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# CO2 HUFF-N-PUFF PROCESS IN A LIGHT OIL SHALLOW SHELF CARBONATE RESERVOIR

Annual Report for the Period
January 1, 1995 through December 31, 1995

By
Scott C. Wehner, R. J. (Bob) Boomer, Roger Cole,
John Prieditis and Joe Vogt

September 1996

Performed Under Contract No. DE-FC22-94BC14986

Texaco Exploration & Production, Inc.
Midland, Texas

**Bartlesville Project Office**
**U. S. DEPARTMENT OF ENERGY**
**Bartlesville, Oklahoma**

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Prepared for
U.S. Department of Energy
Assistant Secretary for Fossil Energy

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## ABSTRACT

The application of cyclic $CO_2$, often referred to as the $CO_2$ Huff-n-Puff process, may find its niche in the maturing waterfloods of the Permian Basin. Coupling the $CO_2$ H-n-P process to miscible flooding applications could provide the needed revenue to sufficiently mitigate near-term negative cash flow concerns in the capital intensive miscible projects. Texaco Exploration & Production Inc. and the U. S. Department of Energy have teamed up in an attempt to develop the $CO_2$ Huff-n-Puff process in the Grayburg/San Andres formation; a light oil, shallow shelf carbonate reservoir within the Permian Basin. This cost-shared effort is intended to demonstrate the viability of this underutilized technology in a specific class of domestic reservoir.

A significant amount of oil reserves are located in carbonate reservoirs. Specifically, the *carbonates* deposited in *shallow shelf* (SSC) environments make up the largest percentage of known reservoirs within the Permian Basin of North America. Many of these known resources have been under waterflooding operations for decades and are at risk of abandonment if crude oil recoveries cannot be economically enhanced[1,2]. The selected site for this demonstration project is the Central Vacuum Unit waterflood in Lea County, New Mexico.

Miscible $CO_2$ flooding is the process of choice for enhancing recovery of light oils[3] and already accounts for nearly 12% of the Permian Basin's daily production.[4] There are significant probable reserves associated with future miscible $CO_2$ projects. However, many are marginally economic at current market conditions due to large up-front capital commitments for a peak response which may be several years in the future. The resulting negative cash-flow is sometimes too much for an operator to absorb. The $CO_2$ H-n-P process is being investigated as a near-term option to mitigate the negative cash-flow situation--allowing acceleration of inventoried miscible $CO_2$ projects when coupled together.

The $CO_2$ Huff-n-Puff process is a proven enhanced oil recovery technology in Louisiana-Texas Gulf-coast sandstone reservoirs[5,6]. Application seems to mostly confine itself to low pressure sandstone reservoirs[7]. The process has even been shown to be moderately effective in conjunction with steam on heavy California crude oils[8,9]. A review of earlier literature[5,10,11] provides an excellent discussion on the theory, mechanics of the process, and several case histories. Although the technology is proven in light oil sandstones, it continues to be a very underutilized enhanced recovery option for carbonates. However, the theories associated with the $CO_2$ H-n-P process are not lithology dependent.

It is anticipated that this project will show that the application of the $CO_2$ Huff-n-Puff process in shallow shelf carbonates can be economically implemented to recover appreciable volumes of light oil. The goals of the project are the development of guidelines for cost-effective selection of candidate reservoirs and wells, along with estimating recovery potential.

This project has two defined budget periods. The first budget period primarily involves tasks associated with reservoir analysis and characterization, characterizing existing producibility problems, and reservoir simulation of the proposed technology. The final budget period covers the actual field demonstration of the proposed technology. Technology transfer spans the entire course of the project.

This report covers the concluding tasks performed under the first budget period and the initial results of the second budget period.

Work is complete on the reservoir characterization components of the project. The near-term emphasis was to, 1) provide an accurate distribution of original oil-in-place on a waterflood pattern entity level, 2) evaluate past recovery efficiencies, 3) perform parametric simulations, and 4) forecast performance for a site-specific field demonstration of the proposed technology. Macro zonation now exists throughout the study area and cross-sections are available. The Oil-Water Contact has been defined. Laboratory capillary pressure data was used to define the initial water saturations within the pay horizon. The reservoir's porosity distribution has been enhanced with the assistance of geostatistical software. Three-Dimensional kriging created the spacial distributions of porosity at inter-well locations. Artificial intelligence software was utilized to relate core permeability to core porosity, which in turn was applied to the 3-D geostatistical porosity gridding. An Equation-of-State was developed and refined for compositional simulation exercises. These tasks were highlighted in the 1994 Annual Report.

The 1995 Annual Report will provide some conclusions to some of the work reported previously. However, this report deals predominently with, 1) parametric simulation exercises, 2) site-specific simulation; history matching the waterflood and forecasted recovery, and 3) initial results from the field demonstration of the process.

A successful demonstration of the $CO_2$ Huff-n-Puff process could have wide application. The proposed technology promises several advantages. It is hoped that the $CO_2$ Huff-n-Puff process might bridge near-term needs of maintaining the large domestic resource base of the Permian Basin until the mid-term economic conditions support the implementation of more efficient, and prolific, full-scale miscible $CO_2$ projects.

## EXECUTIVE SUMMARY

Texaco Exploration and Production Inc. (TEPI) was awarded a contract from the Department of Energy (DOE) during the first quarter of 1994. This contract is in the form of a cost-sharing Cooperative Agreement (Project). The goal of this joint Project is to demonstrate the Carbon Dioxide ($CO_2$) Huff-n-Puff (H-n-P) process in a light oil, shallow shelf carbonate (SSC) reservoir (Grayburg and San Andres formation) within the Permian Basin. The selected site is the TEPI operated Central Vacuum Unit (CVU) waterflood in Lea County, New Mexico. The CVU produces from the Grayburg and San Andres formations.

TEPI's mid-term plans are to implement a full-scale miscible $CO_2$ project in the CVU. However, the current market precludes acceleration of such a capital intensive projects in many similar reservoirs. This is a common finding throughout the Permian Basin SSC reservoirs. In theory, it is believed that the "immiscible" $CO_2$ H-n-P process might bridge the longer-term "miscible" projects with near-term results. A successful implementation would result in near-term production, or revenue, to help offset cash outlays of the capital intensive miscible $CO_2$ project. The DOE partnership provides some relief to the associated R & D risks, allowing TEPI to evaluate a proven Gulf-coast sandstone technology in a waterflooded carbonate environment. A successful demonstration of the proposed technology would likely be replicated within industry many fold--resulting in additional domestic reserves.

The principal objective of the CVU $CO_2$ H-n-P project is to determine the feasibility and practicality of the technology in a waterflooded SSC environment. The results of parametric simulation of the $CO_2$ H-n-P process, coupled with reservoir characterization, assisted in determining if this process was technically and economically ready for field implementation. The ultimate goal is to develop guidelines based on commonly available data that operators within the oil industry can use to investigate the applicability of the process within other fields. The technology transfer objective of the project is to disseminate the knowledge gained through an innovative plan in support of the DOE's objective of increasing domestic oil production and deferring the abandonment of SSC reservoirs. Tasks associated with this objective are carried out in what is considered a timely effort.

The application of $CO_2$ technologies in Permian Basin carbonates may do for the decade of the 1990's and beyond, what waterflooding did for this region beginning in the 1950's. With an infrastructure for $CO_2$ deliveries already in place, a successful demonstration of the $CO_2$ H-n-P process could have wide application. The proposed technology promises a number of economical advantages. Profitability of marginal properties could be maintained until such time as pricing justifies a full-scale $CO_2$ miscible project. It could maximize recoveries from smaller isolated leases which could never economically support a miscible $CO_2$ project. The process, when applied during the installation of a full-scale $CO_2$ miscible project could mitigate up-front negative cash-flows, possibly to the point of allowing a project to be self-funding and increase horizontal sweep efficiency at the same time. Since most full-scale $CO_2$ miscible projects are focused on the "sweet spots" of a property, the $CO_2$ H-n-P process could concurrently maximize recoveries from non-targeted acreage. An added incentive for the early application of the $CO_2$ H-n-P process is that it could provide an early measure of $CO_2$ injectivity of future full-scale $CO_2$ miscible projects and improve real-time recovery estimates--reducing economic risk. It is hoped that the $CO_2$ H-n-P process might bridge near-term needs of maintaining the large domestic resource base of the Permian Basin until the mid-term economic conditions support the implementation of more efficient, and prolific, full-scale miscible $CO_2$ projects.

This project has two defined budget periods. The first budget period primarily involves tasks associated with reservoir analysis and characterization, characterizing existing producibility problems, and reservoir simulation of the proposed technology. The final budget period covers the actual field demonstration of the proposed technology. Technology transfer spans the entire course of the project. This report covers the concluding tasks performed under the first budget period and the initial results of the second budget period.

Work is complete on the reservoir characterization components of the project. The near-term emphasis was to, 1) provide an accurate distribution of original oil-in-place on a waterflood pattern entity level, 2) evaluate past recovery efficiencies, 3) perform parametric simulations, and 4) forecast performance for a site-specific field demonstration of the proposed technology. Macro zonation now exists throughout the study area and cross-sections are available. The Oil-Water Contact has been defined. Laboratory capillary pressure data was used to define the initial water saturations within the pay horizon. The reservoir's porosity distribution has been enhanced with the assistance of geostatistical software. Three-Dimensional kriging created the spacial distributions of porosity at inter-well locations. Artificial intelligence software was utilized to relate core permeability to core porosity, which in turn was applied to the 3-D geostatistical porosity gridding. An Equation-of-State was developed and refined for compositional simulation exercises. These tasks were highlighted in the 1994 Annual Report.

The 1995 Annual Report provides conclusions to some of the work reported previously. However, this report deals predominently with, 1) parametric simulation exercises, 2) site-specific simulation; history matching the waterflood and forecasted recovery, and 3) initial results from the field demonstration of the process. Simulation results suggest that reservoir characterization of flow units is not as critical for a $CO_2$ H-n-P process as for a miscible flood. Entrapment of $CO_2$ by gas hysteresis is considered the dominant recovery factor for a given volume of $CO_2$. The repetitive application of the process was found to be unwarranted in a waterflooded environment. Future history matching of the performance will allow better forecasts and evaluation of the economic impact available with this underutilized process.

## INTRODUCTION

### CVU Development History.

The Vacuum Field was discovered in May, 1929 by the Socony-Vacuum Oil Company--a predecessor of Mobil. The discovery well was the New Mexico "Bridges" State Well No. 1 (drilled on the section line of Sec's 13 & 14, T16S R34E). The well was shut-in until 1937 when pipeline facilities became available to the area. The field is located 22 miles west of Hobbs in Lea County, New Mexico (**Fig. 1**). Field development began on 40-acre well spacing. By 1947 the field limits were defined. The CVU was infill drilled on 20-acre spacing during 1978-1979. Further reservoir development began in the late 1980's with sporadic infill drilling on 10-acre spacing--which continues. Enhanced recovery operations by waterflooding are in progress across the entire Vacuum field. Water injection at CVU was initiated in 1978.. A polymer augmented waterflood was initiated and completed during the mid-1980's. The CVU has performed well under waterflooding with ultimate recoveries (primary + secondary) forecast at 44.8% of original oil-in-place (OOIP). A plot of the CVU production and injection history is found in **Fig. 2**. The flood is quite mature in some areas, yet would be considered an adolescent in others due to varying reservoir qualities. Miscible $CO_2$ Flooding was initiated in 1985 by Phillips in the southeastern portion of the field, immediately east of the CVU. **Fig. 3** identifies the Unitized operations of the Vacuum field. In addition to the San Andres/Grayburg producing horizons, there are 12 other formations that are, or have been productive in the Vacuum field. These, mostly deeper horizons were developed predominantly during the 1960's.

