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BEFORE THE
OIL CONSERVATION COMMISSION
Santa Fe, New Mexico
July 24, 1963

EXAMINER HEARING

IN THE MATTER OF:
(Continued from July 10, 1963 examiner hearing) Application of Shell Oil Company for a unit agreement, Lea County, New Mexico. Applicant, in the above-styled cause, seeks approval of the East Pearl-Queen Unit Area comprising 2440 acres of State and Fee lands in Township 19 South, Range 35 East, Lea County, New Mexico. CASE 2850

IN THE MATTER OF:
(Continued from July 10, 1963 examiner hearing and readvertised) Application of Shell Oil Company for a waterflood project, Lea County, New Mexico. Applicant, in the above-styled cause, seeks authority to institute a waterflood project on its East Pearl Queen Unit by the injection of water into the Queen formation through 31 wells in Sections 15, 21, 22, 26, 27, 28, 34, and 35, Township 19 South, Range 35 East, Lea County, New Mexico. CASE 2851

BEFORE: Daniel S. Nutter, Examiner

TRANSCRIPT OF HEARING

MR. NUTTER: We will call Case 2850.

MR. DURRETT: Application of Shell Oil Company for a unit agreement, Lea County, New Mexico.

MR. MORRIS: Off the record.

(Whereupon, a discussion off the record was held.)

MR. NUTTER: Is there objection to consolidation of Cases 2851 and 2852? The cases will be consolidated and continued

for an hour and a half.

* * * * * * * * *

AFTERNOON SESSION

MR. NUTTER: The hearing will come to order, please. We'll now call Cases 2850 and 2851, which have been consolidated for hearing.

(Whereupon, Applicant's Exhibits Nos. 1 through 6-EE marked for identification.)

MR. MORRIS: Mr. Examiner, I am Richard Morris of Seth, Montgomery, Federici and Andrews, Santa Fe, appearing on behalf of the applicant, Shell Oil Company, in these two cases. We will have one witness, Mr. George Carnahan, and I ask that he be sworn at this time.

(Witness sworn.)

GEORGE G. CARNAHAN

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

DIRECT EXAMINATION

BY MR. MORRIS:

Q Please state your name and position.

A George G. Carnahan, Senior Reservoir Engineer, Shell Oil Company, Roswell, New Mexico.

Q Have you previously testified before the New Mexico Oil Conservation Commission or one of its examiners?

A No, I haven't.

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Q Then would you briefly outline your education and professional experience in the oil business?

A I have a Bachelor's and Master's Degree in Petroleum Engineering from the University of Oklahoma; had five and a half years experience as production engineer and in reservoir engineering in West Texas and New Mexico.

Q Are you familiar with Shell's application in Cases 2850 and 2851?

A Yes, I am.

Q Did you do most of the reservoir engineering work in connection with the waterflood project that is the subject of this hearing?

A Yes, I did.

MR. MORRIS: Mr. Examiner, are the witness' qualifications acceptable?

MR. NUTTER: Yes, sir, they are.

Q (By Mr. Morris) Referring to what has been marked as Exhibit No. 1 in this case, Mr. Carnahan, would you point out the pertinent data on that exhibit?

A Exhibit No. 1 is a plat which outlines the proposed East Pearl Queen Unit, which comprises 2440 acres of State and Fee lands, Township 19 South, Range 35 East, Lea County, New Mexico. Injection wells are color coded red and green, and they will be subject to later testimony. All wells within a two mile radius of the proposed injection wells are located and identified as to

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producing formation. Also indicated are lessees within a two mile radius.

Q We will come back to Exhibit 1 a little bit later, Mr. Carnahan, but would you refer to what has been marked as Exhibit No. 2, the unit agreement for the East Pearl Queen Pool? Referring to that agreement, what are the unitized formations covered by that unit agreement?

A As defined by the unit agreement, Section 1, subparagraph 2, page 2, the united formation is that certain stratigraphical interval underlying the unit area, extending from the top of the Queen formation to a depth of 50 feet below the base of Zone 4 of the Queen formation.

I would like to define a little more clearly exactly the meaning of Zone 4 as mentioned. Shell has divided the productive Queen sand interval underlying the unit area into four main zones, and two subzones, which have been designated Zones 1, 2 A and B, 3 A, B, and 4, the lowestmost zone being Zone 4. The correlation of these zones will be discussed later.

MR. NUTTER: Are all of those zones in the Queen?

A They're all in the Queen.

MR. NUTTER: So in effect you have all of these zones defined as unitized zones from the top of the Queen below the base of Zone 4; the base of Zone 4 would include all of them?

A Would include all the Queen sand zones.

Q (By Mr. Morris) This classification of zones is Shell's

classification; that may or may not be recognized by other operators in the area?

A That is exactly right.

Q Does the unit agreement recognize and provide for the waterflood project to be conducted in the unit area?

A Yes, it does provide for the waterflood to be operated within the unit area, and the participation in this project is based on a split formula; phase one being the expected remaining primary production; phase two being the anticipated secondary production.

Q Does the agreement contain the standard provisions with respect to subsequent joinder that are found in other unit agreements?

A Yes, it does provide for subsequent joinder to the unit.

Q Does the agreement contain provisions making the operation of the unit and then, of course, necessarily, the waterflood project subject to regulation by the Oil Conservation Commission?

A Yes, Section 15, subparagraph 1, page 14, so provides.

Q Who are the working interest owners within this unit area?

