition, which are substantial, there are also some very substantial interests of the United States of America of various Indian wards. In my opinion these interests should have the effect of the maximum development that can be obtained and are entitled to, and I think they should not be penalized in terms of development of the reservoir by the higher drilling cost of some of the operators.

Then the next factor I would like to consider is the emphasis that has been placed on secondary recovery operations. Now, it is true and has been emphasized by a lot of testimony, that Shell did participate in Sunray's LPG project, it is Shell's project to participate in any experimental secondary recovery project. I might add that we are hopeful of its success. However, it is necessary to view this project realistically in terms of what it actually is, namely an experimental project for the injection of LPG as has been admitted by the testimony of the applicants.

They have just now completed injecting the gas into their pipeline.

Therefore, it would seem somewhat premature at this time during the early phases of primary recovery, to regard a project of this nature as a substantial factor in establishing fieldwide spacing in a 47,000 acre area.

Furthermore, insofar as this secondary recovery through the use of LPG is concerned, we consider it quite significant that they did not use an 80 acre pattern as they suggested would have to be followed, but they used instead what was in essence a 20 acre pattern consisting of four 40 acre locations with the injection well in the center.

Now, if the applicant contends that it seriously believes that some jeopardy might be done to future secondary recovery operations by having wells drilled on a 40 acre basis, as a matter of fact, they said anything less than 80 acre basis, and if they have conceded this is a continuous reservoir and if this LPG is in what they regard as in a better paying location, it is difficult for me to understand why they would jeopardize this project themselves starting on a 20 acre basis.

I think Shell's testimony has established with regard to secondary recovery operations, that the ultimate pattern will have to be, at least will be, on a nature of 40 acre rather than 80 acre pattern.

Finally, I would like to point out that insofar as the doctrine

of correlative rights is concerned, it has been quite convincingly illustrated by the exhibits and by the testimony of the Gulf Oil Corporation that many inequities may develop by virtue of the use of the floating spacing pattern proposed by the applicants, particularly where wells are drilled along lease boundary lines. Such inequities violate the principal of correlative rights as set forth in the New Mexico Statutory provision and this Commission's regulation. Thank you.

MR. KELLOUGH: May I very briefly summarize. In a case of this kind there are three basic issues. First your reservoir performance, that is your reservoir characteristics and performance, second the economics and third the correlative rights. Now, referring only to the high points of these three issues, if you are looking at, considering as this Commission must do, the question of the reservoir characteristics and performance, I'm sure we will all agree that this oil pool is not one big solid porous mass that ties this room in four miles wide and four miles wide, or square. You remember the longitudinal exhibit that ran clear across the room, looks like 66, the applicants themselves did not rely on that interpretation as to what is productive. When they figure reserves they go over to the exhibit based on the microlog which showed numerous variations, and showed a much smaller area. There has been in this case, I think, two clinchers.

You have heard two entirely diametrically opposed

theories.

The applicants on one hand have stated in their opinion that there is continuous porosity and continuous permeability throughout. On the other hand the witnesses for the Shell have presented to you their opinion that this pool consists of lenses of permeability overlapping and massing throughout this pool. The clinchers that would appear to tip the scale, the balance in the scale, is number one, the evidence that you have gas lower than oil, oil higher than gas in this reservoir. Now, no real explanation has ever been given for that, no satisfactory explanation, the only inference I submit that can be inferred is that because of the lenticularity of the nature of this pool, you must have local traps that will cause that condition. It would seem that it would be impossible if you had a continuous permeability, continuous porosity, this pool has been layed down over millions of years, that you would have gas below the oil.

Second, unescapable point, is that you have in this pool in certain parts of it undersaturated oil. In other words, the oil in that part of the pool has less gas than it could absorb, and on the other part of the same reservoir you have either a gas cap or certainly you have a very high gas-oil ratio well. So if there is a great continuity and continuation of porosity and permeability, then it would seem most unlikely that in part of the reservoir you would have the oil which had not absorbed the gas.

Now then, as to the question of economics, you have first the testimony of the applicants in their pilot area several months ago where it was unquestionably economical to drill a well on 40, and you have the evidence of Gulf in its own wells, and you have heard the testimony of Shell and as to applicant's testimony, you'll recall that the engineer testified in basing his calculations on recovery where he concluded that a well would not be off on 40 acres, he did not give any average porosity, but he took certain areas of this field aggregating about half of the total area to be included. He used only a small portion of acreage in the pool and upon that basis calculated reserves which were way under those which had been calculated by his associates in the former hearing.