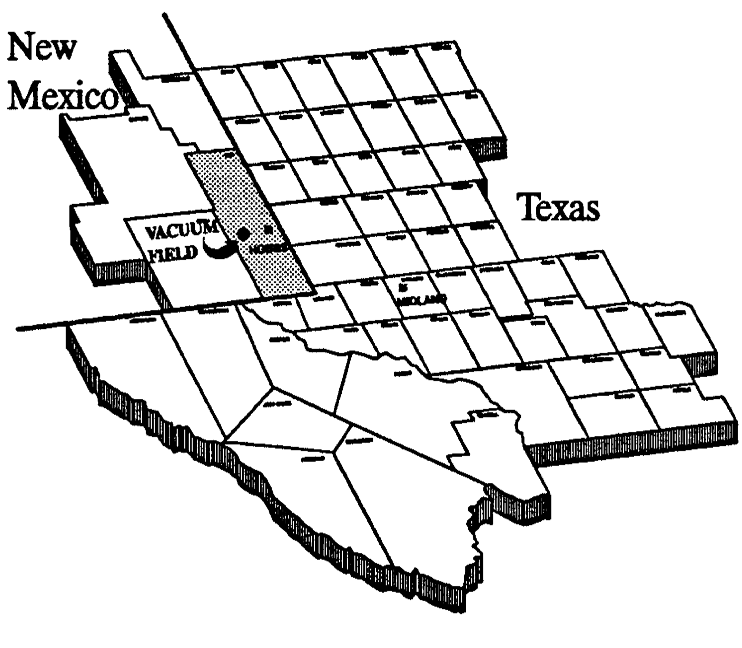


**Fig. 1:** Regional location of Central Vacuum Unit.

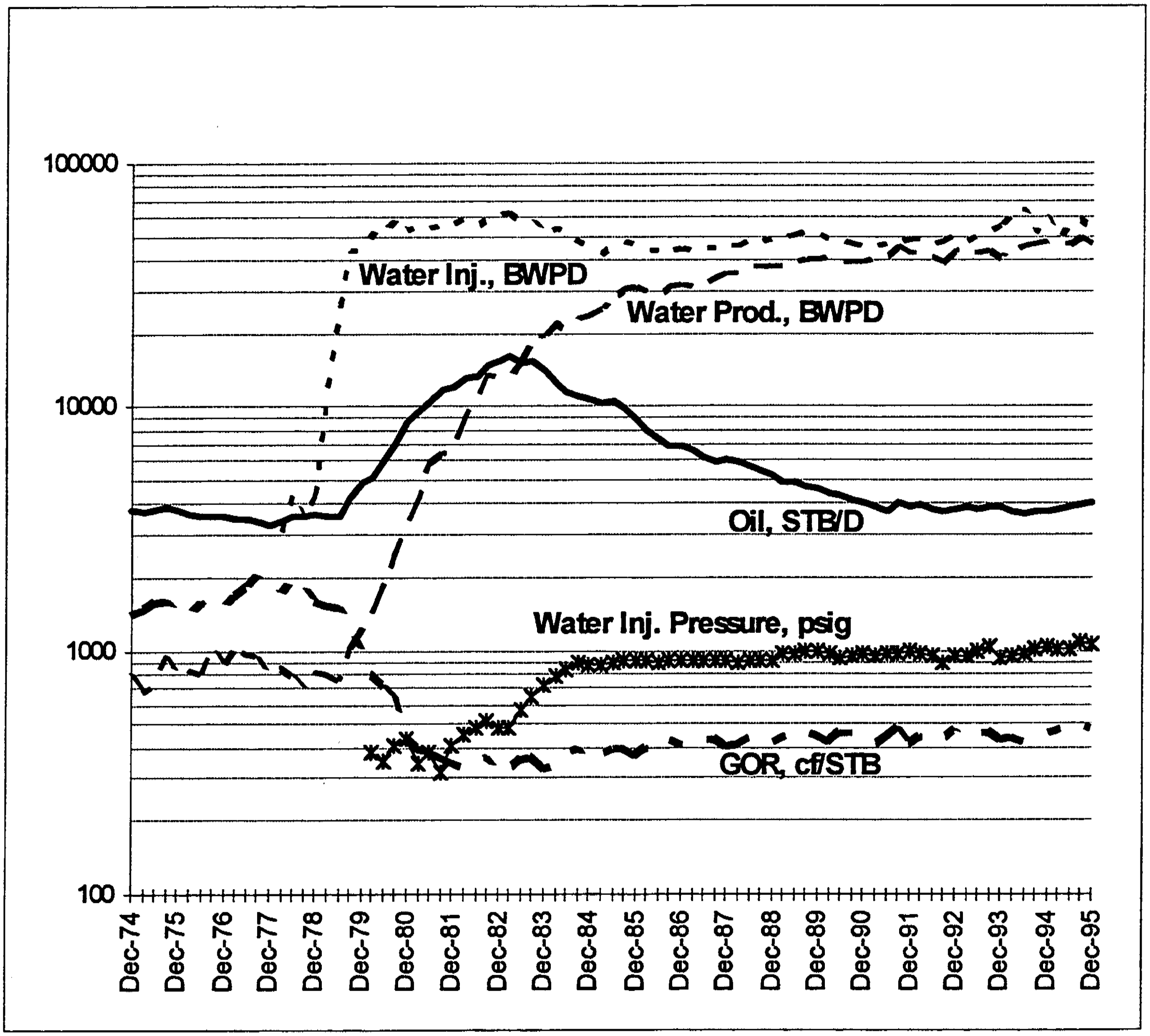


**Fig. 2:** Central Vacuum Unit production and injection history. Textbook waterflooding character.

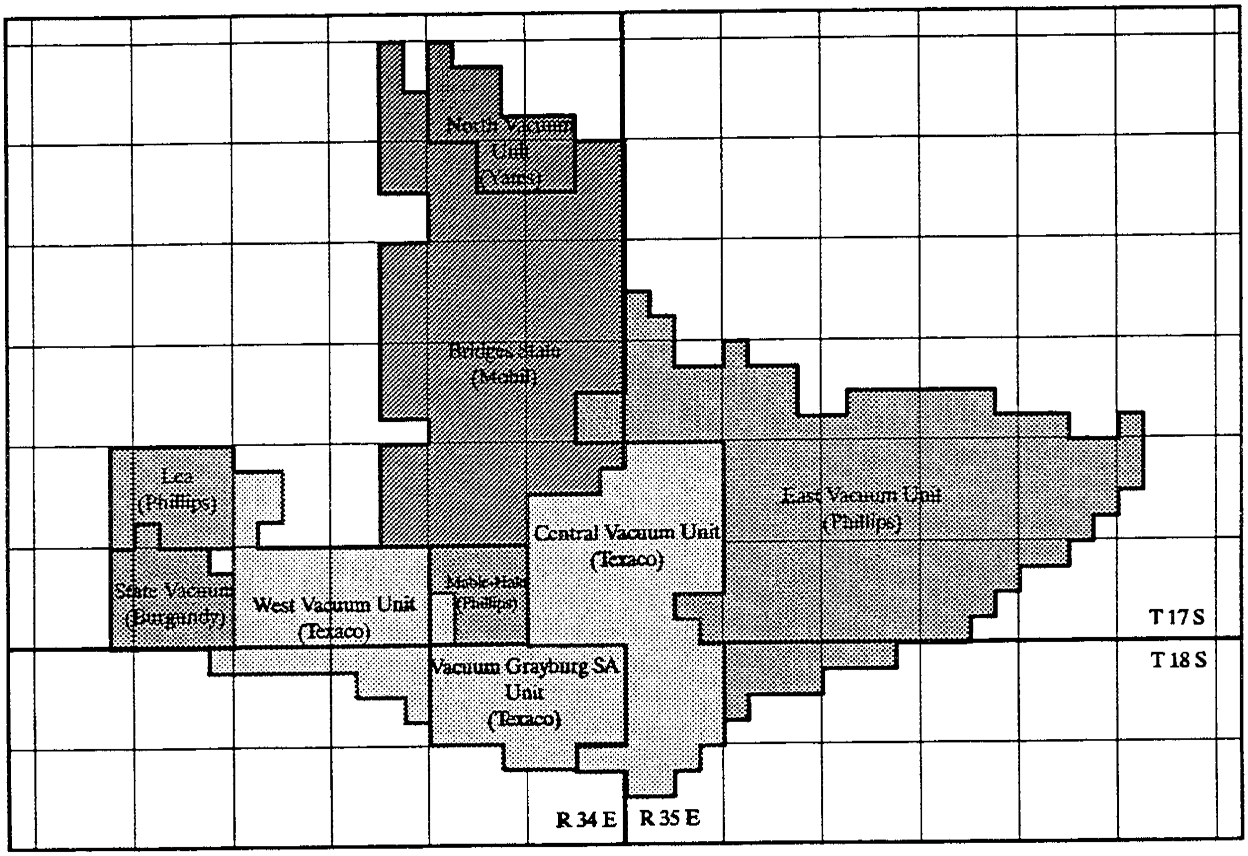


Fig 3: Unitized Acreage of Vacuum Field, Lea Co., New Mexico.

## Geology

The Vacuum field lies on the margin between the Northwest Shelf and Delaware Basin (**Fig. 4**). Production is primarily from the Permian Guadalupian age San Andres formation. Less than 15% of the Unit's OOIP is located in the overlying Grayburg formation. The San Andres is composed of cyclical evaporites and carbonates recording the many "rises" (transgressing) and "falls" (regressing) of sea level occurring around 260 million years ago in a climate very similar to the present day Persian Gulf. The San Andres pay zone is divided by the Lovington sand member. The Grayburg formation is composed of cyclical carbonates and sands. The oil has been trapped in porous dolomites and sands that developed on a structural high. The productive intervals are sealed by overlying evaporites. Stratigraphically to the north, the porous dolomites pinch out into non-porous evaporites and evaporite filled dolomites. The porous zones are thinning and dip below the free oil-water contact (~4,700 ft.) in the southerly, basinward direction. A structural map is provided in **Fig. 5**.

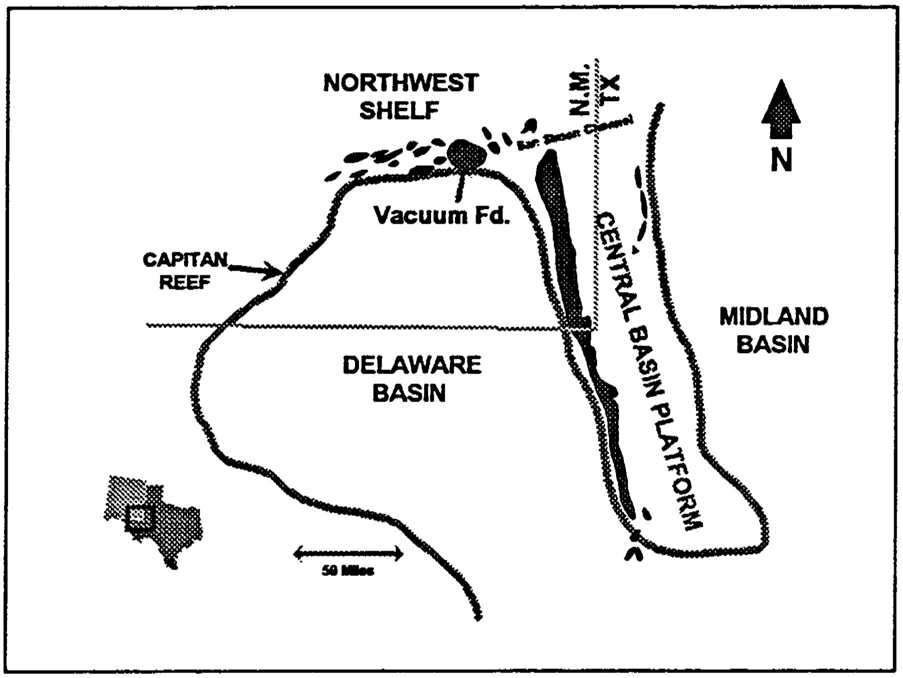


**Fig. 4**: Permian Basin and relative position of Vacuum field.

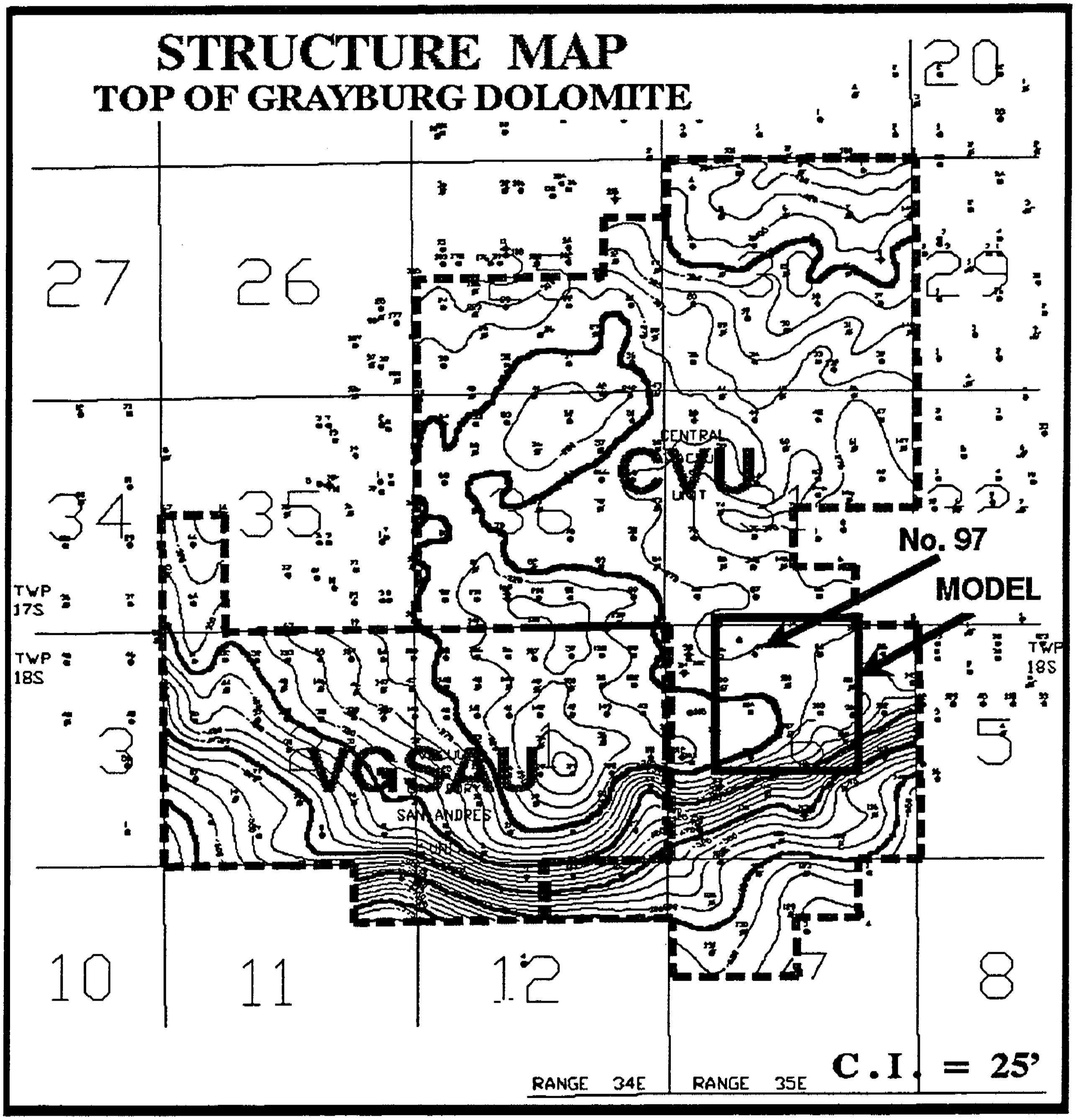


Fig. 5: Limits of Central Vacuum Unit with structural contours on Grayburg Dolomite. Shelf-Basin margin

Lithologically, the Grayburg formation consists of relatively dense dolomite with some anhydrite. It contains interbedded dolomitic sand stringers. The San Andres formation consists of dense medium crystaline and oolitic dolomite with some anhydrite. The pay is a fine to medium crystalline oolitic dolomite with slight fracturing and some solution cavities. Productive intervals consist of a series of permeable beds separated by relatively impermeable strata. The impermeable strata extend over large areas of the field and are believed to serve as effective barriers to prevent cross-flow between the permeable beds. The gross pay would be characterized as heterogeneous.

The Grayburg/San Andres formations produce a 38.0° API oil from an average depth of 4,550' within the CVU. The original water-free oil column reaches as much as 600' in height. Porosity and permeability in the pay interval can reach a maximum of 23.7%, and 530 md, respectively. The porosity and permeability over the gross pay interval averaged 6.8% and 9.7 md, respectively. Based on core studies, the net productive pay averages 11.6% porosity and 22.3 md. Although current saturations in the near wellbore vicinity have not been directly measured, core studies suggest typical residual oil saturations to waterflooding in swept zones to be in the range of 30-35%. Oil saturations in poorly swept zones, created by the heterogeneous architecture of the reservoir, could approach initial conditions. Hypothetically, this leaves a significant volume of uncontacted and immobile oil in the near wellbore vicinity of producing wells, which is the target of this $CO_2$ H-n-P process.

**Brief of Project & Technology Description**

This project has two defined budget periods. This report concludes a discussion of work predominantly completed and covered in the 1994 Annual Report, and work to-date under the second budget period. The first budget period primarily involved tasks associated with reservoir analysis and characterization, characterizing existing producibility problems, and reservoir simulation of the proposed technology. The near-term emphasis was to, 1) provide an accurate distribution of original oil-in-place on a waterflood pattern entity level, 2) evaluate past recovery efficiencies, 3) perform parametric simulations, and 4) forecast performance for a site-specific field demonstration of the proposed technology. The second, and final budget period incorporates the actual field demonstration of the technology.

It was anticipated that detailed reservoir characterization and a thorough waterflood review would help identify sites for the field demonstration(s). Numerical simulation would help define the specific volumes of $CO_2$ required, best operational practices, and expected oil recoveries from the demonstration sites.

**Basic Theory and Objective.** Under certain conditions the introduction of $CO_2$ can be very effective at improving oil recovery. This is most apparent when operating at pressures above the minimum miscibility pressure (MMP) of the system. As depicted in **Fig. 6**, recovery efficiencies are notably less under immiscible conditions.

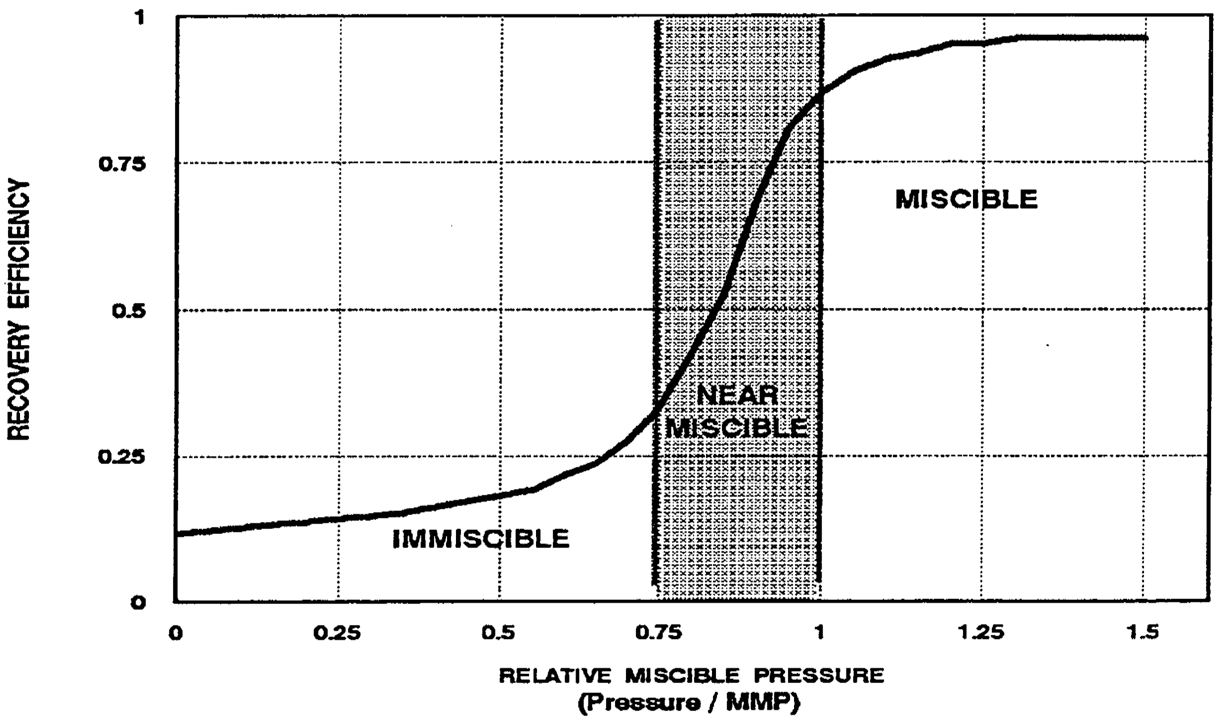


**Fig. 6:** Generalized Recovery Efficiency vs. Relative Minimum Miscibility Pressure.

The $CO_2$ H-n-P process has traditionally been applied to pressure depleted reservoirs. The $CO_2$ is injected down a production wellbore in an immiscible condition. Theoretically the $CO_2$ displaces the majority of the mobile water within the wellbore vicinity, while bypassing the oil-in-place. The $CO_2$ then absorbs into both the oil and remaining water. The water will absorb $CO_2$ quickly but only a relatively limited quantity. Conversely, the oil can absorb a significant volume of $CO_2$ although it is a much slower process. For this reason the producing well is shut-in for what is termed a soak period. This soak period is typically 1-4 weeks depending upon fluid properties and reservoir conditions. During this soak period the oil will experience swelling, viscosity and interfacial tensions will decrease, and the relative mobility of the oil will therefore increase. Once the well is returned to production, the swelled oil will flow toward the wellbore (pressure sink). Incremental production normally returns to its base level within six months. Previous work has shown that diminishing returns would be expected with each successive application. Most wells are exposed to no more than two or three cycles of the $CO_2$ H-n-P process. **Fig. 7** visually illustrates the proposed $CO_2$ H-n-P process.