A Shell currently owns a 100 percent working interest and approximately 82 percent or 2,000 acres. The remaining acreage, being 440 acres, is operated currently by Gulf Oil Corporation, Mid Texas Gas and Oil Corporation, Collier Drilling Company, J. D. Sanford, E. G. Colton, and the Cabot Corporation. Shell Oil

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Company is designated the unit operator in the unit operating agreement.

Q Of these working interest owners that you have mentioned, how many have committed their acreage to the unit agreement?

A To date, acreage-wise, 93 percent have committed to the unit. To break this down, of the State lands involved, 89 percent of the working interest in State lands have committed to the unit, and 97 percent of the working interest in Fee lands have committed to the unit. Tract-wise, there being 29 tracts, 90 percent of the working intereat in 90 percent of the tracts have committed. The breakdown of this, 86 percent of the State land tracts have committed to the unit and 93 percent of the Fee land tracts have committed to the unit.

Q What part of the total acreage is State-owned?

A 46 percent, or 1120 acres, are State lands.

Q Has this unit agreement been submitted to the State Land Office?

A Yes, it has, and tentative approval has been given.

Q Now, 46 percent of the acreage is State acreage, that would make 54 percent of the acreage Fee acreage, right?

A That is correct.

Q What is the status of the approval of this unit agreement by the royalty interests and overriding royalty interests in the Fee acreage?

A There are two of the 14 State tracts have overriding royalty interest against them. All of these interests have either signed or have indicated that they will sign as to these two tracts.

Q I believe the only thing we have left out on that point is the status of the overriding royalty interest on the State acreage. Have we covered that?

A Yes. I said there were two of them.

Q Going back to Exhibit No. 1 for a moment, would you give the basis for the unit outline as it is shown on that exhibit?

A Yes. Shell initiated an action by calling together all Pearl Queen Field operators in June, 1962 to discuss the feasibility of secondary recovery operations for the Field. As a result of this meeting, the Field was tentatively divided into four areas of study, the first area, the east area, being primarily in Sections 21, 22, 27, 28, and 34, Township 19 South, 35 East; the west area being Sections 28, 29, 30, 31, 32, and 33 in Township 19 South, 35 East; the south area being Sections 3, 4, 9, and 10, Township 20 South, Range 35 East; and the fourth area, the northeast area, being Sections 23 and 24, Township 19 South, Range 35 East.

The reason for the division of the field was that since both Shell and Gulf desire to continue operations in the field, the acreage comprising the east and west areas were divided along operational lines. The south area, which comprised acreage at

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that time and currently under step-out development, with most wells being top allowable. The northeast area was also under development, with production being from two lower sand zones, approximately 100 feet below the base of Zone 4, which have not been found to be productive in the other areas of the field.

As a result of this meeting, Shell prepared a study of the east area, now designated the East Unit, recommending the immediate initiation of waterflood operations. The East Unit, as outlined in the Exhibit 1, takes in all wells in the East Half of the field, including the northeast area, which produce from the proposed unitized interval. I might add one thing; I think that I covered it here, but I would like to bring it out, that in the subdivision in these various areas, one of the primary reasons for so doing, in addition to what I discussed, was that the east and west areas were in the later stages of depletion and were rapidly approaching stripper production.

Both the south area and the northeast area, like I mentioned, were currently being developed, and a majority of the wells were top allowable; and it was felt that in order to successfully unitize this area and be able to proceed rapidly with a waterflood project, that it would be necessary to include these areas so that we might proceed on to waterflood the area which was seriously depleted.

Q Do you have a cross section showing what you have previously referred to as the unitized interval, being these Zones

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1, 2, 3, and 4 of the Queen, and also showing the relationship of those zones to one another?

A Yes, Exhibit No. 3, which is entitled East Pearl Queen Unit Waterflood Study. I would like to refer to figure 13 towards the back part of the book, about a third of the way through, which is entitled Index to Cross Sections, East Pearl Queen Unit. I would in particular like to refer to Cross Section C-C', which you will notice there is a north-south cross section; then refer on to figure 16 which is C-C' cross section.

MR. MORRIS: I might state, Mr. Examiner, we are going to be referring to various figures in this exhibit from time to time, and will be presenting the whole thing as an exhibit insofar as it's pertinent to Mr. Carnahan's testimony.

Q (By Mr. Morris) Go ahead.

A This figure No. 16, Cross Section C-C' shows the correlation of the top of the Queen through the four main zones and the two sub-zones that I previously mentioned. Also shown on the cross section is Zone 5, which is not to be included, or is not included in the unitized formation. This Zone 5 is one of the two lower productive sand intervals which is productive in the northeast portion of the field. These zones, Zones 1 through 4, can be correlated throughout the field; however, in some areas the sand development is not of reservoir quality.

To specifically outline the unitized formation, as previously mentioned, the top of the Queen is the top interva'

and 50 feet below the base of Zone 4 is the base of the unitized interval.

Q This cross section also contains the well that is the key well mentioned in the unit agreement, from which these zones should be picked, is that correct?

A Yes. The Trainer Rushing No. 1, which is the third well from the right, is referred to in subsection 1, paragraph 2, as being the reference well for outlining the unitized formation.

Q Could you give a little more detailed information on the characteristics of Zones 1, 2, 3, and 4, by reference to other figures within this Exhibit 3?

A Yes. Briefly, before I refer to the exhibit, I would like to describe lithologically the character of these sands. In addition to being zoned, more or less, the character of the sands are very similar to each other and I will give a brief description which should cover them all.

Lithologically, the sand zones are fine-grained gray dolomitic and anhydritic sandstones interbedded with tan anhydritic dolomite anhydrite. The reservoir characteristics, average-wise, for the four zones and two sub-zones: average permeability, 12 millidarcies; average porosity, 15.1 percent; connate water saturation, 35 percent.