And furthermore, when you consider testimony of the geologist for the applicants, where he stated the upper sand averaged 15 feet and the lower sands from 4 to 6, making an average pay thickness of about 20 feet, if you compute that on the same figures that were used by the applicant's other witness, then according to that computation a well would be profitable on 40 acres.

Issue No. 3, is the question of correlative rights, and though we submit that this floating well spacing pattern will undoubtedly result in a cluster of wells through the streak of the field, they have testified that the heart of the pull is down the middle. The opportunity to cluster the wells anywhere you want, you are bound to have clustering of the wells on the center of the field,

and you wouldn't have 80 acre spacing in anybody's book. It is no answer to say this will be temporary for only one year. It's no answer to say that you are only going to be hurting for a little while. It's the duty of the Commission to protect the correlative rights of the parties now and not let them suffer for a temporary period however short or however long it may be.

Now then, if you pass on that consideration to the proposal that this should be temporary because you don't have enough information to know the performance of the pool, it all ought to be built on 80 acres. I submit how that argument goes to a challenge on the statewide rules. If that is true, you should have 80 acres for statewide rules in any pool. If you don't get enough information, I don't know how to space the pool. If the argument is valid, the lack of information to justify 80 acre spacing, that is a challenge to the statewide rules and not any specific valid argument in this particular case. For these reasons we ask that the application be denied.

MR. PORTER: Mr. Campbell.

MR. CAMPBELL: If the Commission please, I would be less than honest if I didn't admit that some of the statements just made on behalf of Shell Oil Corporation and Gulf Oil Corporation give me a slight lift, even at this hour of the evening after some of the spacing cases that I have been in in which they have been participants. I quite agree with the gentleman with Shell that in order

for the Commission to justify even a temporary 80 acre spacing order in a reservoir at 5,000 feet depth, it must be an unusual reservoir. It is my opinion that perhaps the only time such an order is justified is when you have either a very poor or a very good reservoir. So far as I am concerned, from the testimony of the witnesses of Shell themselves, this has been established at best as a poor reservoir, and it seems to me that what little information is available at this time clearly indicates that the reservoir condition due to rapid pressure declines below the bubble point, and this is also from Shell's own witnesses, indicates that there are conditions in this reservoir which require careful study.

That was recognized by practically all the operators in this pool when they participated in the installation of a pilot pressure maintenance program at a stage of development in this field where it had only been one percent depleted; to me that is a very unusual situation. At least in the spacing cases with which I am acquainted, such a condition has never been present. It seems to me that the crux of this thing boils down to whether there is sufficient basis for the arguments by the protestants to justify to the Commission the risk that obviously exists so far as our people are concerned, and I think they are just as honest in their opinions as the witnesses for the protestants so long as there is a risk, that to develop this field at this stage on a narrow spacing program might adversely affect the ultimate recovery of the oil.

It seems to me that is the basic question of conservation a part of all these controversies about how much it cost this company or that company to drill a well or how quick they get their money back. It seems to me the responsibility of the Commission would be if they feel there is some risk involved, to see that that risk is not taken unless there is a serious disadvantage to somebody if the risk must be taken. The only disadvantage that has been testified to here that I have heard, and I have tried to get it from a number of witnesses, is that they have assumed and made arrangements on the basis that they were going to drill on 40 acre spacing. I don't think that the inconvenience or even loss of revenue to an individual operator in the field justifies the risk which we believe exists that you may not get the greatest ultimate recovery from this reservoir, to me that is the crux of the matter, and I don't think any of the evidence that has been introduced here today or yesterday even can get around that basic proposition.

If the Commission should permit the drilling of these additional wells, and if it should result in the pressure maintenance program not having the effectiveness that it would under the other basis, it not only would risk a tremendous amount of capital which could be used to find oil fields somewhere else in the San Juan Basin, but it would run the risk of loss of oil, a natural resource which this Commission has the obligation to protect.

MR. PORTER: Does anyone also have anything in this case?

The Commission will take the case under advisement.

# C E R T I F I C A T E

STATE OF NEW MEXICO )
: SS
COUNTY OF BERNALILLO )

I, ADA DEARNLEY, Court Reporter, do hereby certify that the foregoing and attached transcript of proceedings before the New Mexico Oil Conservation Commission at Santa Fe, New Mexico, is a true and correct record to the best of my knowledge, skill and ability.

IN WITNESS WHEREOF I have affixed my hand and notarial seal this 25th day of October, 1957.

Ada Dearnley
Notary Public-Court Reporter

My commission expires:

June 19, 1959.