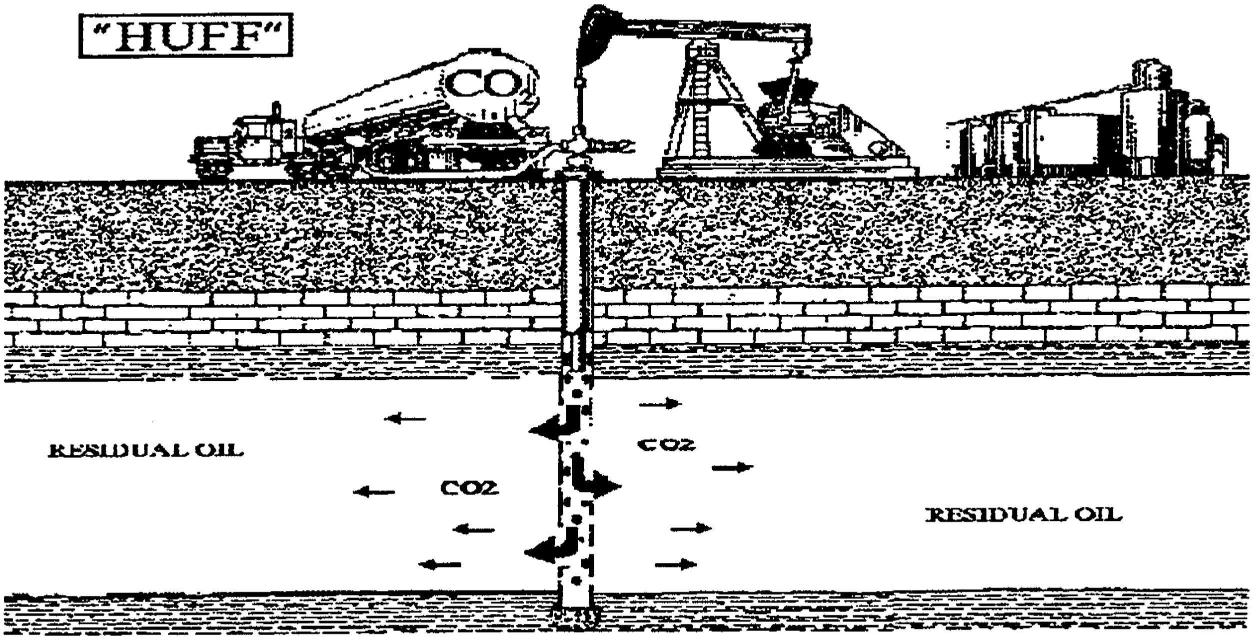


Fig 7a: Injection or "Huff" phase of hte Project

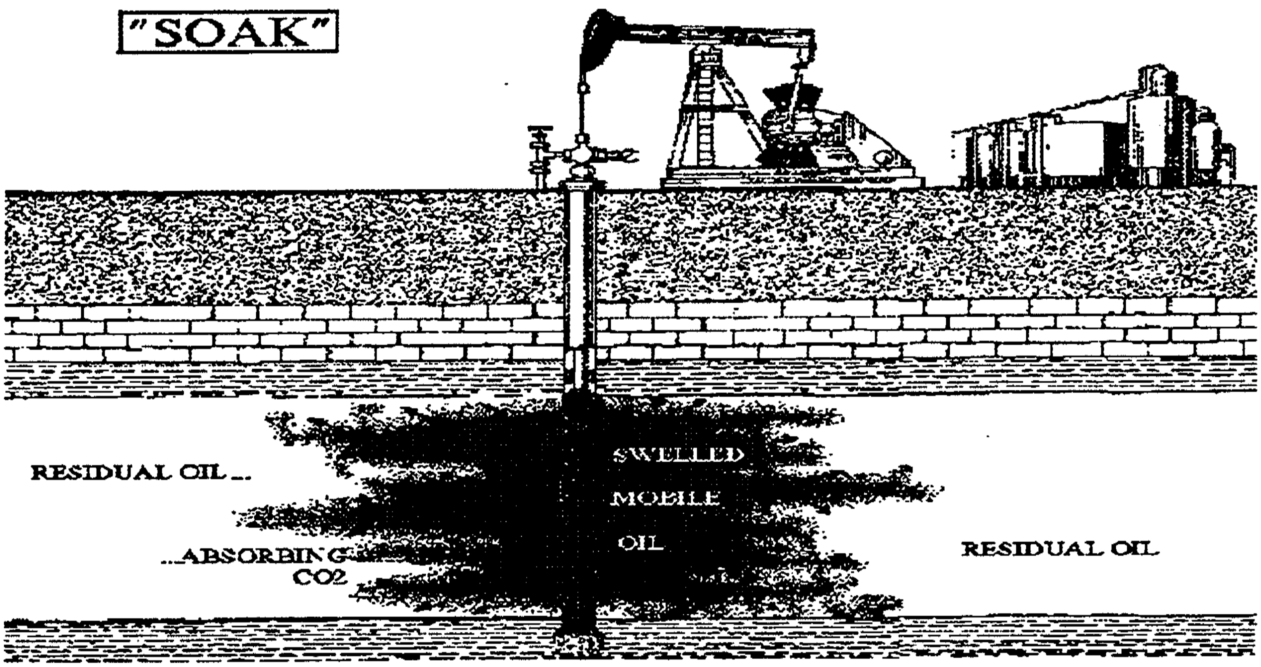


**Fig. 7b: The "Soak" phase of the Project.**

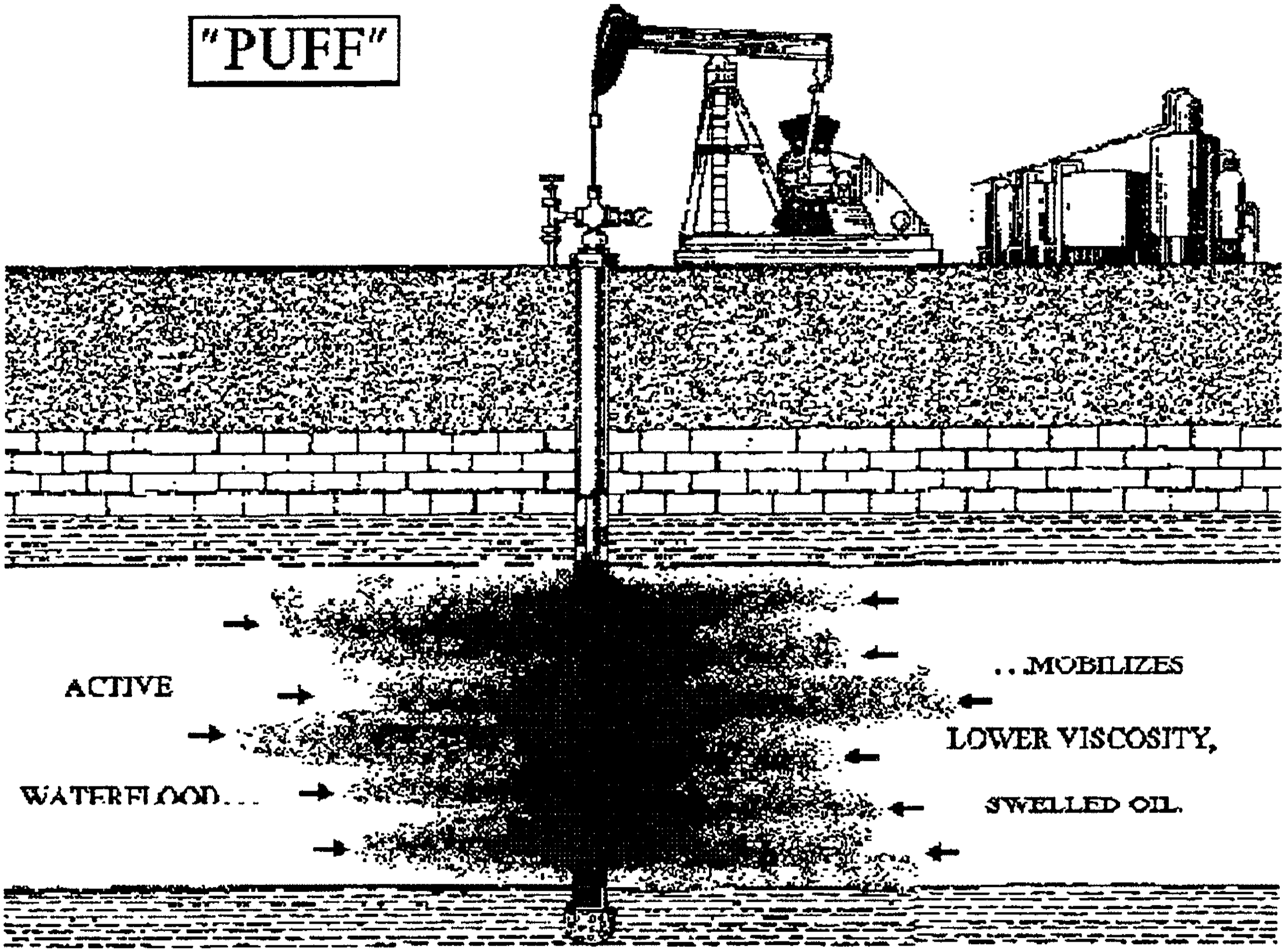


Figure 7c: The production or "Puff" phase of the Project

The vast majority of field trials have been conducted in low-pressure environments. Trials in moderate water-drive reservoirs have met with limited success. **Fig. 8** shows a linear relation between these reservoir-drive mechanisms and recovery efficiency developed by TEPI from Gulf-Coast sandstone reservoir trials. The Drive Index is simply a measure of the contribution of reservoir-drive mechanisms for a given reservoir. The relationship depicted suggests that an operator should avoid higher pressure water-drive reservoirs, or in the case of CVU--waterfloods.

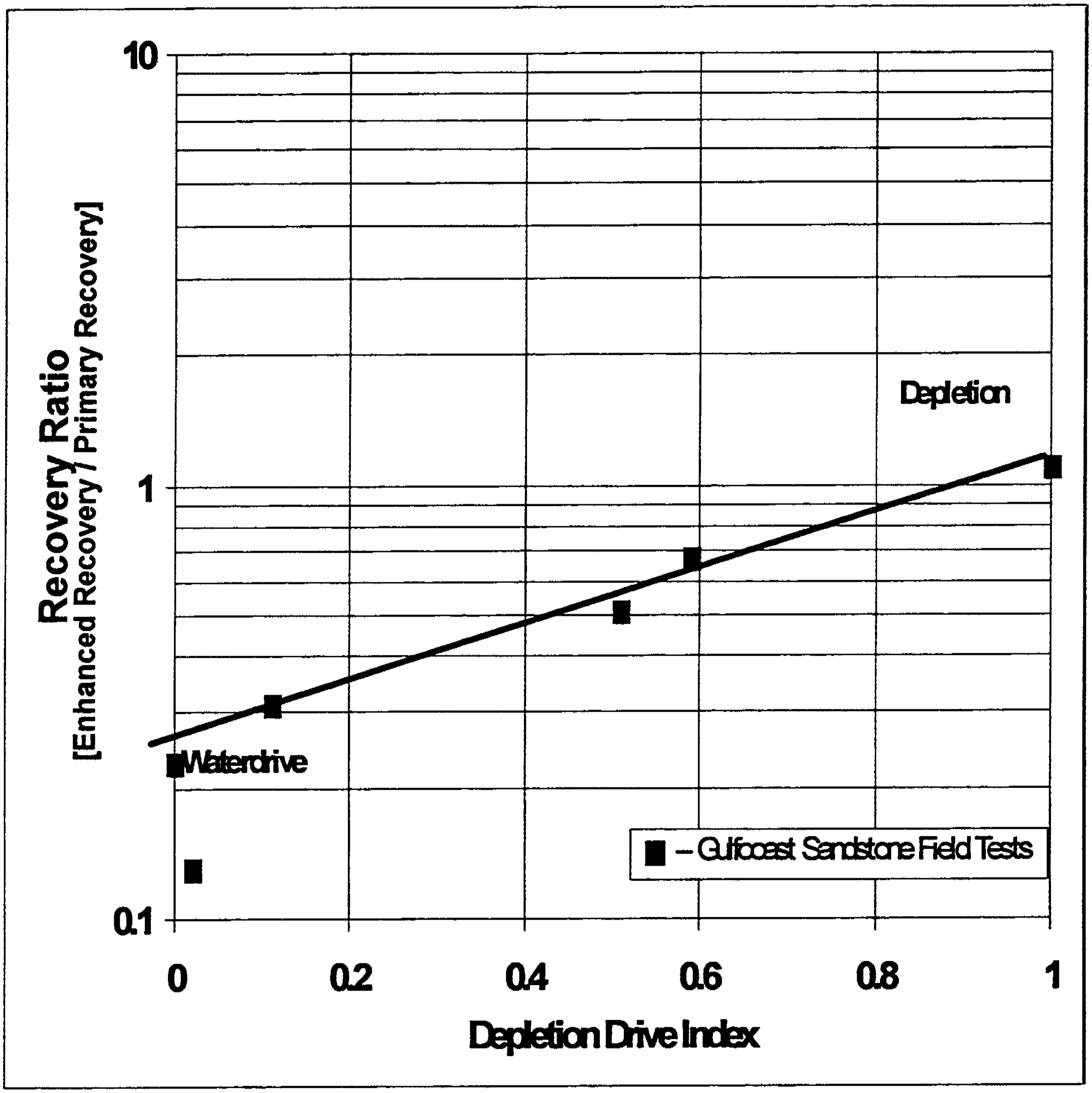


**Fig. 8:** Relation between Drive Index and Recovery Efficiency of the $CO_2$ H-n-P process. Developed from Gulf-Coast sandstone reservoir field trials.

Unfortunately, as with the case at CVU, major oil reserves available to Permian Basin operators are associated with maturing waterfloods.

After further review of Fig. 6, it was hypothesized that $CO_2$ H-n-P recovery efficiencies might be improved in the waterflooded environment by utilizing immiscible injection steps and miscible, or near-miscible production steps. The near-wellbore vicinity of producing wells is the pressure sink in the system. Further, it might be possible to gain an advantage in certain reservoir environments by temporarily ceasing offset water injection--creating somewhat of a pressure depletion environment. If an operator could inject in an inefficient manner, manipulating pressures and rates, such that a limited amount of oil was mobilized and/or fingering of the injectant occurred, then a 2-3 fold improvement in recovery efficiencies might be obtained. Once a given volume of $CO_2$ was injected, the offset injection could be restarted. The pressure in the near-wellbore vicinity could increase to, or exceed, MMP conditions during the soak due to the active waterflood. Under these conditions, a more significant swelling of the oil would be experienced in the near-wellbore producing area than in a pressure-depleted reservoir. The no-flow pressure boundary of the waterflood pattern would also serve to confine the $CO_2$, reducing leak-off concerns. When the well is returned to production, the mobilized oil would be swept to the wellbore by the waterflood. Energy introduced to the typical pressure depleted reservoir normally would dissipate away from the subject wellbore, further reducing efficiency. A study was initiated to investigate the possibilities.

## DISCUSSION

Work is complete on the reservoir characterization components of the project. Macro zonation exists throughout the study area and cross-sections are now available. The Oil-Water Contact has been defined. Laboratory capillary pressure data was used to define the initial water saturations within the pay horizon. The reservoir's porosity distribution has been enhanced with the assistance of geostatistical software. Three-Dimensional kriging created the spacial distributions of porosity at inter-well locations. Artificial intelligence software was utilized to relate core permeability to core porosity, which in turn was applied to the 3-D geostatistical porosity gridding. An Equation-of-State was developed and refined for compositional simulation exercises. These topics dominated the 1994 Annual Report. Some final reservoir characterization comments regarding variances between geostatistical findings, and the waterflood review are provided in this 1995 report. Additionally, the findings from the parametric simulations, site-specific simulation history match and forecast, and field demonstration of the $CO_2$ H-n-P process are provided.