These sand zones produce primarily under solution gas drive, no indication of any other drive mechanism. Referring to Exhibit 3 again and in other figures 2, 3, 4, and 5, these are

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structural maps contoured on the top of Zones 1, 2-A, 3-A, and 4. Water levels are present in all zones; however, only the water level in Zone 1 shown on figure 2 and in Zone 4, which would be figure 5, are shown as they occur within the unit area. The accumulation is controlled downstructure by these water levels and upstructure by porosity deterioration where the sands are cemented and the porosity is below reservoir quality.

Figures 6, 7, 8, 9, 10, 11, are quality isopacous maps on each of the four main sand zones and sub-zones. These maps were contoured on a factor of porosity as a percent times the net feet of pay present in each well in that particular zone. These figures were arrived at from an analysis of the available logs and core analysis data in the area. It can be seen from looking at these maps and referring back to the structural position of these various zones that as you go upstructure, which would be to the northeast, these sand zones tend to deteriorate where there is no pay present in those zones. Also, the downstructure quality of these sand zones is limited in the case of Zones 1 and 4 by the water level which is present in the unit area.

Q Mr. Carnahan, these structural maps and isopacous maps were originally prepared by you in looking at this portion of the pool with a view toward waterflooding, is that correct?

A That is right.

Q Based on your study, what are your proposals for waterflooding in this area?

A Referring back to Exhibit 1, which is an outline of the unit area, and referring in particular to the color coded injection wells, we have established or plan to establish an 80-acre five-spot pattern flood. This pattern has been determined to be the most efficient pattern, considering the zone characteristic of this reservoir. A total of 13 injection wells and 28 producers are included in this project.

As seen, the injection wells are color coded, as I mentioned, red and green; the green indicating single injection wells, the red being dual injection wells. To more fully explain this, I would like to refer now to Exhibits 4-A and B, which are diagrammatic sketches of typical single and dual injection wells respectively. Copies of these exhibits have been given to the State Engineer.

Referring in particular to Exhibit 4-A, diagrammatic sketch of single injection well, briefly I will discuss what we plan to do here. We plan to inject down plastic-coated tubing with a packer set above the prospective injection zones, the casing tubing annulus filled with fresh water inhibited, casing is cemented to the surface and to protect any fresh water zones that may occur above the top of the red beds behind the casing is also cemented above all the perforations.

Exhibit No. 4-B is a diagrammatic sketch of a dual injection well. In this we plan to utilize two strings of plastic-

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coated tubing, a dual packer set above Zone 1 and a single packer set between Zone 1 and the lower zones, being 2, 3, and 4, whichever of those may be open. The casing is again filled with inhibited water. The casing is set such that the cement is up behind the pipe above the uppermost perforation. The casing is cemented to the surface to protect the fresh water below the red beds.

To describe actually why we plan to use this dual injection system, this was set up mainly to flood Zone 1, which is volumetrically the single largest zone, comprising 38 percent of the productive reservoir volume in the East Unit. By so selectively injecting into this zone and separating it from injection into the lower three zones and sub-zones, we feel like that we can control the flood advance and ultimately recover more oil by way of the waterflood.

Exhibits 5-A and B are casing and cement details and injection tubing, packer, and perforations, respectively, on the proposed injection wells. Copies of these exhibits have also been given to the State Engineer.

Q I might interrupt you there, Mr. Carnahan.

MR. MORRIS: While we have given copies of Exhibits 4-A and B and 5-A and B to the State Engineer, I think it's only fair to say we only give 5-B to you this morning, but the other exhibits were furnished some time ago, is that right, Mr. Irby?

MR. IRBY: That's correct.

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Q (By Mr. Morris) Excuse me, go ahead.

A Exhibit 5-A is a casing and cement detail on the 31 injection wells. Listed for both the surface and production casing is the casing size, the depth at which it is set, the amount of cement used in cementing the pipe, and the top of the cement.

Exhibit 5-B, which is a detail on the injection tubing, packers, and perforation for the 31 injection wells. Listed on this exhibit is, first, the type of injection well, referring back to the single or dual type which we have previously mentioned; and also a breakdown in the case where we have for the upper and lower injection intervals where they may be present. Here we have indicated the gross perforated interval, the size and the depth of the tubing, the type and the depth at which the packers are set for both the upper and the lower injection intervals.

For the dual, where we are using a dual injection system, we are using a retrievable dual packer with hydraulic hold-down similar to the Baker Model "K". For the single, where we're only using one packer for one string of tubing, we are using a hydraulic hold-down in a packer similar to the Baker Model "R".

To proceed on, Exhibits 6-A through EE are logs on all of the 31 injection wells, and actually there's nothing much to explain on these. They are logs which show the interval at which we are contemplating our waterflood project on the injection wells.

Q Those logs have been submitted to the Commission and are part of the Commission's files?

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A That is correct.

Q Still referring to Exhibit 3, Mr. Carnahan, is there some information in here showing the production history of the wells in the proposed unit and waterflood area?

A Yes. Referring, like you said, to Exhibit 3, figure 20 -- excuse me -- this figure which is found on Exhibit 3, I might add, is the oil production history with predicted continued primary and waterflood performance for the East Pearl Queen Unit. We have indicated here the production from the start in January, 1957, plotted through July, 1962.