### Geostatistical Realizations

The geostatistical portion of the project has been completed. The majority of this work was consumated and reported on during 1994.[12] Geostatistics, along with other more common approaches, were used to distribute wellbore porosity data to interwell locations (cells) within the geological model. Krigged porosity values were generated using Texaco's Gridstats program. Normalized wireline porosity data from 322 wells in the project area were input to the program, along with picks for the top of the Grayburg Dolomite, Grayburg Sandstone, and San Andres. This exercise was expected to provide a more realistic distribution of the data than the typical algorithm used in standard mapping software. Initial geostatistical results proved too conservative relative to current and forecast recoveries. However, continued investigation into the impact of various inputs resulted in relatively similar results. As it turned out, the difference between the geostatistics and other approaches stemmed from a mis-formatted datafile. The following table (**Table 1**) compares the three methods of porosity distribution and the resulting OOIP. The previously accepted OOIP determination suggested 225.0 MMBO. The distribution of the original hydrocarbon accumulation, as determined by the three approaches is provided in **Fig. 9**.

**Table 1:** Comparison of Geostatistical approaches relative to OOIP calculations.

| MODEL TYPE | OOIP CENTRAL VACUUM UNIT |
|---|---|
| STRATAMODEL DETERMINISTIC (POWER FACTOR = 2) | 209.6 MMBO |
| STRATAMODEL STATISTICAL (POWER FACTOR = 5) | 201.4 MMBO |
| GRIDSTATS (Texaco Geostatistics Software) | 211.1 MMBO |

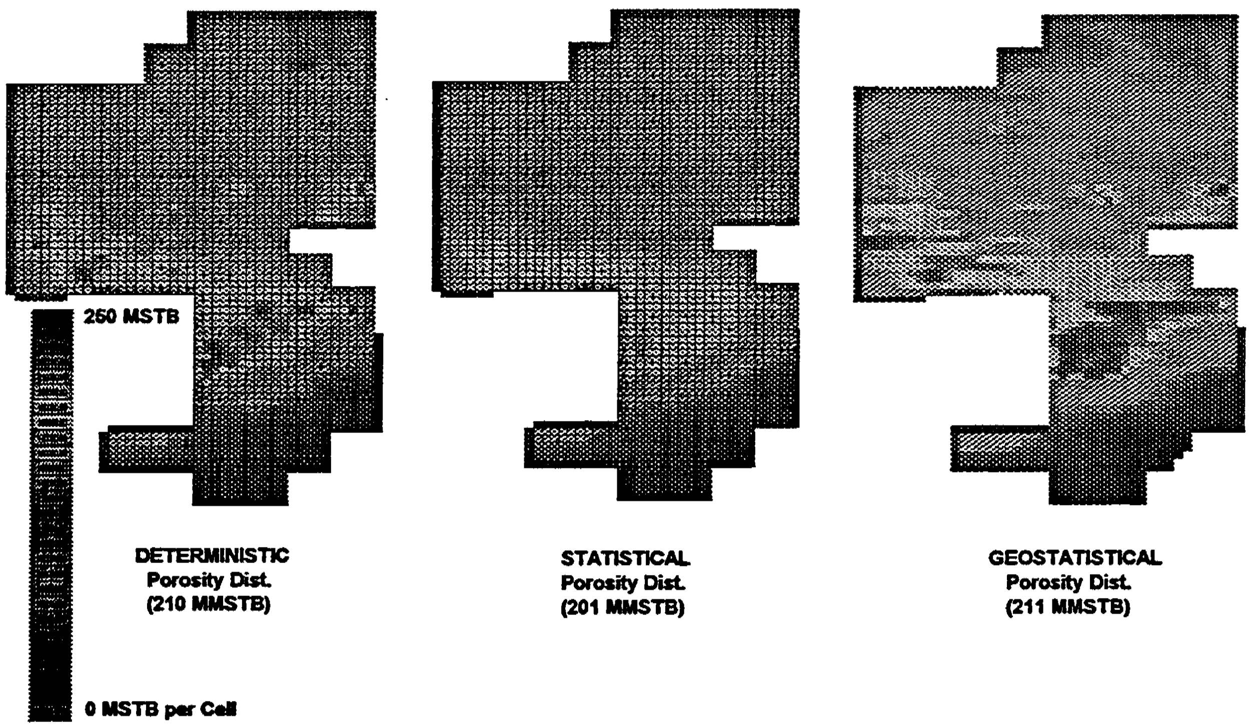


Fig. 9: Comparison of OOIP distribution based on three investigations.

The neural network, which was introduced in earlier reports, was applied to the porosity distributions to define the permeability. Capillary pressure data, also previously reported, was combined and used in calculating the OOIP reported above.

Resulting OOIP calculated from the geostatistical (Texaco's Gridstats program) derived porosity compares favorably to that using the distributions (deterministic and statistical) within the Stratamodel program. The lower value for the Stratamodel Statistical (Power Factor=5) model was to be expected. The porosity values of actual wireline measurements are not maintained at wellbore cells with this particular approach. The resulting calculations tend to represent the reservoir flow units as a more continuous architecture, with lower porosity in any given zone of comparison (i.e. the data is heavily averaged). The Stratamodel Deterministic and GridStats (geostatistics) approaches were quite similar in OOIP calculations. But, it is only the geostatistical approach that does not rely heavily on any user defined input (power factor for scaling). Had the investigators chosen different scaling factors in Stratamodel, the results could have been quite variable, or the Stratamodel Statistical approach could have even had a similar result to the other two. Both the Geostatistical and StrataModel Deterministic approaches match fairly well with the estimated ultimate recovery forecast trends. Since no flow simulation was planned for the large Project study area, no conditional simulation was done--all grids were made using kriging.

Attention in the first half of 1995 refocused on a smaller study area which encompasses the site-specific simulation area and impending initial field demonstration(s). The geostatistical exercise was repeated in this area for added modeling detail. A total of twenty stratigraphic porosity grids were made for this smaller study area. Five zones were created by kriging, and the same five zones by three successive conditional simulations. The five gridded zones are a 13 layer grid for the Grayburg Dolomite, a 7 layer grid for the Grayburg Sandstone, a 30 layer grid for the Upper San Andres, a 15 layer grid for the Lovington Sandstone, and a 90 layer grid for the Lower San Andres. Each cell is 132' X 132' on a side. The layers are approximately 4.00' thick. This model covers that same vertical component of gross pay as the larger study, after excluding some non-pay footage from the bottom of the model. The site-specific model for compositional simulation was extracted from this work.

**Waterflood Review**

A proper review of past operations is not complete without a comparison to the initial hydrocarbons in the formation. The procedures for calculating Original Oil-In-Place (OOIP) within Stratamodel software were developed and tested. OOIP was calculated for each cell in the model. Calculating OOIP in this manor required porosity, permeability, and initial water saturation, $S_{wi}$ values for each cell in the model. Porosity was derived from the distribution of porosity data from each well location. Permeability was determined for each cell using the Neural Network described in previous reports. Initial water saturation was calculated for each cell using the Leverett "J" function (described in earlier reports). Polygons for unit boundaries and water flood patterns were added to the model. These polygons allowed summation of OOIP for specific areas and individual waterflood pattern review. Details of this work were previously supplied.[12] Summation by stratagraphic sequence is also possible, allowing each of the five sequences to be summed individually. Many parameters, such as net pay, hydrocarbon pore volume, efficiency's, etc. were investigated and mapped. Many of these parameters have been included in **Appendix "A"** of this report in both Tabular and Figure format.

Current observations are that overall, either, 1) the property is experiencing ultimate recovery efficiencies above normal, at approximately 44.8% OOIP, 2) the OOIP is too low, or that 3) two independent approaches to estimating ultimate recoveries, although equivalent in findings, resulted in erroneous forecasts. Investigations continued during the later half of 1995. The site-specific modeling helped address this issue during the history matching phase. The history matching went very smoothly. This is believed to be due to the detail provided in the geologic model, coupled with the initialization parameters developed within this study. The simulation suggests that the calculation of, and distribution of hydrocarbons is good. Overall, volumes and efficiencies fit with structural and geologic trends. Therefore, it is inferred that the ultimate recovery efficiency is above normal when compared to other San Andres waterfloods.

A review of waterflood efficiencies was conducted. It was anticipated that this detailed review would allow proper selection of the field demonstration site(s) for the proposed technology. The results of the parametric simulation studies were to be coupled with the waterflood review information. The intent was to be able to select a sufficient variation in reservoir conditions/character to support the parametric studies findings. In turn, this information would ultimately assist in developing guidelines to assist operators in selecting candidate sites based on this information and actual field trials. The waterflood review was performed parallel to the parametric simulation exercises which eventually concluded that reservoir characterization has relatively limited impact on this near-wellbore process as it relates to the $CO_2$ H-n-P (see discussion under Parametric Simulation topic). Following the actual demonstration, this data may still prove beneficial to the analysis.

Based on review of the available data, a site-specific model area was selected. It is located in the northern area of Section 6, T18S - R35E, Lea County, New Mexico (Fig. 5). This model area represents average reservoir conditions known to exist within the Project study area. It includes four (4) of the original 40-acre 5-spot injection patterns. This model area was drilled on a 10-acre well spacing -- providing modern logging suites in early 1995. The size of the model allows for the potential to analyze results from more than one field demonstration. This configuration was selected as a safety precaution, should the initial site fail mechanically. The data helped refine the model and provides a future measure to the geostatistical efforts. The drilling was not part of the cost-share DOE project.

**Compositional Simulation Study**

The reservoir characterization work[12] was incorporated into models for computer simulation. Western Atlas' VIP-COMP Simulation software was utilized. An equation-of-state (EOS) with nine pseudocomponents was developed using the Zudkevitch-Joffe-Redlich-Kwong approach to represent interactions between $CO_2$ and oil.[12] Extra efforts were made at this stage to assure an adequate match of phase properties, including $CO_2$ densities over an anticipated wide-pressure range. The EOS was able to match the behavior of slim-tube tests[13] at, above, and below the MMP of 1,250 psia. This added credibility to the EOS and was important since the $CO_2$ would be in contact with hydrocarbons over a wide pressure range.

A parametric simulation study of the $CO_2$ H-n-P process was employed to identify reservoir parameters that might be favorable or unfavorable to the process and to provide insight into the best operational procedures. The results from the parametric study were incorporated into a site-specific simulation which was used for history matching the waterflood and forecast recoveries.

**Parametric Simulations.**[14] A radial model with 25 grid cells in the radial direction was used. The model employed geometrical spacing between the grids but included local grid refinement for better definition near the wellbore. An injector was placed in the outside radial grid so waterflooding could be simulated and pressure in the model maintained. Porosities, saturations, and net pay were representative of the site selected for the field demonstration. Relative permeability curves obtained from laboratory measurements were used.

In some previous H-n-P's in a waterflooded environment, the total liquid production rate increased.[6] This increase represented the majority of incremental H-n-P oil. However, there is no mechanism in a simulator to cause an increase in total liquid production over an extended period of time. In this study, an attempt was made to keep the steady total liquid production rate constant before and after the H-n-P. This made it necessary to operate the simulator sometimes with a well rate constraint rather than a bottom-hole pressure constraint.

*Parameters Investigated.* The reservoir parameters investigated in the study were the degree of reservoir heterogeneity and the magnitude of the watercut at the start of the H-n-P. The sensitivity to the number of layers in the model was also investigated as part of the study of the effects of reservoir heterogeneity. The operational parameters investigated were the $CO_2$ slug size, the $CO_2$ injection pressure (and rate) during the huff, the soak time, the gas production rate during the puff, and the number of H-n-P cycles. For consistency, most of the study was done using a slug size of 25,000 Mcf$CO_2$. A slug size of 25,000 Mcf$CO_2$ provides about 80 Mcf$CO_2$ per foot of net pay for the cases studied here.

*Simulator Limitations.* Commercial reservoir simulators normally do not directly incorporate a number of the mechanisms which have been identified or suggested as being present in the $CO_2$ H-n-P process. As part of this exercise, methods were identified which could be used to indirectly compensate for the absence of potentially important flow mechanisms in the simulator. These included primarily increases in the gas-oil capillary pressure to very large levels to approximate diffusion during the soak period and increases in the oil relative permeability curve (and even reductions in the residual oil saturation) during the puff to approximate suggested oil relative permeability hysteresis. The VIP-COMP simulator can also include directional relative permeability so that a decrease in the gas relative permeability can be modeled as desired. Diffusion tends to bring oil back toward the well during the soak period, and an increase in the oil relative permeability increases oil production. Recovery efficiency, or $CO_2$ utilization, in this parametric study could have been improved if these options had been incorporated in the predictions. However, they were not invoked during this study but were instead left to be used as needed for future history matching of the project.

*Typical H-n-P Behavior.* Typical performance for a 25,000 Mcf$CO_2$ injection is shown in **Fig. 10**. Following a soak period, a typical case showed a large increase in the oil rate beginning about 10 to 15 days after the well was placed back on production. The peak oil rate was typically 2 to 5 times the base rate. Prior to the peak response time, the production was primarily gas (mostly $CO_2$) with little water or oil. A large percentage of the $CO_2$ which had been injected was produced back before the oil peak. After the peak, the oil rate diminished rapidly with time, returning to the base rate within 40 to 80 days. The incremental oil recoveries were typically between 1.5 to 3.0 MSTB. Good $CO_2$ utilizations were in the 10 Mcf/STB range, which are similar to the factors for standard $CO_2$ floods and are much greater than the factors of about 1 Mcf/STB previously reported in the literature for H-n-P processes. However, as noted earlier, including additional flow mechanisms could improve the utility. The objective of the parametric study was to compare the relative effects of selected parameters rather than predict the actual performance. It should, however, be realized that factors of 1 Mcf/STB are extremely small. Because 1 Mcf$CO_2$ occupies about 0.5 reservoir barrels for the situation here, a utility of 1 Mcf/STB means that one reservoir barrel $CO_2$ would recover about two reservoir barrels of oil.

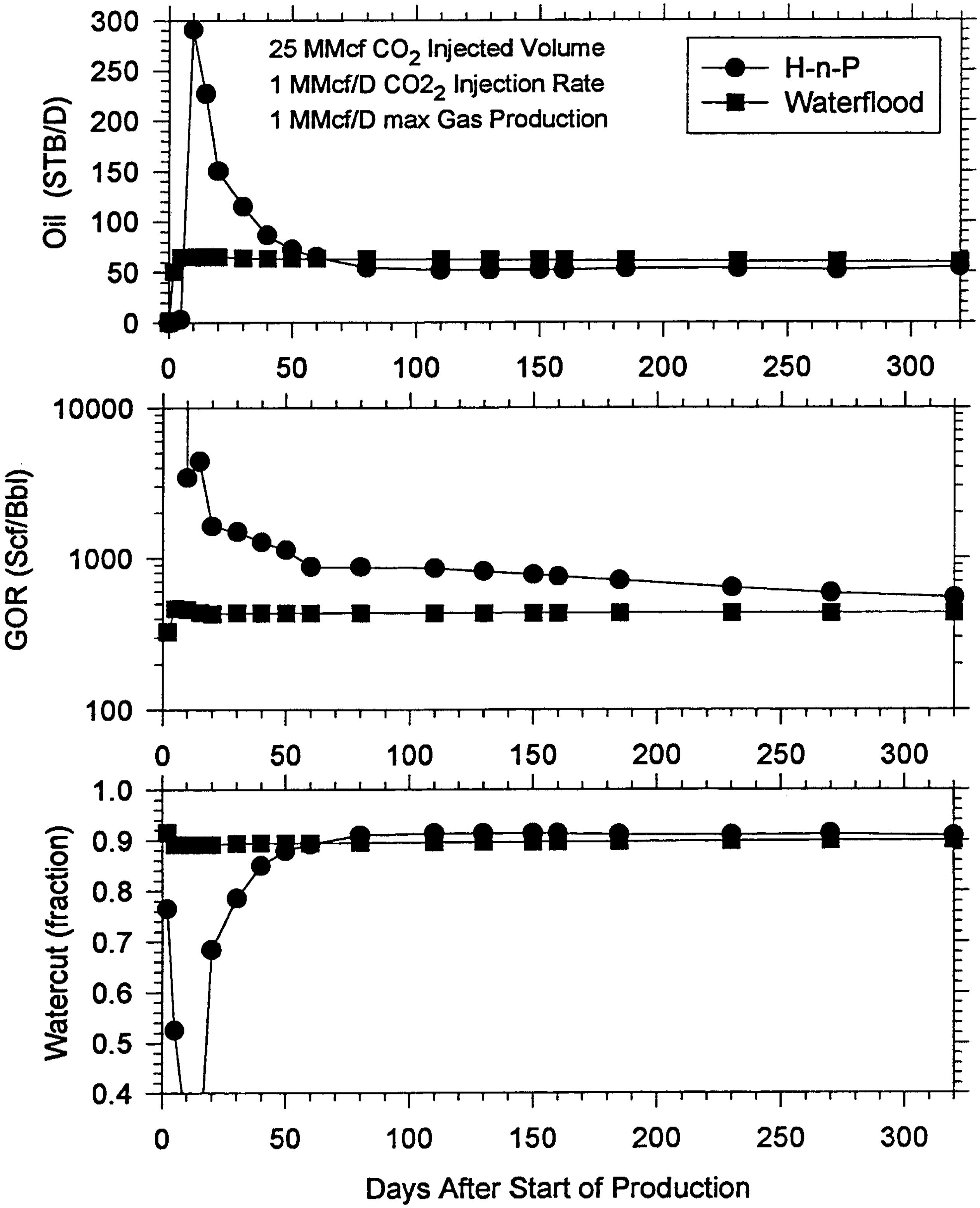


Fig. 10: Typical Simulated $CO_2$ H-n-P Performance.

Most of the $CO_2$ which was injected was produced back before or during the peak oil production. In the model, the $CO_2$ which was injected, except for the trapped volume, was ultimately produced back. The gas-oil ratio (GOR) did remain high for several months after the well was put back on production.

The water-oil ratio (WOR) returned to its base level soon after the oil production peaked. The WOR was not reduced for an extended period of time. Although a long-term reduction in the WOR would be desirable, such a change can not be expected. A previous study showed that the WOR is determined by the fractional flow of oil and water coming to the well from the larger part of the reservoir outside of the zone contacted by a process such as a H-n-P.[15]

**Table 2**
Effect of Important Parameters on Oil Production

| | Incremental Oil (MSTB) | Utility (Mcf/STB) |
|---|---|---|
| **$CO_2$ Volume Injected, MMcf** | | |
| 78 | 5.1 | 15.3 |
| 50 | 3.7 | 13.5 |
| 25 | 2.3 | 10.9 |
| 10 | 0.9 | 11.1 |
| **Watercut, Fraction [25 MMcf Case]** | | |
| 0.85 | 1.4 | 17.9 |
| 0.90 | 2.3 | 10.9 |
| 0.97 | 3.1 | 8.1 |

***Parametric Study Results.*** The effect of key parameters are shown in **Table 2**. Incremental recovery is defined as increased production over that of the waterflood after the well is put back on production.

The effect of **reservoir heterogeneity** was investigated by changing the base reservoir description. The layer permeabilities were altered. An initially very surprising result was that the H-n-P process was not found to be very sensitive to reservoir heterogeneity. This is directly opposite to standard $CO_2$ floods which are very sensitive to reservoir heterogeneity. An explanation can be provided by considering the differences in the standard $CO_2$ flood and the H-n-P. In a standard flood, high reservoir heterogeneity degrades performance because $CO_2$ inefficiently keeps channeling through zones in which the oil has already been recovered. In a H-n-P this does not happen. Rather, all the $CO_2$ which is injected, except for the trapped volume, is ultimately produced back from all the layers, even from the thief zones. All the zones are just processed one time. A thief zone does not degrade a H-n-P process unless the $CO_2$ permanently channels away. Reservoir heterogeneity does not appear to degrade the Huff-n-Puff process substantially unless there are very high permeability zones without vertical permeability. The presence of vertical permeability largely prevents high permeability streaks from degrading the process. A large amount of vertical permeability is not needed and values as little as 0.1 to 0.2 md are effective. The vertical permeability makes a layered system with heterogeneity more effective than a completely homogeneous system. If vertical permeability is present, the $CO_2$ enters the high permeability streaks but can move vertically into other layers. If there is no vertical permeability, zones of very high permeability will degrade the process since the $CO_2$ is confined primarily to the high permeability layers.

An additional finding, which also indicates that reservoir heterogeneity is not critical for the H-n-P process, is that predicted H-n-P performance was not found to depend significantly on the **number of layers** used in the simulation model. Similar results were found with 1, 2, 5, and 12 layer models. Even though a one-layer model is completely homogeneous, the results from a one-layer model were typically within 20% of the results from multi-layer models. The results shown in Fig. 10 are from a one-layer model. Previous investigators have also suggested that one-layer models are sufficient for modeling H-n-P processes.[8, 16]

Another surprising result was that the H-n-P process in waterflooded (water drive) environments appeared to work better for wells with a **higher water-cut**. These wells have an oil saturation close to the residual oil saturation to waterflood. The incremental oil recovery was somewhat higher and the $CO_2$ utilization was somewhat lower for a high water-cut case. The peak H-n-P oil rate was not found to be a strong function of the prior watercut. Consequently, a well with a high water-cut showed a large relative increase in the oil rate.

As previously discussed, the original idea of the CVU H-n-P process was to try to inject the $CO_2$ below the MMP of 1,250 psia, and then let the pressure build during the soak period. However, the simulation model suggested that an operator could not inject the $CO_2$ below the MMP. For the CVU cases, the reservoir is above the MMP. Near-wellbore average pressure reached the MMP rather rapidly after beginning injection in this simple model. Furthermore, the pressure rapidly reached the MMP even when the well was shut-in without injection and when offset injection was stopped 15 days in advance. Oil recoveries in the $CO_2$ H-n-P process simulated here were not found to depend strongly on the injection pressure or rate. **Injection pressures** from the MMP to 3000 psia were investigated, and it was found that the process was not degraded significantly at successively higher pressures when above the MMP.

Limiting the **gas production rate** between 500 and 3,000 Mcf/D did not greatly affect the incremental oil production. It was found that slightly higher incremental recoveries occurred with the higher gas production rates.

The volume of incremental oil was found to depend on the volume of $CO_2$ injected. As the **volume of $CO_2$** was increased, the incremental oil recovery was increased, but also the start of oil production during the puff was delayed.

In agreement with previous simulation studies, soak times longer than a few days did not produce different results.[8,16] Current commercial simulation models may not adequately handle the soak period.

Multiple H-n-P cycles were not found to be very effective. The reason was that the main recovery mechanism was gas trapping, and the majority of trapping occurred in the first cycle. The repetitive application of the process was seen as unwarranted in the waterflooded environment.

***Dominant Mechanism***. Entrapment of $CO_2$ by gas hysteresis was found to be the dominant recovery mechanism. This study supports the conclusion of Denoyelle and Lemonnier that a trapped gas saturation is the main cause of incremental oil for a H-n-P in a light oil reservoir.[17] The mechanisms of oil swelling and viscosity reduction are important in the production of the initial oil peak, but they do not result in permanent incremental oil. In the present study, if a trapped gas saturation generated by gas relative permeability hysteresis was not used in the H-n-P simulation, virtually no incremental oil was predicted. The trapped $CO_2$ in the H-n-P zone prevents the H-n-P zone from being resaturated with oil that is flowing toward the well from further out in the reservoir. What happens without a trapped gas saturation is that although the H-n-P initially produces oil from the affected region by reducing the oil saturation to very low levels, oil from further out in the reservoir enters the affected zone as it flows toward the well and re-establishes an oil saturation similar to the saturation before the H-n-P. In other words, without a trapped gas saturation, the oil and water flowing into the H-n-P zone return the oil and water saturations to the values that would have existed without a H-n-P. A trapped gas saturation prevents resaturation by oil.

In the simulator, a trapped gas saturation has a tendency to reduce the total liquid production rate. This effect was not used in the parametric studies or the site-specific forecast. For both these cases, an attempt was made to keep the steady total liquid production rate constant before and after the H-n-P by operating the simulator sometimes with a well-rate constraint rather than a bottom-hole pressure constraint.

***Summary***. Reservoir description was found not to be as important a parameter in a H-n-P as in a standard $CO_2$ flood. This indicates that most wells could be H-n-P candidates unless they have problems that would cause the $CO_2$ to channel permanently away. H-n-P operations can be flexible because H-n-P predicted performance was found to be similar over a range of injection pressures and gas production limits. Injection volume is an issue because recoveries were found to be related to the total $CO_2$ volume injected, similar to typical miscible floods.

**Site-Specific Study.**[18] The model site covers 160 acres (four original 40-acre five-spot patterns) in the north half of Section 6 (outlined in Fig. 3). The model covers an area that was developed on 10-Acre spacing in early 1995. The site spans varying reservoir quality. The northwest pattern is more contiguous, and has exhibited textbook waterflood characteristics. The southeast quarter is more heterogeneous and has had a much poorer waterflood history. The model site covers the margin between the Northwest Shelf and the Delaware Basin. Producers are located on the periphery of the model. Four interior producers are considered candidates within the model area; however, CVU Well No. 97 was chosen as the most representative of the reservoir and is the only pattern comprehensively evaluated to date.

The 160-acre model was finely gridded with 26 rows and 22 columns (132 ft. × 132 ft.). Twelve layers were incorporated to model flow units identified by earlier geostatistics work. A cross-section through the model is provided in **Fig. 11**. Additional local grid refinement was imposed at the cell encompassing the producing wellbore in an effort to more accurately mimic the process.

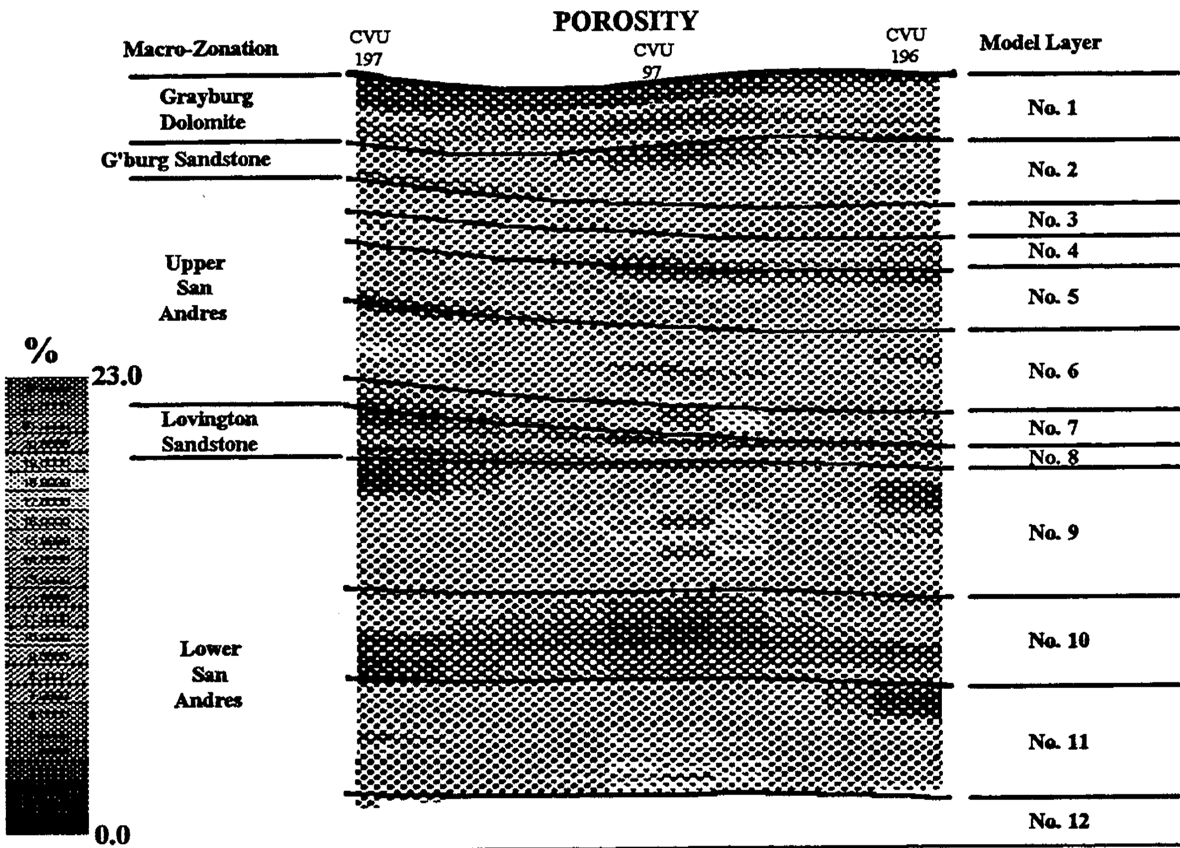


**Fig. 11:** East-West cross-section through Porosity model. Macro-zonation and model layer numbers identified.

A short investigation was performed to evaluate the significance of grid size and various finite difference approximations on predicted oil recovery. A clear significance of nine-point versus five-point finite difference approximations was found when dealing with a courser grid. Local grid refinement in this case did not appear to have a significant effect on oil recovery. A finer grid was made which resulted in similar recoveries for both the five-point and nine-point approximations. The conclusion of these initial exercises was that local grid refinement may not be necessary for a nine-point formulation. The benefits of local grid refinement to the analysis of near wellbore effects, such as pressure, which were expected to dominate much of the field demonstration were not specifically addressed. Local grid refinements were ultimately deemed necessary since the injected volume would otherwise only reflect changes in a single cell.

The full model contained 6,924 cells (6,864 cells, exclusive of local grid refinement). History matching the waterflooded period of 1978 (start of waterflood) through 1995 was performed. The historical oil rates were used as input to the simulator, and the water production rates were history matched primarily by adjustments in the oil relative permeability curve. Although the primary production is available, it cannot be accurately history matched with the current equation-of-state since it was developed from Pressure, Volume, and Temperature (PVT) studies on the waterflooded oil properties. No PVT data is available prior to waterflooding. The relative permeability adjustments were kept within the range of laboratory data. A forecast of the process was developed for a demonstration at CVU No. 97, and is provided in **Fig. 12**. **Appendix "B"** contains the Input and Output datasets from this exercise. A moderately large gas-oil capillary pressure and trapped gas hysteresis were the only special relative permeability features used in developing the forecast. In addition, the steady total liquid production rate was kept constant before and after the H-n-P by operating the simulator with a well-rate constraint rather than a bottom-hole pressure constraint.

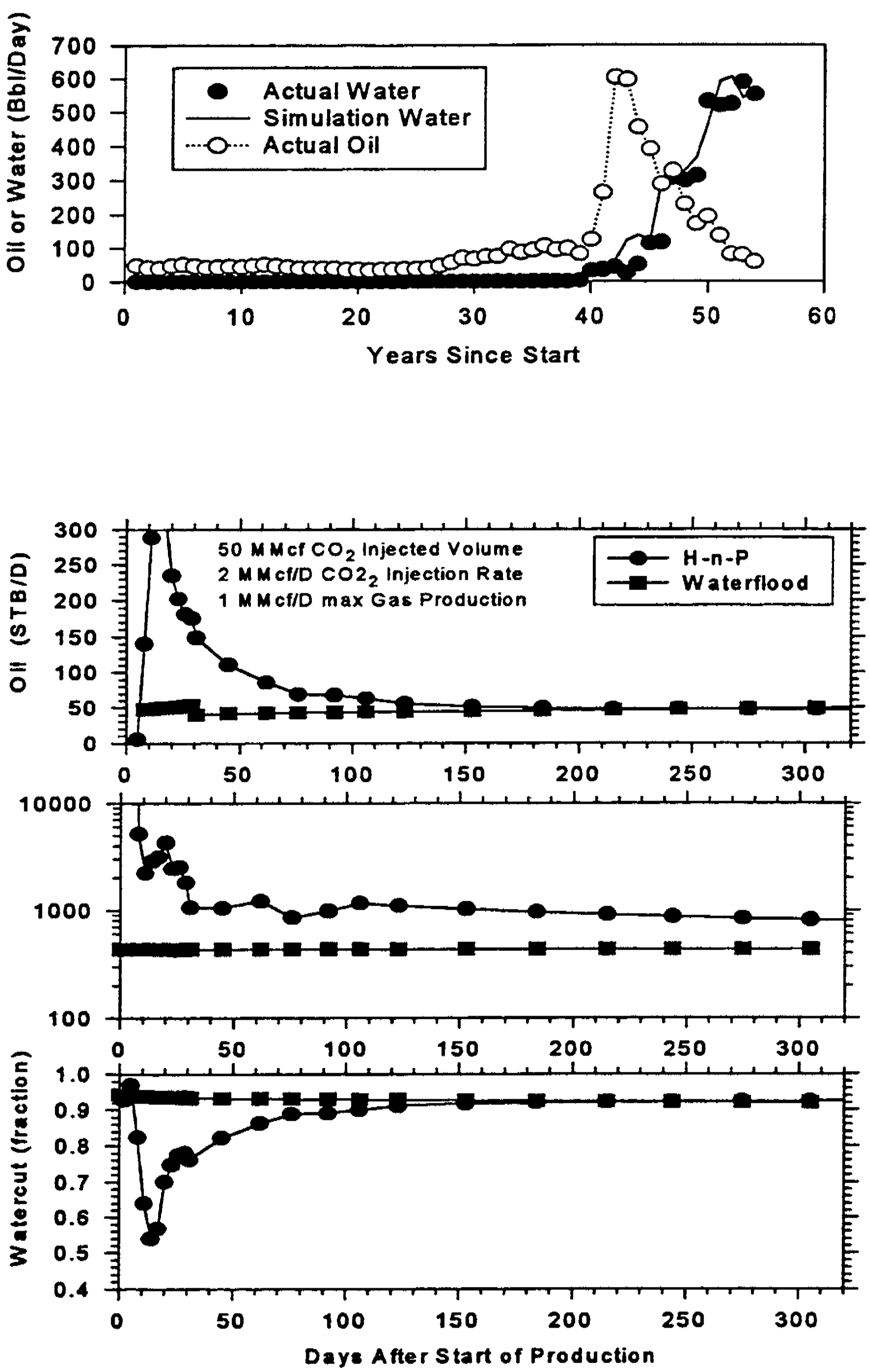


Fig. 12: Demonstration History Match (primary + secondary) and $CO_2$ H-n-P Prediction for CVU No. 97.