At that time that was the amount of production we had in the time the report was written. From there, based on the analysis of the performance of the wells, we have extrapolated or predicted the continued primary production which, if allowed to continue without any secondary recovery or waterflood operation, should be complete by the early part of 1968. This is indicated by the dark hashered lines, being the continued or predicted continued primary. The small hashered lines were a start of injection indicated at approximately the first of 1964; indicated, like I say, by the small light hashered lines is the predicted waterflood performance by utilizing the pattern which we have previously discussed.

Q Now this information shown on this figure 20 was prepared as part of this report which was dated last November. Is the information, though, that is shown on figure 20 -- has that

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proved to be correct and by the more recent production history of the wells in this unit?

A Yes. The monthly production rates from August, 1962, through May, 1963, have fallen very closely on the predicted continued primary performance curve. Actual May production from the unit area, there was 16,684 barrels, while predicted production for this month was 17,200 barrels. Cumulative production through May, 1963, has been 1,715,903 barrels. The average per well daily production for May, 1963, was 10.8 barrels. During May there were 50 wells producing, two wells shut-in, four wells temporarily abandoned, giving a total of 56 wells that have or are currently producing from the unit area.

I might add that four of these 50 wells are now top allowable. The per well daily production, as I mentioned, during May, 1963, at 10.8 barrels, was based strictly on the wells that actually produced oil during the month. So during May, using 50 wells, based on an extrapolation of the last nine months of the average per well daily production, the current average rate is below 10 barrels per day which I feel should classify the project as stripper.

Q Could you amplify a little bit, Mr. Carnahan, on what your plan of operation would be, assuming that the waterflood project as you propose it is approved by the Commission?

A Yes. We plan to start construction of waterflood installations immediately. We hope that injection can be commenced,

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at least on a limited basis, during the later part of this year.

Q Would you plan to put all of the wells within the project area, all of the injection wells on injection at this time?

A This kind of boils down to the fact that currently Gulf Oil Corporation is studying the west area which we'll probably assume will be designated the West Unit; and their development or their status of their unit is not quite as far along as ours, although we hope it will be complete sometime around the first of this year, so that if they are delayed beyond the time when we're ready to start injection, which it appears like they will be, we plan to start injection on a limited basis in the North Half of the unit which comprises primarily Zone 4.

Referring back to Exhibit No. 3, the quality isopacous map of Zone 4, which is figure 11, you can see that Zone 4 is restricted to the East Unit, the water level downstructure and porosity deterioration to the north. We contemplate initially starting injection in the wells in the area comprising approximately 1,000 acres of the 2440 acres, to inject water into Zone 4 and other zones that may be present in this area in order to start our flooding operation; and then we plan to expand it as soon as we can be assured of cross line agreements with Gulf in the West Unit.

Q But at the present time it is your intention, is it not, to put the whole unit on production at the same time, if that is possible, taking into account the progress made in the Gulf Unit?

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A That is correct. We would prefer to put the whole thing on at once, but it's like I say, subject to timing with the other unit in the area.

Q Have you made any computations concerning the allowables to which you would be entitled under Rule 701 of the Commission's rules, assuming the approval of this project?

A Yes. Initially we visualize, should we start injection on a limited basis, that the project area would include approximately 1,000 acres in Sections 15, 21, 22, 23, 27, and 28. The allowable for this acreage would amount to 1,008 barrels per day, based on 24 proration units utilizing the 42-barrel basic unit waterflood allowable.

The entire project area, including 2400 acres, the allowable would be based on 59 proration units; utilizing the 42 basic waterflood allowable would amount to 2478 barrels per day.

Q What would be the rate at which you would anticipate injecting water in this waterflood project?

A Should we continue on the limited area to start with, we visualize approximately 3,000 barrels per day to be injected in ten injection wells. The full scale flood would amount to injecting approximately 10,000 barrels through 31 injection wells per day, barrels per day. The total water requirement for the full scale waterflood should amount to approximately 50,000,000 barrels of water, of which 20,000,000 or 40 percent will be make-up water. The other 60 percent will be recycled produced water.

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Q What is going to be the source of that injected water, Mr. Carnahan?

A Currently we have narrowed our investigation to two possible sources, being the Capitan Reef located approximately 20 miles southwest of the proposed unit area, and Ogalala fresh water which is located nearby to the proposed unit. Both these waters are compatible with the Queen water. We intend on utilizing a closed injection system in either case.

Q Compatibility tests have been made on both possible sources of water?

A That is correct.

Q Do you have some figures to offer that would give the over-all picture on the benefits to be derived from instituting waterflood in this proposed area?

A Yes. Making reference again to Exhibit 3, figure 20, which is the oil production history with predicted continued primary and waterflood performance, the estimated primary recovery from the unit as estimated and indicated here is 2,192,000 barrels of oil. Combined primary and secondary recovery from the unit area is estimated at 6,780,000 barrels of oil. This amounts to a recovery, additional recovery due to waterflood operations, of an estimated 4,588,000 barrels.

Q From those figures, Mr. Carnahan, it's obvious there's going to be substantially enhanced recovery by this waterflood project and recovery of oil that would not otherwise be recovered.

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I think it would be safe to say that that would result in the prevention of waste, is that correct?

A I would say so, yes.

Q Are correlative rights going to be protected by operating the flood in the manner which you are proposing?

A Yes. Referring again to Exhibit No. 1, as I've previously mentioned, we anticipate a cross line agreement with the West Gulf Unit; the Gulf Unit, which is to the west of our unit, which we anticipate them continuing on with our five-spot flood pattern. In our discussions with them, we also have some acreage in that unit -- the unitized interval to the northeast is not productive, the Zones 1 through 4 are not productive in the northeast area of the field and to the south. In the south area these wells do produce from Zones 1 and 2 and 3; 1, 2, and 3. However, as I mentioned, they have been developed later.