**Field Demonstration**

Even though simulation exercises suggested reservoir heterogeneity would not play a large role, a well with average reservoir characteristics of the CVU was desired. Additionally, the parametric study showed that a higher water-cut production stream would have a better $CO_2$ utilization ratio. CVU No. 97 was selected in part based on these guidelines. The well has several distinct, relatively thin, higher permeability flow units which are common within CVU. The remainder of the net pay is of average reservoir quality.

CVU No. 97 was drilled in 1938 to a depth of 4,725 ft. An open-hole completion was made with 7.0 in. casing set at 4,099 ft. Cement was circulated back up into the surface casing. This completion left 161 ft. of impermeable strata above the pay zone exposed in the 6.125 in. wellbore. Casing integrity or unknown thief zones have been cited in the literature to be primary causes of failure in other work. A casing-inspection log and cement-bond log revealed a competent wellbore. Additionally, there is no record of fluid production from, or losses to, the exposed non-pay interval at CVU.

A volume of 50,000 Mcf$CO_2$ was required. The volume was determined to be sufficient for the storage volume available in the near wellbore vicinity, yet small enough to reduce concerns of any loss of $CO_2$ beyond the interwell distance if the three higher flow-capacity zones took all the injectant. Based on average reservoir parameters, this volume would expose the reservoir to less than a 100 ft. radius of $CO_2$.

**Downhole Operations.** The production equipment was removed from the wellbore after tagging 10 ft. of fill material at total depth. Since the well had been acidized in recent months, no further remedial action was performed. An on-off tool and injection packer trimmed for $CO_2$ service was run on 2.875 in. coated tubing and set in the casing. Inhibited water was placed on the backside. Testing frequency was stepped up in the prior month to confirm a stabilized production trend.

**Surface Operations.** The theory of ceasing offset water injection was not strongly supported by simulation. However, recognizing that simplistic models may not have the capability to quantify this case, the offset injection was shut-in 17 days before $CO_2$ injection commenced at CVU No. 97.

***$CO_2$ Storage/Injection Equipment.*** A pipeline alternative was investigated, but was found to be somewhat costlier for the near-term demonstration component of this project. The $CO_2$ transportation and pumping services were awarded to $CO_2$, Inc. out of Midland, Texas. The $CO_2$ was trucked 50 miles from a site near Allred, Texas. Each truck could haul 345 Mcf$CO_2$. Storage vessels were set in order to eliminate night deliveries. Approximately 145 round-trips were required for the project. The storage vessels were manifolded into a trailer mounted quintuplex positive displacement pump, with self-contained booster, which was connected to the wellhead. Injection rate and volume, temperature, and pressures were continuously recorded.

***Test Separator.*** Frequent and detailed testing was planned for the duration of the project. Therefore, a dedicated horizontal, three-phase, skid-mounted test vessel was fabricated for the demonstration and set at the well site. Data gathering was automated. Flowing tubing pressure, casing pressure, and temperature are monitored continuously. Liquid volumes are measured daily. Gas production rates and volumes are also being measured. Automated gas sampling provides a daily sample for gas chromatography. Liquid samples are initially gathered daily for visual inspection, API gravity determination and occasional compositional analysis. Testing frequencies will decrease with time. The well was connected to the separator with polyethylene pipe. The test separator dumps liquids through another polyethylene pipe to the existing production satellite.

***Produced Gas Handling.*** One of the major hurdles this demonstration faced was disposal of the produced gas stream. Original plans fell apart when the existing gas purchaser committed to significant new gas contract volumes. The added volumes did not leave enough plant capacity for the $CO_2$ (acid gas) within the facility.

Air quality regulations would not permit venting the hydrocarbon enriched $CO_2$ stream to the atmosphere. A $CO_2$ processing facility, operated by Phillips Petroleum Company, was in operation on the offsetting lease (miscible $CO_2$ flood). A contract was consummated to temporarily dispose of the $CO_2$ contaminated gas production. An idle 6.0 in. gas line, which passed by both the demonstration site and a satellite at the offset $CO_2$ flood, was used to deliver the contaminated gas to the $CO_2$ processing facility. Polyethylene pipe was used at both ends to tie the delivery line into the satellite and test separator.

**Initial Results.** Injection was initiated November 13 and completed on December 7, 1995. Based on the offset miscible $CO_2$ flood injection rates and pressures, an average rate of 1,500 Mcf$CO_2$/Day was expected in the demonstration. Actual injection averaged 2,210 Mcf$CO_2$/Day over 23 days net injection. Two days (separate incidents) were lost to mechanical problems involving the injection pump. Injection line temperature fluctuated between -14°F and 20°F, averaging 3.4 °F. Wellhead injection pressure averaged 644 psig and did not exceed 817 psig.

Concern over the open-hole section, lower injection pressures and higher injection rates than expected prompted an injection profile once half the target volume was injected. The $CO_2$ was found to be distributed within both the Grayburg and San Andres formations. Although the injectant was confined to the pay zone, the distribution was somewhat weighted toward the Lower San Andres. The injectant was at the reservoir temperature of 101°F by the time it reached the bottom injection interval. The estimated average bottomhole injection pressure of 2,175 psig never approached the parting pressure of the formation (3,200 psig). It is doubtful that any part of the near-wellbore vicinity was able to maintain a pressure below the MMP of 1,250 psig as originally desired.

Offset producers were monitored on a regular basis for $CO_2$ breakthrough. Levels remained in the normal 4-5% background range.

Once the target volume was in place, offset water injectors were returned to active service. CVU No. 97 was shut-in for a 20-day soak period--6 days longer than plan due to labor issues. Wellhead pressure averaged 630 psig during the last week of injection and had increased steadily to 889 psig during the soak period. Although common in the CVU water injectors, it is unknown if any cross-flow from higher permeability to lower quality zones occurred in the producing wellbore during the soak period.

CVU No. 97 was returned to active status under flowing conditions on December 27, 1995. Flowing tubing pressure averaged 631 psig with choke settings between 13/64 in. and 18/64 in. Initially, production averaged 901 Mcf/Day. Smaller choke settings produced an average rate of 409 Mcf/Day with no apparent effect on liquid hydrocarbon production. No appreciable water production has been seen although rates are beginning to increase. Compositional analyses of the gas stream are running at 94% $CO_2$. Liquid hydrocarbon production was initially too small to measure and began increasing on the third day. Samples are being collected and retained. The fluid is colorless, suggesting that lighter hydrocarbons are being effected. The well had achieved a 70 BOPD rate by the tenth net day of flow-back (average pre-demonstration was 68 BOPD). The rate should improve when the hydrostatic head is removed from the pay zone. Approximately 27% of the injected $CO_2$ volume has been produced. Simulation exercises suggest that the peak oil response will not occur until 60% of the $CO_2$ has been produced back.

Winter weather is hampering flowback, exasperating hydrate formation. An in-line heater was temporarily placed near the wellhead until liquid volumes increased sufficiently to eliminate the need. The gas flow line freezes in the evenings where liquids collect. The line has been leveled in an attempt to control the situation.

**Fig. 13** provides the field demonstration history through January 18, 1995. Supporting data is provided in the **Appendix "C"**. Monitoring continues with optimism toward a successful demonstration based on these early results.

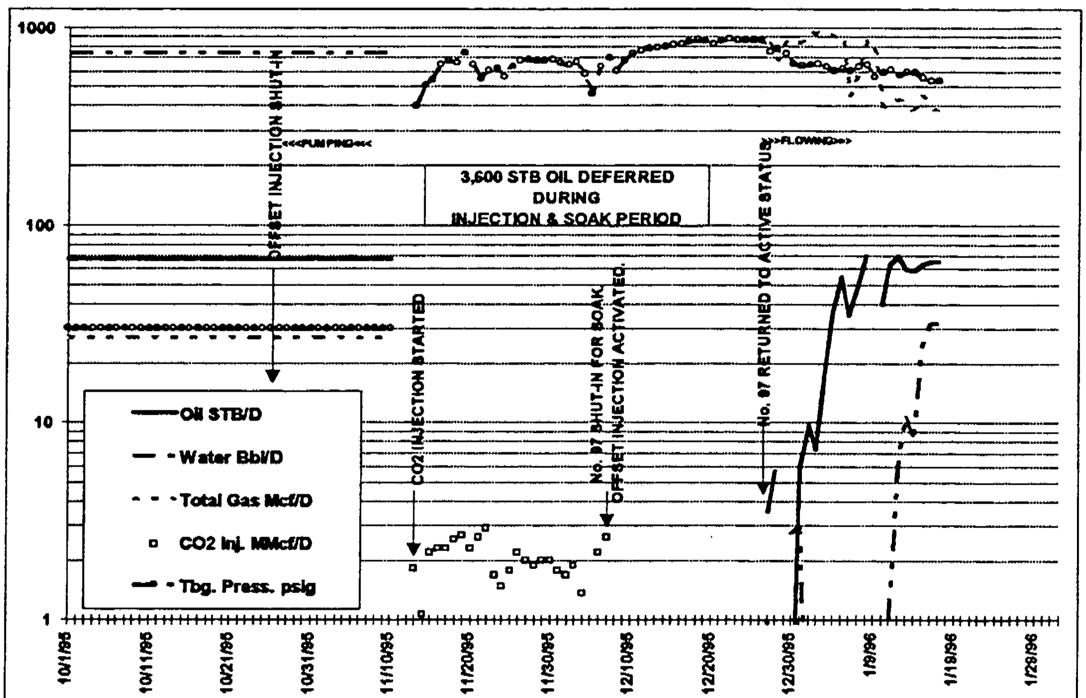


Fig. 13: $CO_2$ H-n-P Demonstration History.

### Miscellaneous

An industry Consortium led by the Colorado School of Mines selected the Central Vacuum Unit as a site to conduct 4-Dimensional, 3-Component (compressional & shear) seismic studies. The project is attempting to monitor dynamic reservoir conditions associated with the introduction of $CO_2$ into the reservoir along with stress field changes. The information gained through this seismic demonstration complements the subject project. The information may provide necessary data for refinements to the reservoir model (layering, flow capacity, fracture orientation, etc.) and fluid characterization (saturations, fluid flow; etc.). Their consideration of the CVU as a demonstration site was made possible by the fact that the accumulation of data from this $CO_2$ Huff-n-Puff project is available in the public domain; obligated by the use of DOE funding. The 4D, 3C Seismic project is being conducted in parallel, at no cost to the DOE. The Consortium is expected to release details of the work by mid-1996.

### Technology Transfer

Technology transfer activities during the 1995 period consisted of updates of project progress and findings through 1) a newsletter published by the New Mexico Petroleum Recovery Research Center, 2) Society of Petroleum Engineer publications and presentations, 3) Joint Project Advisory Team Meetings, and 4) GO-Tech, an Internet site jointly sponsored by the Petroleum Technology Trade Council and the Independent Producers Association of America.

### Conclusions

A successful demonstration of the $CO_2$ Huff-n-Puff process could have wide application. The proposed technology promises several advantages. It is hoped that the $CO_2$ Huff-n-Puff process might bridge near-term needs of maintaining the large domestic resource base of the Permian Basin until the mid-term economic conditions support the implementation of more efficient, and prolific, full-scale miscible $CO_2$ projects.

Paramount to considering the technology is the need for adequate disposal or processing of the hydrocarbon laden $CO_2$ gas. Winter months add to the operational problems encountered with flowing hydrate prone wells.

Reservoir description was found not to be as important a parameter in a H-n-P as in a standard $CO_2$ flood. H-n-P predicted performance was found to be similar over a range of injection pressures and gas production limits. Recoveries were found to be related to the total $CO_2$ volume injected, similar to typical miscible floods. Gas trapping by hysteresis was found to be the dominant factor influencing recoveries.

A need for model refinement has been demonstrated by the differences between predictions and early results (injection rates & pressures). Monitoring of the CVU field demonstration continues. Early results do not provide enough data to make an informed opinion; the project continues under cautious optimism. Over the next several months, production will be monitored and history matched with the compositional simulator. The mechanisms investigated during the parametric simulation exercise will be incorporated as warranted. Following a successful demonstration and associated history matching, the development of guidelines for the cost-effective selection of candidate sites, along with estimation of recovery potential, will be pursued. Additionally, the economic benefits of the proposed process will be reviewed.

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***** APPENDIX *****

| | |
|---|---|
| "A" | Waterflood Review: Tabular Data & Miscellaneous Maps |
| "B" | VIP-COMP Simulation Input/Output Data |
| "C" | Field Demonstration Historical Performance Data |