There appears to be a restriction permeability-wise as we drilled one dry hole in Section 3, and Mr. C. W. Trainer drilled his Lynam No. 1 and completed as a well offsetting the Mid Texas State lease. This is the only well which offsets our unit to the south. We have anticipated there or discussed with them that they are considering forming a waterflood unit and hope that we can establish a tentative cross line agreement, although it doesn't appear to be too severe, sometime in the later part of 1964. Those wells are currently now starting to decline, so I think they are going to start to be more interested in initiating some type

of additional recovery.

Q Do you have anything further that you wish to add to your testimony in these consolidated cases?

A No, I believe that fairly well covers what I intended to discuss here.

Q Now Exhibit 2 was the unit agreement with which you stated to be familiar, and Exhibit 6 are the logs. Were Exhibits 1, 3, 4, and 5 prepared by you or under your direction?

A Yes, those exhibits were prepared by me and under my direction.

MR. MORRIS: We offer Exhibits 1 through 6 into evidence.

MR. NUTTER: Applicant's Exhibits 1 through 6 will be admitted in evidence.

(Whereupon, Applicant's Exhibits Nos. 1 through 6-EE admitted in evidence.)

MR. MORRIS: That's all I have at this time.

MR. NUTTER: Does anyone have any questions of Mr. Carnahan? Mr. Irby.

CROSS EXAMINATION

BY MR. IRBY:

Q Mr. Carnahan, you said that about 60 percent of the water injected would be recycled water?

A Yes, we anticipate that the make-up water or the additional water which we will have to procure will amount to approximately 40 percent of the total water required, which would amount

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to 20,000,000 barrels.

Q The total water requirement is 20,000,000 barrels?

A The total water that we'll have to procure outside in order to project; the 30,000,000 would be recycled water.

Q I see.

A I might add here that in reference to an earlier case by Mr. Buckles, in which this 10 to 1 ratio was discussed of injection water requirement to oil recovery, this is very close to what we have utilized here. We have approximately 50,000,000 barrels of water to be injected, and approximately 5,000,000 barrels of oil to be recovered secondary-wise.

Q What is going to be the determining factor in your decision as to whether you use water from the Capitan Reef or the Ogalala?

A I'll have to say that primarily it will be based on economics as to the feasibility of using one or the other of the two waters. Like I mentioned, we have studied several possible sources in this area in which some of them have been tested and proved to be unsatisfactory to supply water for the project. We have tried to coordinate our efforts along this line with the other unit so we could establish a source which would be sufficient for flooding the entire area, and participate, whereby it would be cheaper for everybody concerned to establish one source of water for the whole area; but like I say, primarily it will be economics.

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Q Have you any knowledge of the chemical quality of the water in the reef?

A I have an analysis if you would care to know what it is.

Q Please.

A On the Capitan Reef water, the analysis that we had made, the chlorine content, 1470 parts per million.

Q Clorine?

A Chloride, excuse me. I am sorry.

Q That was how much?

A 1470. HCO_3, 410 parts per million; CO_3, zero; SO_4, 2580.

Q What was that CO_3?

A There was no indication of any.

Q And the next one?

A SO_4, 2580 parts per million. Sodium, 1240; calcium, 750; magnesium, 250; no iron; total solids, 7,005; H_2S, 305.

Q 305?

A 305, yes. No dissolved oxygen.

MR. MORRIS: We'd be glad to give you a copy of this.

MR. IRBY: That would be better.

A I can give you a copy of this.

MR. MORRIS: Unless you have some question that you want to bring out right now.

Q (By Mr. Irby) The principal components that I find here, that chloride is 1470 and sodium 1240?

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MR. NUTTER: I believe that was 1400 --

A Chlorides, 1470. That's the one we kind of got mixed up on chlorine.

Q (By Mr. Irby) And the total dissolved solids, 7,005?

A Yes.

Q No iron?

A No iron, no oxygen.

Q No iron, no oxygen. That's good.

MR. IRBY: That's all the questions I have. Thank you.

BY MR. NUTTER:

Q You stated that the selection of the water source would be a matter of economics. Have you made any preliminary cost estimates on what it would cost you to transport this Capitan Reef water from a point 20 miles away?

A A considerable amount. This is one thing that may weigh heavily on possible use of fresh water. However, there's a possibility that we might possibly use this source for maybe some other floods in the area, such that then the cost per barrel would naturally be reduced, so this is what we are thinking about.

Q This is what you were talking about, attempting to coordinate your water supply?

A Yes, maybe for these units and some other floods, too. If it was just for this field, I am sure it wouldn't be economical; but the over-all picture, it might prove to be economical.

Q Have you made any preliminary estimates on what the cost

would be to bring the Capitan Reef water up here?

A I believe it was somewhere in the neighborhood of $400,000 plus an operation cost which would be considerably higher, due to the necessity of pumping water; where if we went to Ogalala which is primarily developed to the north of here, we would have the aid of gravity drainage. Very expensive.

Q Is Ogalala water present in this immediate area?

A Yes. Actually, the Ogalala isn't present in the Pearl acreage as such, but within a six-mile radius of the field there is good Ogalala development and unappropriated water.

MR. NUTTER: Mr. Irby, go ahead.

BY MR. IRBY:

Q And you would probably have to pipe your water several miles if you went for the Ogalala?