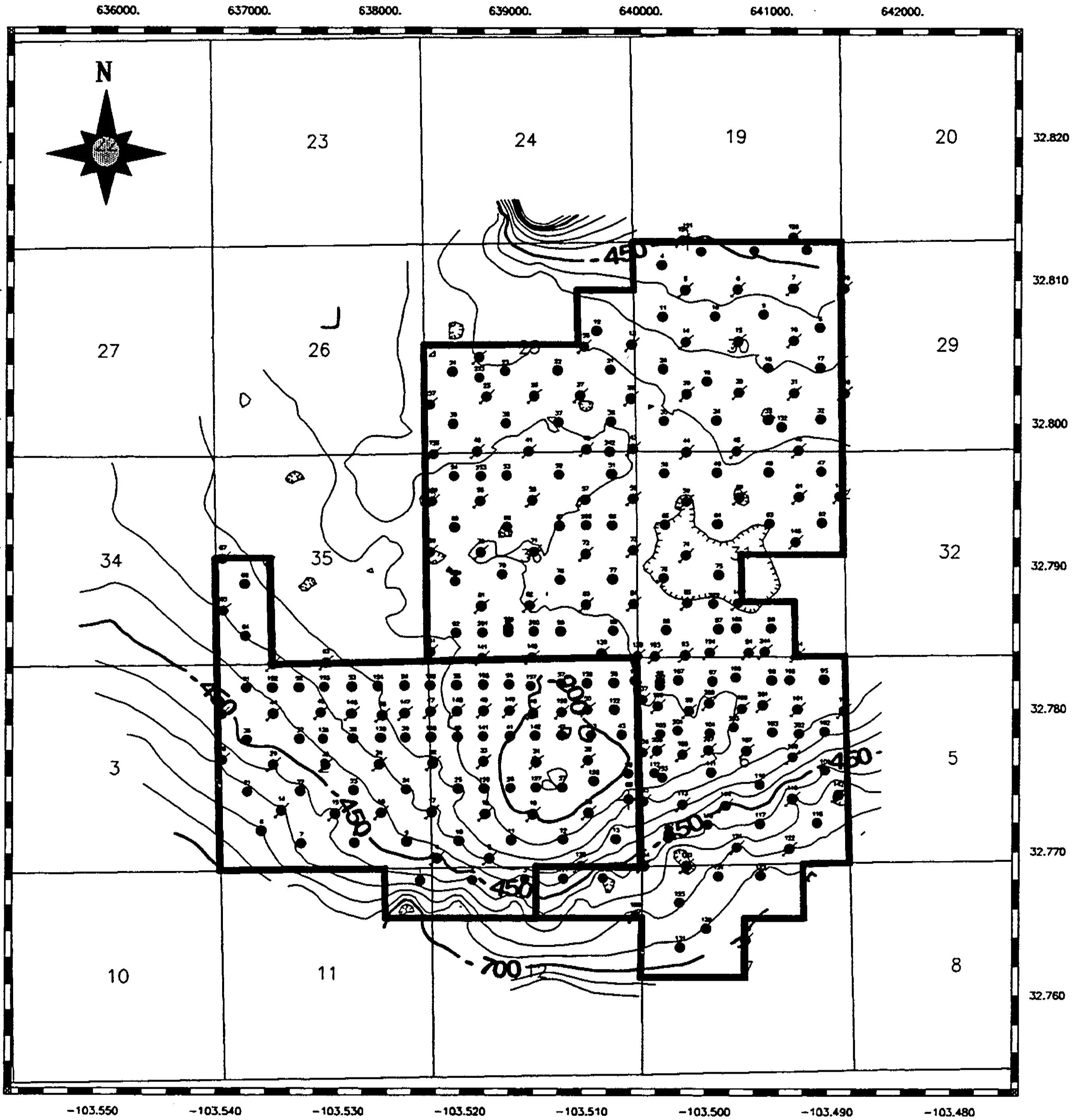
## *** APPENDIX "A" ***

# TABLE A-1

## WATERFLOOD REVIEW
CENTRAL VACUUM UNIT

| | Injector Centered Pattern | Injector Survey Position Lat. | Injector Survey Position Long. | TPV, MRVB | OOIP, MSTB | HCPV, MRVB | Avg. Swi Gross Pay % | Oil Cum. @ Start of WF MSTB | Reserves @ 1-1-95... Oil Cum. MSTB | Oil Cum. % OOIP | Log Oil Rate vs. t... Harmonic Decline Remaining MSTB | E.L. or E.F.? | Great = * Good Fit? | Total MSTB | Total % OOIP | Log Oil Cut vs. Cum. Oil... Linear Decline Remaining MSTB | Great = * Good Fit? | Total MSTB | Total % OOIP | Variance of Oil Cut Relative to Oil Rate % | @ Start of WF Avg. Sw Gross Pay % | 01/01/95 Avg. Sw Gross Pay % | @ E.L. (avg. 2 mnth's.) Avg. Sw Gross Pay % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CV5 | 32.8096 | -103.5009 | 4,938 | 1457.1 | 1913.2 | 38.7 | 168 | 219.2 | 15.0 | 7.2 | EL | Y | 226.4 | 15.5 | 46.1 | Y | 265.3 | 18.2 | 17 | 68.7 | 70.0 | 70.6 |
| 2 | CV6 | 32.8096 | -103.4966 | 5,004 | 1562.0 | 2050.9 | 40.9 | 88 | 112.3 | 7.2 | 4.6 | EL | N | 116.9 | 7.5 | 11.6 | N | 123.8 | 7.9 | 6 | 64.7 | 65.3 | 65.5 |
| 3 | CV7 | 32.8096 | -103.4921 | 4,683 | 1409.4 | 1850.5 | 39.4 | 70 | 96.0 | 6.8 | 0.0 | EL | Y | 96.0 | 6.8 | 26.0 | Y | 122.0 | 8.7 | 27 | 65.7 | 66.4 | 66.7 |
| 4 | CV13 | 32.8059 | -103.5053 | 5,140 | 1586.6 | 2083.2 | 40.4 | 249 | 364.8 | 23.0 | 43.3 | EL | Y | 408.1 | 25.7 | 23.0 | Y | 387.8 | 24.4 | -5 | 68.8 | 71.5 | 72.3 |
| 5 | CV14 | 32.8060 | -103.5009 | 6,223 | 2207.2 | 2898.0 | 46.5 | 148 | 249.1 | 11.3 | 31.4 | EL | Y | 280.5 | 12.7 | 26.5 | Y | 275.6 | 12.5 | -2 | 60.4 | 62.3 | 62.9 |
| 6 | CV15 | 32.8060 | -103.4966 | 6,226 | 2178.2 | 2860.0 | 45.8 | 146 | 242.5 | 11.1 | 96.2 | EL | N | 338.7 | 15.5 | 68.0 | N | 310.5 | 14.3 | -8 | 60.9 | 62.7 | 64.3 |
| 7 | CV16 | 32.8060 | -103.4921 | 4,638 | 1685.2 | 2212.7 | 47.6 | 195 | 248.4 | 14.7 | 33.9 | EL | N | 282.3 | 16.8 | 20.6 | N | 269.0 | 16.0 | -5 | 61.5 | 62.9 | 63.6 |
| 8 | CV25 | 32.8023 | -103.5172 | 6,558 | 1761.4 | 2312.7 | 35.2 | 671 | 1183.2 | 67.2 | 114.5 | EL | Y* | 1297.7 | 73.7 | 27.4 | Y | 1210.6 | 68.7 | -7 | 80.1 | 89.4 | 90.7 |
| 9 | CV26 | 32.8023 | -103.5133 | 7,135 | 2178.8 | 2860.8 | 40.0 | 619 | 1111.1 | 51.0 | 85.4 | EL | Y* | 1196.5 | 54.9 | 27.0 | Y* | 1138.1 | 52.2 | -5 | 73.8 | 82.1 | 83.0 |
| 10 | CV27 | 32.8023 | -103.5096 | 7,504 | 2912.9 | 3824.6 | 50.9 | 601 | 1004.3 | 34.5 | 63.7 | EL | Y* | 1068.0 | 36.7 | 23.1 | Y* | 1027.4 | 35.3 | -4 | 63.1 | 69.5 | 70.2 |
| 11 | CV28 | 32.8021 | -103.5054 | 6,542 | 2200.1 | 2888.7 | 44.1 | 394 | 703.8 | 32.0 | 34.9 | EL | Y* | 738.7 | 33.6 | 19.7 | Y* | 723.5 | 32.9 | -2 | 66.9 | 72.6 | 73.1 |
| 12 | CV29 | 32.8023 | -103.5009 | 5,087 | 1826.3 | 2397.9 | 47.0 | 233 | 509.2 | 27.9 | 176.3 | EL | Y* | 685.5 | 37.5 | 65.8 | Y* | 575.0 | 31.5 | -16 | 62.5 | 69.0 | 71.8 |
| 13 | CV30 | 32.8024 | -103.4966 | 5,384 | 1744.5 | 2290.5 | 42.4 | 328 | 580.9 | 33.3 | 348.3 | EF | N | 929.2 | 53.3 | 158.4 | N | 739.3 | 42.4 | -20 | 68.5 | 74.1 | 79.7 |
| 14 | CV31 | 32.8023 | -103.4921 | 7,103 | 2689.4 | 3531.2 | 49.6 | 407 | 576.8 | 21.4 | 130.9 | EL | Y | 707.7 | 26.3 | 228.5 | Y | 805.3 | 29.9 | 14 | 61.6 | 64.4 | 67.4 |
| 15 | CV40 | 32.7985 | -103.5181 | 7,658 | 2352.3 | 3088.5 | 40.2 | 701 | 1327.1 | 56.4 | 182.9 | EL | Y* | 1510.0 | 64.2 | 43.7 | Y* | 1370.8 | 58.3 | -9 | 74.2 | 84.0 | 85.7 |
| 16 | CV41 | 32.7985 | -103.5138 | 6,995 | 2239.9 | 2941.0 | 42.0 | 683 | 1500.2 | 67.0 | 103.4 | EL | Y | 1603.6 | 71.6 | 57.2 | Y* | 1557.4 | 69.5 | -3 | 73.3 | 87.3 | 88.7 |
| 17 | CV42 | 32.7986 | -103.5091 | 7,284 | 2653.9 | 3484.5 | 47.7 | 695 | 1386.8 | 52.3 | 186.3 | EL | Y* | 1573.1 | 59.3 | 35.0 | Y | 1421.8 | 53.6 | -10 | 67.8 | 79.2 | 81.0 |
| 18 | CV43 | 32.7986 | -103.5053 | 6,947 | 2449.4 | 3216.0 | 46.2 | 571 | 1190.3 | 48.6 | 106.1 | EL | Y | 1296.4 | 52.9 | 19.7 | Y | 1210.0 | 49.4 | -7 | 67.6 | 78.3 | 79.4 |
| 19 | CV44 | 32.7983 | -103.5009 | 7,613 | 2864.1 | 3760.5 | 49.3 | 492 | 1135.5 | 39.6 | 268.0 | EF | Y* | 1403.5 | 49.0 | 83.8 | Y* | 1219.3 | 42.6 | -13 | 62.7 | 72.8 | 75.6 |
| 20 | CV45 | 32.7983 | -103.4969 | 7,373 | 2560.7 | 3362.2 | 45.5 | 546 | 1034.4 | 40.4 | 200.0 | EL | Y* | 1234.4 | 48.2 | 106.4 | Y* | 1140.8 | 44.6 | -8 | 67.3 | 76.2 | 77.7 |
| 21 | CV46 | 32.7983 | -103.4918 | 6,227 | 2488.8 | 3267.8 | 52.4 | 587 | 962.7 | 38.7 | 149.8 | EL | Y | 1112.5 | 44.7 | 72.8 | Y* | 1035.5 | 41.6 | -7 | 63.4 | 70.6 | 72.8 |
| 22 | CV55 | 32.7951 | -103.5178 | 9,578 | 3621.0 | 4754.4 | 49.5 | 723 | 1452.3 | 40.1 | 264.6 | EL | N | 1716.9 | 47.4 | 179.2 | Y* | 1631.5 | 45.1 | -5 | 63.7 | 72.9 | 75.6 |
| 23 | CV56 | 32.7951 | -103.5135 | 8,470 | 2965.1 | 3893.2 | 45.9 | 709 | 1542.3 | 52.0 | 196.5 | EL | Y* | 1738.8 | 58.6 | 121.7 | Y* | 1664.0 | 56.1 | -4 | 68.1 | 79.9 | 82.1 |
| 24 | CV57 | 32.7951 | -103.5092 | 8,394 | 3090.0 | 4057.2 | 48.2 | 709 | 1427.6 | 46.2 | 204.4 | EL | Y* | 1632.0 | 52.8 | 62.1 | Y* | 1489.7 | 48.2 | -9 | 66.0 | 76.3 | 78.2 |
| 25 | CV58 | 32.7951 | -103.5053 | 7,499 | 2871.1 | 3769.7 | 50.2 | 716 | 1434.2 | 50.0 | 351.9 | EF | Y* | 1786.1 | 62.2 | 53.9 | Y* | 1488.1 | 51.8 | -17 | 65.5 | 77.0 | 80.3 |
| 26 | CV59 | 32.7948 | -103.5010 | 8,918 | 3748.0 | 4921.1 | 55.1 | 648 | 1509.4 | 40.3 | 232.5 | EL | Y* | 1741.9 | 46.5 | 124.5 | Y* | 1633.9 | 43.6 | -6 | 58.3 | 69.9 | 72.3 |
| 27 | CV60 | 32.7947 | -103.4968 | 7,036 | 2734.5 | 3590.4 | 50.9 | 651 | 1405.9 | 51.4 | 51.6 | EL | Y | 1457.5 | 53.3 | 47.3 | Y | 1453.2 | 53.1 | 0 | 64.5 | 77.4 | 78.2 |
| 28 | CV61 | 32.7951 | -103.4918 | 8,613 | 3850.7 | 5056.0 | 58.6 | 722 | 1445.5 | 37.5 | 110.0 | EL | N | 1555.5 | 40.4 | 86.6 | Y | 1532.1 | 39.8 | -2 | 56.5 | 66.5 | 67.9 |
| 29 | CV70 | 32.7914 | -103.5178 | 9,418 | 4076.0 | 5351.8 | 56.7 | 736 | 2045.7 | 50.2 | 347.1 | EF | N | 2392.8 | 58.7 | 138.8 | Y* | 2184.5 | 53.6 | -9 | 57.5 | 74.2 | 77.3 |
| 30 | CV71 | 32.7914 | -103.5134 | 9,190 | 3765.0 | 4943.5 | 53.7 | 734 | 2013.6 | 53.5 | 166.5 | EL | Y | 2180.1 | 57.9 | 97.8 | Y* | 2111.4 | 56.1 | -3 | 60.5 | 77.2 | 78.9 |
| 31 | CV72 | 32.7912 | -103.5092 | 7,798 | 3087.5 | 4053.8 | 51.9 | 734 | 1864.3 | 60.4 | 326.6 | EL | Y* | 2190.9 | 71.0 | 140.8 | Y* | 2005.1 | 64.9 | -8 | 63.8 | 81.2 | 84.8 |
| 32 | CV73 | 32.7914 | -103.5054 | 7,915 | 3373.2 | 4429.0 | 55.8 | 726 | 1588.8 | 47.1 | 229.0 | EL | Y* | 1817.8 | 53.9 | 126.6 | Y* | 1715.4 | 50.9 | -6 | 59.9 | 73.0 | 75.7 |
| 33 | CV74 | 32.7910 | -103.5011 | 6,299 | 2430.7 | 3191.5 | 50.8 | 649 | 1478.7 | 60.8 | 396.8 | EF | Y* | 1875.5 | 77.2 | 199.1 | N | 1677.8 | 69.0 | -11 | 66.1 | 81.9 | 87.6 |
| 34 | CV81 | 32.7876 | -103.5178 | 10,530 | 5043.7 | 6622.3 | 62.7 | 731 | 2162.5 | 42.9 | 348.7 | EL | N | 2511.2 | 49.8 | 335.8 | Y | 2498.3 | 49.5 | -1 | 50.9 | 67.2 | 71.1 |
| 35 | CV82 | 32.7877 | -103.5139 | 11,944 | 5817.5 | 7638.3 | 63.8 | 727 | 2198.6 | 37.8 | 909.1 | EF | Y | 3107.7 | 53.4 | 413.7 | Y | 2612.3 | 44.9 | -16 | 48.9 | 63.7 | 70.3 |
| 36 | CV83 | 32.7877 | -103.5092 | 9,667 | 4623.4 | 6070.6 | 62.7 | 727 | 2217.2 | 48.0 | 398.4 | EF | Y* | 2615.6 | 56.6 | 358.1 | Y* | 2575.3 | 55.7 | -2 | 51.7 | 70.2 | 74.9 |
| 37 | CV84 | 32.7877 | -103.5054 | 8,902 | 4249.3 | 5579.3 | 62.5 | 728 | 1948.8 | 45.9 | 599.1 | EF | Y* | 2547.9 | 60.0 | 301.5 | Y* | 2250.3 | 53.0 | -12 | 52.6 | 69.0 | 76.1 |
| 38 | CV85 | 32.7877 | -103.5010 | 7,937 | 3679.9 | 4831.6 | 60.7 | 686 | 1748.2 | 47.5 | 342.3 | EF | N | 2090.5 | 56.8 | 323.6 | Y | 2071.8 | 56.3 | -1 | 54.8 | 70.8 | 75.9 |
| 39 | CV141 | 32.7840 | -103.5178 | 9,982 | 4945.0 | 6492.7 | 64.9 | 710 | 1563.9 | 31.6 | 544.3 | EF | Y | 2108.2 | 42.6 | 445.2 | Y | 2009.1 | 40.6 | -5 | 49.2 | 59.4 | 65.4 |
| 40 | CV140 | 32.7840 | -103.5137 | 10,229 | 5134.1 | 6741.0 | 65.8 | 706 | 1713.2 | 33.4 | 308.0 | EL | Y | 2021.2 | 39.4 | 370.3 | Y | 2083.5 | 40.6 | 3 | 48.1 | 59.9 | 63.9 |
| 41 | CV139 | 32.7842 | -103.5092 | 10,206 | 5216.6 | 6849.3 | 67.0 | 717 | 1901.7 | 36.5 | 347.8 | EF | Y | 2249.5 | 43.1 | 198.3 | Y | 2100.0 | 40.3 | -7 | 47.2 | 61.1 | 64.3 |
| 42 | CV138 | 32.7840 | -103.5051 | 9,067 | 4663.7 | 6123.5 | 67.4 | 740 | 1916.5 | 41.1 | 528.0 | EF | Y* | 2444.5 | 52.4 | 294.9 | Y* | 2211.4 | 47.4 | -10 | 48.1 | 63.7 | 69.1 |
| 43 | CV93 | 32.7840 | -103.5012 | 10,096 | 5029.0 | 6603.1 | 65.3 | 738 | 1922.8 | 38.2 | 644.3 | EF | Y* | 2567.1 | 51.0 | 350.5 | Y* | 2273.3 | 45.2 | -11 | 49.1 | 63.1 | 69.0 |
| 44 | CV94 | 32.7842 | -103.4960 | 10,690 | 5266.9 | 6915.4 | 64.5 | 722 | 1731.8 | 32.9 | 525.9 | EF | Y | 2257.7 | 42.9 | 700.0 | Y | 2431.8 | 46.2 | 8 | 49.1 | 60.4 | 67.2 |
| 45 | CV137 | 32.7810 | -103.5048 | 10,301 | 5186.6 | 6810.0 | 66.0 | 729 | 1990.9 | 38.4 | 1474.4 | EF | N | 3465.3 | 66.8 | 984.5 | N | 2975.4 | 57.4 | -14 | 48.2 | 62.8 | 77.1 |
| 46 | CV99 | 32.7801 | -103.5010 | 11,776 | 5746.2 | 7544.8 | 63.9 | 729 | 1756.7 | 30.6 | 660.2 | EF | N | 2416.9 | 42.1 | 461.0 | Y | 2217.7 | 38.6 | -8 | 48.9 | 59.4 | 65.1 |
| 47 | CV100 | 32.7803 | -103.4966 | 12,847 | 5976.8 | 7847.6 | 60.9 | 697 | 1619.8 | 27.1 | 1022.5 | EF | N | 2642.3 | 44.2 | 1489.5 | N | 3109.3 | 52.0 | 18 | 50.8 | 59.4 | 71.1 |
| 48 | CV101 | 32.7802 | -103.4921 | 10,555 | 4113.3 | 5400.7 | 51.1 | 708 | 1247.5 | 30.3 | 285.6 | EL | N | 1533.1 | 37.3 | 1400.0 | N | 2647.5 | 64.4 | 73 | 61.3 | 67.5 | 70.7 |
| 49 | CV136 | 32.7773 | -103.5048 | 7,853 | 3524.6 | 4627.8 | 58.8 | 523 | 1418.7 | 40.3 | 673.7 | EL | N | 2092.4 | 59.4 | 1101.3 | N | 2520.0 | 71.5 | 20 | 54.2 | 67.9 | 81.4 |
| 50 | CV106 | 32.7771 | -103.5015 | 10,111 | 4542.5 | 5964.3 | 58.9 | 362 | 953.9 | 21.0 | 390.1 | EF | N | 1344.0 | 29.6 | 705.2 | N | 1659.1 | 36.5 | 23 | 50.5 | 57.5 | 64.0 |
| 51 | CV107 | 32.7773 | -103.4963 | 10,119 | 3972.6 | 5216.1 | 51.4 | 415 | 826.8 | 20.8 | 886.7 | EF | N | 1713.5 | 43.1 | 773.1 | N | 1599.9 | 40.3 | -7 | 57.9 | 62.8 | 72.6 |
| 52 | CV108 | 32.7768 | -103.4926 | 7,071 | 2033.7 | 2670.2 | 37.7 | 463 | 727.5 | 35.8 | 477.6 | EF | N | 1205.0 | 59.3 | 1301.3 | N | 2028.8 | 99.8 | 68 | 73.4 | 77.9 | 92.9 |
| 53 | CV135 | 32.7738 | -103.5048 | 7,608 | 2755.6 | 3618.1 | 47.4 | 325 | 742.8 | 27.0 | 385.5 | EF | N | 1128.3 | 40.9 | 798.5 | N | 1541.3 | 55.9 | 37 | 61.7 | 68.3 | 77.6 |
| 54 | CV113 | 32.7739 | -103.5015 | 6,681 | 2106.7 | 2766.1 | 41.3 | 71 | 396.0 | 18.8 | 350.0 | EF | Y | 746.0 | 35.4 | 610.8 | N | 1006.8 | 47.8 | 35 | 63.5 | 69.3 | 77.9 |
| 55 | CV114 | 32.7735 | -103.4981 | 5,756 | 1787.0 | 2346.4 | 40.7 | 153 | 325.3 | 18.2 | 247.5 | EL | Y | 572.8 | 32.1 | 154.7 | N | 480.0 | 26.9 | -16 | 66.0 | 69.6 | 73.8 |
| 56 | CV115 | 32.7739 | -103.4926 | 3,688 | 710.3 | 932.6 | 25.2 | 163 | 265.0 | 37.3 | 74.8 | EL | Y | 339.8 | 47.8 | 57.0 | Y | 322.0 | 45.3 | -5 | 82.2 | 85.5 | 87.7 |
| 57 | CV134 | 32.7693 | -103.5048 | 5,031 | 1192.3 | 1565.5 | 31.0 | 211 | 448.1 | 37.6 | 101.5 | EL | Y | 549.6 | 46.1 | 150.5 | N | 598.6 | 50.2 | 9 | 76.6 | 82.3 | 85.3 |
| 58 | CV133 | 32.7694 | -103.5099 | 4,486 | 1546.4 | 2030.4 | 45.2 | 548 | 838.4 | 54.2 | 212.9 | EL | N | 1051.3 | 68.0 | 262.9 | Y | 1101.3 | 71.2 | 5 | 73.3 | 81.1 | 87.4 |
| 59 | CV120 | 32.7693 | -103.5013 | 2,195 | 428.6 | 562.8 | 25.6 | 135 | 366.9 | 85.6 | 108.2 | EL | Y | 475.1 | 110.8 | 169.6 | N | 536.7 | 125.2 | 13 | 84.0 | 96.6 | 104.2 |
| 60 | CV121 | 32.7706 | -103.4971 | 1,961 | 348.3 | 457.4 | 23.3 | 116 | 216.0 | 62.0 | 9.3 | EL | Y | 225.3 | 64.7 | 265.8 | N | 481.8 | 138.3 | 114 | 85.8 | 91.9 | 100.3 |
| | | Avg. | | 7644.6 | 3071.0 | 4032.3 | 49.9 | 522.1 | 1166.6 | 38.6 | 301.7 | | | 1470.2 | 47.7 | 289.1 | | 1457.6 | 48.8 | | 62.4 | 71.8 | 75.9 |