A In either case we would have to pipe it several miles. There's not an adequate source. We've tested everything and studied everything in the immediate area, and there's no adequate source to sustain the injection rates which we will require for the flood operation.

Q But if you go for the reef water, you'll have to pipe approximately three times as far as the Ogalala?

A The indication would be, yes, roughly in that magnitude.

Q There isn't sufficient produced oil field brine in the area to sustain your flood?

A There is production in the Monument area; however, I

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believe there's some other floods which have other designs on this water. We have investigated this and feel like that we couldn't depend upon it to be a source for the whole unit, because some of these other floods I believe would have first call on it, plus the fact it's very corrosive and would provide some additional problems which we hope we wouldn't have with these other two waters. So combining those two things, we have more or less eliminated that as a possible source. The pipe lining would also require something in the neighborhood of 12 to 15 miles of pipeline to come from the distribution system over there, also. So there are quite a few factors which kind of make it really not satisfactory for our use here.

BY MR. NUTTER:

Q Is there any Devonian water available in this area?

A There is some up north, South Vacuum-Devonian. We have investigated this also and have an analysis of the water. Current production up there is not enough to supply our requirements, and there is some doubt as to whether we could depend on it for the length of time when we're going to be requiring it; so that if we used it we would have to supplement it from some other source, which would probably require the building of two pipelines, at least for a portion of the way. So we have more or less discontinued this for our use here.

Q In your opinion, Mr. Carnahan, what is the source of water going to be if you can get it, Ogalala fresh water?

A What is the source?

Q Yes, sir.

A Well, like I say, I haven't been given an okay on which one of the two. I made my recommendations and we have discussed it, but I haven't been given an okay as to which one that I'm going to have to worry about here.

Q Which appears to be the most economical to you?

A It would appear on the surface that the use of the Ogalala would be, over-all, if you are just discussing the use of water for just this one particular area.

Q Mr. Carnahan, I note here on Exhibit No. 5-A that there's quite a variation in the setting depth of the surface pipe. To what do you attribute that among these wells?

A Well, probably inexperience to start with, and trying to make sure that we protect everything. I think some of the -- I was just trying to look, we have a short string of our own here, a couple, three of them, being Kimberley No. 4, 98 feet. I guess that's what you are referring to?

Q Yes, sir.

A Allen State No. 3, 96 feet, and P.E. No. 2, 94 feet. Well, those latter two wells were drilled later on, later in development; and I would assume that -- I know there's no problem, as far as I know we were well into the red beds when we set the pipe. It appears like there was quite a bit of pipe wasted, really, surface pipe was.

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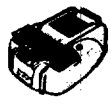

Q You feel that the short strings have been adequate and some of the longer strings would have been more than adequate?

A Actually just poor economics. However, there may be some other individual problems that may have caused them to set that deep for one reason or another.

Q The cement on the production string is given as surface on some of the wells and as a figure on others. Is that an estimate or top that's taken from a survey, or just what?

A Now I have indicated estimated would be actually estimated based on the volume of cement, utilizing a factor of one sack of cement per cubic foot. We felt like that was a very conservative estimate. Utilizing this would be utilizing Neat Cement, actually we would probably -- we wanted to make sure that these are conservative estimates.

Now I realize it looks a little strange to say that you have an estimated at surface, because it ought to be, you ought to be able to see it, most of these were on wells that were not operated by Shell and we did not have that information available to us as to whether they actually saw it or not.

Q But of the total wells here, only a couple of them are actually survey tops?

A That is right. Those indicated as "S" are survey tops and there's only one of them, I believe, on the production casing.

Q I notice on your Exhibit 5-B that in some of these wells, I think most of them are equipped with 5-1/2 inch pipe. There may

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be a few that have 4-1/2 inch pipe. But you are going to use a rather small tubing diameter, particularly on the dual injection wells?

A Yes, this has posed somewhat of a problem to us. We initially, before we went into this dual type of injection, we investigated what we could get in the wells and what requirements we were going to need for these particular zones. The injection into each one of the wells is not going to be 150 barrels per zone or a total of 300 barrels per well. It is primarily based on the sand volume into which we are going to be injecting, and there's only about one or two of them that we're not going to be able to inject quite the volume which we would like to, based on the sand volume. It has actually worked out fairly convenient.

Q You will be restricted to an amount that you desire --

A In a couple of wells, that's right. This is due to the size of the casing and the size of the tubing that we are going to be able to put in there. We are going to approach the volumes such as we desire, so we consider ourselves lucky that we didn't have 2-7/8 casing in some of the wells that we want to use this dual injection.

Q What is the inner diameter of this tubing that has the outside diameter of 1.315?

A The inside diameter -- I don't happen to have that figure available to me as to what the inner diameter is. We primarily wanted to list the outside to show what we could get in the pipe.

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Q Get in the pipe?

A Right.

Q I notice also, Mr. Carnahan, that up in the north end there you show some net feet of pay in Zone No. 1,that would be on figure 6, on the C-1 Trainer Signal State lease, the No. 1 and 2 Wells?

A Yes.

Q Now that Zone No. 1 is not going to be flooded in the north end, however?

A That is very true. The sand volume, we feel, up there is indicated to us to be actually from the log analysis we show 52 feet or a number of 52, which might represent a figure like five feet of ten percent porosity.

Q This is porosity feet?

A Right. It could represent a figure of five feet of pay, ten percent porosity, which will give you 10.5 percent. The log analysis indicated that this was very close to what we considered a cut-off, being ten percent porosity. We didn't feel like it would warrant the additional equipment to try to inject into one and produce out of the other for this very thin, poorly developed section in Zone 1. It could very well be, although these figures were included in the parameter,that the logs were reading pretty close, and it could be that it was actually not of pay quality and we would be wasting our money trying to inject into it.

Q However, this tract will share on that parameter right

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there?

A That's right. If you figured the amount of oil that would be in there and what could be recovered, it would not pay out the additional expense, tubing-wise and injection facilities, to inject into one and produce out of the other. We feel it is more or less isolated. As you notice, there are several wells that have no pay indicated to the side of that.

Q Right, it's an island?

A That's right, and it truly might not be there.

Q But that island will not be flooded?

A That is true, it will not be flooded.

MR. NUTTER: Are there any other questions of Mr. Carnahan? Mr. Irby.

BY MR. IRBY:

Q To go back to Mr. Nutter's questioning on this depth of setting of the surface casing, I believe you stated that in all cases it is set into the red beds. Do you find that the red beds surface is highly eroded and -- well, not at all uniform in this area as it is in the northern part?

A That is very true. In fact, actually there has been some fresh water found out here very shallow, between 30 and 50 feet, primarily in the north area of the field, although this has been tested and we consider this is a possible source of water. We utilized some of this water to put out a fire on Hooper 1 when we drilled it. We know that we have water to put out a fire and

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to drill with, but we don't have enough to inject into. The south end of this field, there doesn't appear to be any fresh water at all, even this very shallow sand or whatever it may be is not even water-bearing or not present to the south; the red beds are very close to the surface.

There is a very limited amount of fresh water, it's not Ogalala,in the north part of this field, and it appears to be rather patchy and not too well developed. I don't know if that answers your question, but I will answer, yes, that the red beds surface is very irregular.

Q The irregularity of the red beds might to some degree account for the difference in the setting of this surface casing?

A That very well could be, just the fact that they didn't know whether they had gotten to them or not, or they just weren't there.

Q Can you tell me what the location would be of the well in the reef that provided you the water analysis?

A Well, of course, now, the Ogalala Reef covers a pretty good size area.

Q Ogalala?

A Excuse me, you are talking about the Capitan Reef. Well, I still say, the Capitan Reef covers a very large area. As I mentioned, the use of this water would possibly be in conjunction with the use somewhere else so that the exact location of the well would be somewhat dependent, to try to centrally locate it,

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on where we might try to use the water. I cannot give you an exact location. I don't have a lease.

Q I think I can get it this way. This analysis that you are going to send me gives the location of the well from which it was taken?

A I'll have to check. I don't happen to have that information. It may be in the report. I'll have to glean through it. I didn't write the report myself, but I am sure they will certainly know where they got the water from. I will try to make it a point to tell you where it came from, if you so desire.

MR. IRBY: Good, that will take care of it.

MR. NUTTER: Any other questions? Mr. Durrett.

BY MR. DURRETT:

Q Mr. Carnahan, were you present this morning and did you hear Mr. Buckles' testimony in a previous waterflood case?

A Yes.

Q Did you hear him testify -- I believe he testified that in his opinion it was usually more desirable and more feasible to use salt water in waterflood operations if it was available in the area, reasonably available.

A I'll have to agree with him in principle, --

Q I would like to have your opinion on that, if you will.

A -- and maybe disagree a little bit, specifically. I'll agree with this point that he made, that usually a formation, a sand formation, has a higher permeability to salt water than it

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does to fresh water. This is somewhat dependent upon the clay content of the sand itself. If it's a bentonitic type of sand, why, you are going to have a very serious permeability restriction due to the swelling of the clays, where you may end up where you can't inject anything. As far as we are concerned in particular here, we have run injectivity tests using cores selectively through this area, using Ogalala, Capitan Reef, and also Monument-San Andres water. We can find very little difference.

We couldn't account for it, maybe in just laboratory measurement in the actual permeability or the actual restriction that we have. We do not have or anticipate anything because we do not have a bentonitic or clay type sand here. What he's talking about, he may have -- I'm not familiar with the Langlie-Mattix Field and he may have more of a clay or a shaly problem there, and in his case it may be that he would definitely want to use salt water under those circumstances.

But to generally say that you would always want to use salt water to inject into a formation, this might be all right to say but then again, if you've got to pay for it and try to make any money out of doing it, then you are going to have to base what you use a little bit on economics. It doesn't make much sense to inject water to lose money, and you may be faced with that if you have to go a long distance to get a particular type of salt water to inject.

I will agree with him there is a reduction. This has

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been noted in textbooks for years, that salt water will usually show a higher permeability to a given sand than fresh water will.

Q Let me ask you this question in connection with the costs of the water that you propose to use. Could you give us some estimate of what you think it's going to cost you to obtain the water you propose to use in this field?

A It might be a little difficult, actually, when you speak of cost, and I believe he mentioned a figure for his in the magnitude of one and a half cent per barrel, this would be a function of the quantity of water which you are going to use. Otherwise, if you are talking about using large volumes of water, you can end up processing it at a little cheaper rate than if you are going to have to operate one well to produce a small amount of water, which he was discussing there. Then the cost per barrel goes up because maybe he could put a little larger pumping unit on and cost him a little bit more money and produce a lot more water. He is restricted, he only needs so much water. I can't give you a cost per barrel if that's what you are looking for, as to what it's going to cost us per barrel to inject it.

I would say it is going to be considerably less than a cent and a half a barrel on a field-wide project, which we've discussed here, that we are contemplating to develop a source sufficient for all of these units, including the East Unit.

Q At any rate --

A Considerably lower than one and a half cents.

Q At any rate, you wouldn't consider it to be more than one and a half cents?

A No, I wouldn't.

Q I have one final question, Mr. Carnahan. In your exhibits or somewhere in our file, do we have the footage description of your proposed injection wells?

A The footage description?

Q Yes, or by unit or some way so we can describe the wells.

A Well, of course, I have them named over here and located here.

Q Locations?

A You mean particular location on each?

Q Yes, so if we approve this application we don't have to pick it off a map.

A In our application, we have the wells located as to section and unit; in a letter, I believe.

MR. MORRIS: That's correct, but we don't have it tied down to the name of the well.

A You mean the numbering system?

Q (By Mr. Durrett) Yes.

A Well, we are in the process right now of deciding which numbering system we are going to use. I think, this is my opinion, but I think this is what we are going to use. It will be something in the neighborhood, like the wells located in Section 22;

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then starting with the same sequence, by which we currently alphabetically number the proration units, we will use the numbers one through equivalent of letter "P". The well will be designated,-- for instance, the Shell Rushing Well No. 2, which is an indicated injection well, will be designated as 22-2.

MR. MORRIS: Mr. Durrett, if you just want the unit and section of the wells as listed on Exhibit 5, well, I'll be glad to sit down and furnish you a list of the name of each well and the unit and the section in which it's located.

MR. DURRETT: Thank you, Mr.Morris. That will be completely adequate, I believe.

MR. NUTTER: Are there any other questions of Mr. Carnahan? He may be excused.

(Witness excused.)

MR. NUTTER: Do you have anything further, Mr. Morris?

MR. MORRIS: I would like to make one brief statement. In case we could possibly have left any confusion in the record as to what we intend to do on putting the wells on injection in this unit area, if approved, Shell would intend to place all of the wells on injection as soon as possible. We are not proposing this as a two-stage flood in any sense. The testimony given by Mr. Carnahan concerning the limited flood that might be initiated in the northern part of this unit would be merely a stop-gap and very temporary measure to just get this waterflood project going; but with the full intention of putting the whole, all of these

injection wells on injection just as soon as possible.

MR. NUTTER: I understand. Mr. Carnahan, one other question. You mentioned that some of these tracts had not been committed yet, and you gave a breakdown by whether they were State tracts or Fee tracts and so forth. Would you identify the tracts that have not been committed?

MR. CARNAHAN: Just one minute here. Of the three tracts that have not been committed, they amount to 160 acres, being the Sanford Union State lease, which is an 80-acre lease located in Section 15.

MR. NUTTER: That has an injection well on it?

MR. CARNAHAN: That has an injection well on it. The Colton Texaco Moran lease, which is located in Section 22, that is a Fee 40-acre lease; and the Colton Gulf State lease,which is located -- the only well located in Section 23, which is a 40-acre State lease.

MR. NUTTER: And it's not an injection well, it would be a producer, right?

MR. CARNAHAN: It is a producer, right.

MR. NUTTER: So of all the acreage which has not been committed, you have two tracts with injection wells on them but it just so happens that each of those tracts is an edge tract or an edge injection well?

MR. CARNAHAN: That is very true.

MR. NUTTER: And you don't have any holes in the pattern

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itself?

MR. CARNAHAN: We are not a bit worried if those don't come in. It's not going to be any detriment anyway to the unit, as far as we are concerned.

MR. NUTTER: Thank you. Did you have anything further, Mr. Morris?

MR. MORRIS: That's all I have.

MR. NUTTER: Does anyone have anything they wish to offer in Cases 2850 and 2851? We will take the Cases under advisement.

* * *

STATE OF NEW MEXICO)
) ss
COUNTY OF BERNALILLO)

I, ADA DEARNLEY, Notary Public in and for the County of Bernalillo, State of New Mexico, do hereby certify that the foregoing and attached Transcript of Hearing before the New Mexico Oil Conservation Commission was reported by me, and that the same is a true and correct record of the said proceedings, to the best of my knowledge, skill, and ability.

WITNESS my Hand and Seal this 25th day of August, 1963.

Ada Dearnley
NOTARY PUBLIC

My Commission Expires:

June 19, 1967.

I do hereby certify that the foregoing is a complete record of the proceedings in the Examiner hearing of Case No. ..... heard by me on ..... 19.....

....., Examiner
New Mexico Oil Conservation Commission

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BEFORE THE
OIL CONSERVATION COMMISSION
Santa Fe, New Mexico
July 10, 1963

EXAMINER HEARING

IN THE MATTER OF:

Application of Shell Oil Company for a unit agreement, Lea County, New Mexico. Applicant, in the above-styled cause, seeks approval of the East Pearl-Queen Unit Area comprising 2440 acres of State and Fee lands in Township 19 South, Range 35 East, Lea County, New Mexico. CASE 2850

IN THE MATTER OF:

Application of Shell Oil Company for a waterflood project, Lea County, New Mexico. Applicant, in the above-styled cause, seeks authority to institute a waterflood project on its East Pearl Queen Unit by the injection of water into the Queen formation through 29 wells in Sections 15, 21, 22, 26, 27, 34 and 35, Township 19 South, Range 35 East, Lea County, New Mexico. CASE 2851

BEFORE: Elvis A. Utz, Examiner

TRANSCRIPT OF HEARING

MR. UTZ: The hearing will come to order, please. The first case on the docket will be 2850. Application of Shell Oil Company for a unit agreement, Lea County, New Mexico.

MR. DURRETT: If the Examiner please, this case, I would like to move that it be continued until the 24th, the Examiner Hearing to be held on the 24th. Mr. Dick Morris, the