| | Injector Centered Pattern | Avg. 1994 Pattern Statistics... Production OIL BOPD | H2O BWPD | OCUT % | GOR scf/STB | H2O Injection Surf. Rate BWPD | %HCPV/Y | Eff. Inj. (est) %HCPV/Y | Press. psig | IWR % | WF Peak Oil from Start Yrs. | Initial WF BrkThru from Start Yrs. | WF BrkThru. (50% H20 Cut) from Start Yrs. | Yr. End '94 Oil Trend Increasing (N*=recent peak) (Y*=recent Work) Y/N | Ft. of Perf's., ft | Net Pay, ft | Ratio of ft. perf'd to ft. net pay, |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CV5 | 7 | 34 | 17 | 145 | 47 | 0.9 | | 1381 | 1.13 | 11.0 | 0.6 | 4.0 | N | | | |
| 2 | CV6 | 5 | 17 | 23 | 76 | 292 | 5.2 | | 1314 | 12.40 | 11.0 | 0.1 | 0.1 | Y | | | |
| 3 | CV7 | 3 | 6 | 32 | 65 | 10 | 0.2 | | 1078 | 1.17 | 3.5 | 0.1 | 3.0 | N | | | |
| 4 | CV13 | 10 | 250 | 4 | 412 | 260 | 4.6 | | 1288 | 1.00 | 4.0 | 0.6 | 0.0 | N | 16 | 12 | 1.33 |
| 5 | CV14 | 12 | 187 | 6 | 124 | 340 | 4.3 | | 954 | 1.69 | 2.5 | 0.5 | 2.5 | N | 48 | 30 | 1.59 |
| 6 | CV15 | 18 | 215 | 8 | 151 | 156 | 2.0 | | 893 | 0.66 | 3.0 | 1.0 | 3.0 | N | 47 | 20 | 2.35 |
| 7 | CV16 | 26 | 91 | 22 | 203 | 226 | 3.7 | | 1334 | 1.87 | 3.0 | 0.5 | 1.5 | N | 10 | 23 | 0.43 |
| 8 | CV25 | 22 | 744 | 3 | 272 | 757 | 11.9 | 8.1 | 864 | 0.98 | 4.3 | 1.0 | 4.5 | N | 20 | 12 | 1.67 |
| 9 | CV26 | 22 | 677 | 3 | 526 | 744 | 9.5 | 6.9 | 807 | 1.06 | 3.5 | 0.1 | 4.0 | N | 22 | 12 | 1.83 |
| 10 | CV27 | 17 | 551 | 3 | 663 | 1209 | 11.5 | 4.3 | 1183 | 2.12 | 3.0 | 1.0 | 3.5 | N | | | |
| 11 | CV28 | 15 | 536 | 3 | 274 | 1112 | 14.1 | 3.5 | 1092 | 2.00 | 2.5 | 0.1 | 3.0 | N | | | |
| 12 | CV29 | 24 | 624 | 4 | 115 | 605 | 9.2 | 2.8 | 1173 | 1.10 | 2.5 | 0.1 | 0.5 | N | 21 | 32 | 0.66 |
| 13 | CV30 | 29 | 484 | 6 | 179 | 925 | 14.7 | 2.0 | 1086 | 1.79 | 2.5 | 0.5 | 0.5 | N | 58 | 16 | 3.63 |
| 14 | CV31 | 33 | 236 | 12 | 495 | 645 | 5.6 | 1.8 | 1313 | 1.99 | 5.5 | 1.2 | 1.3 | Y | 36 | 48 | 0.75 |
| 15 | CV40 | 37 | 1207 | 3 | 273 | 1330 | 15.7 | 10.0 | 822 | 1.06 | 4.5 | 0.1 | 5.5 | N | 17 | 32 | 0.53 |
| 16 | CV41 | 34 | 1001 | 3 | 174 | 1010 | 12.5 | 8.0 | 1025 | 0.97 | 3.5 | 0.1 | 4.4 | N | 24 | 4 | 6.00 |
| 17 | CV42 | 27 | 853 | 3 | 501 | 833 | 8.7 | 6.7 | 842 | 0.94 | 2.7 | 0.1 | 4.0 | N | 21 | 5 | 4.20 |
| 18 | CV43 | 29 | 880 | 3 | 499 | 746 | 8.5 | 5.1 | 755 | 0.82 | 3.5 | 0.1 | 4.4 | N | 21 | 5 | 4.20 |
| 19 | CV44 | 33 | 775 | 4 | 197 | 325 | 3.2 | 4.5 | 939 | 0.40 | 3.0 | 0.1 | 3.1 | N | 14 | 40 | 0.35 |
| 20 | CV45 | 32 | 609 | 5 | 391 | 644 | 7.0 | 4.6 | 1167 | 1.00 | 3.0 | 0.1 | 1.1 | N | 22 | 52 | 0.42 |
| 21 | CV46 | 25 | 540 | 4 | 1074 | 2165 | 24.2 | 6.3 | 839 | 3.81 | 4.0 | 0.1 | 1.8 | N | 22 | 88 | 0.25 |
| 22 | CV55 | 59 | 1365 | 4 | 371 | 1939 | 14.9 | 8.5 | 689 | 1.35 | 4.2 | 0.1 | 4.5 | N | 42 | 76 | 0.55 |
| 23 | CV56 | 43 | 1120 | 4 | 360 | 618 | 5.8 | 9.4 | 938 | 0.53 | 3.0 | 0.1 | 3.9 | N | | | |
| 24 | CV57 | 44 | 1249 | 3 | 503 | 1827 | 16.4 | 6.8 | 951 | 1.41 | 2.0 | 0.5 | 3.5 | N | 21 | 64 | 0.33 |
| 25 | CV58 | 42 | 1036 | 4 | 493 | 1317 | 12.8 | 8.0 | 707 | 1.22 | 2.2 | 0.7 | 3.5 | N | 42 | 44 | 0.95 |
| 26 | CV59 | 40 | 1184 | 3 | 331 | 1569 | 11.6 | 9.8 | 1131 | 1.27 | 2.5 | 1.0 | 3.2 | N | 41 | 136 | 0.30 |
| 27 | CV60 | 37 | 959 | 4 | 469 | 748 | 7.6 | 8.0 | 1057 | 0.75 | 3.5 | 1.0 | 3.2 | N | 25 | 28 | 0.89 |
| 28 | CV61 | 43 | 911 | 4 | 575 | 792 | 6.7 | 7.0 | 892 | 0.82 | 3.5 | 0.1 | 1.5 | N | 42 | 140 | 0.30 |
| 29 | CV70 | 75 | 1521 | 5 | 450 | 1953 | 13.3 | 11.0 | 685 | 1.21 | 5.5 | 1.0 | 6.0 | N | 21 | 128 | 0.16 |
| 30 | CV71 | 74 | 1397 | 5 | 480 | 2145 | 15.8 | 9.6 | 745 | 1.45 | 3.8 | 0.1 | 5.0 | N | 23 | 56 | 0.41 |
| 31 | CV72 | 71 | 1591 | 4 | 464 | 2220 | 20.0 | 10.5 | 861 | 1.33 | 4.8 | 0.1 | 5.6 | N | 22 | 72 | 0.31 |
| 32 | CV73 | 60 | 1205 | 5 | 426 | 1962 | 16.2 | 10.7 | 875 | 1.64 | 4.0 | 1.0 | 3.3 | N | 27 | 100 | 0.27 |
| 33 | CV74 | 53 | 1186 | 4 | 378 | 948 | 10.8 | 9.8 | 880 | 0.76 | 5.0 | 2.0 | 4.0 | N | 45 | 32 | 1.41 |
| 34 | CV81 | 149 | 1931 | 7 | 355 | 1513 | 8.3 | 8.8 | 810 | 0.72 | 4.2 | 0.2 | 5.0 | N | 57 | 200 | 0.29 |
| 35 | CV82 | 124 | 1731 | 7 | 368 | 678 | 3.2 | 7.5 | 685 | 0.36 | 3.5 | 0.1 | 5.6 | N | 41 | 260 | 0.16 |
| 36 | CV83 | 81 | 1155 | 7 | 426 | 1059 | 6.4 | 7.2 | 620 | 0.85 | 3.5 | 0.5 | 5.2 | N | 88 | 212 | 0.41 |
| 37 | CV84 | 74 | 989 | 7 | 399 | 911 | 6.0 | 6.7 | 913 | 0.85 | 3.8 | 0.1 | 5.1 | N | 31 | 168 | 0.18 |
| 38 | CV85 | 77 | 1228 | 6 | 930 | 619 | 4.7 | 5.6 | 702 | 0.47 | 3.3 | 0.1 | 4.8 | N | 32 | 136 | 0.24 |
| 39 | CV141 | 176 | 1395 | 11 | 406 | 1464 | 8.2 | 6.0 | 795 | 0.92 | 6.0 | 0.1 | 5.0 | N | 23 | 96 | 0.24 |
| 40 | CV140 | 103 | 1239 | 8 | 355 | 1344 | 7.3 | 5.5 | 745 | 0.99 | 5.0 | 0.1 | 5.5 | N | 47 | 52 | 0.90 |
| 41 | CV139 | 82 | 1066 | 7 | 465 | 1457 | 7.8 | 5.4 | 744 | 1.26 | 4.0 | 0.1 | 6.0 | N | 27 | 161 | 0.17 |
| 42 | CV138 | 79 | 695 | 10 | 411 | 867 | 6.2 | 4.3 | 948 | 1.10 | 3.3 | 0.1 | 6.0 | N | 46 | 160 | 0.29 |
| 43 | CV93 | 72 | 603 | 11 | 489 | 1506 | 8.3 | 5.4 | 993 | 1.74 | 3.5 | 0.1 | 6.0 | N | 25 | 168 | 0.15 |
| 44 | CV94 | 70 | 365 | 16 | 555 | 775 | 4.1 | 3.4 | 1050 | 1.74 | 3.5 | 0.1 | 6.0 | N | 24 | 219 | 0.11 |
| 45 | CV137 | 198 | 612 | 24 | 402 | 292 | 1.6 | 3.7 | 953 | 0.35 | 3.2 | 1.0 | 8.5 | N | 39 | 181 | 0.22 |
| 46 | CV99 | 99 | 416 | 19 | 241 | 696 | 3.4 | 3.4 | 1021 | 1.31 | 3.5 | 0.1 | 8.5 | N | 58 | 248 | 0.23 |
| 47 | CV100 | 99 | 208 | 32 | 344 | 1124 | 5.2 | 3.6 | 1213 | 3.50 | 2.2 | 0.1 | 10.0 | N | 31 | 221 | 0.14 |
| 48 | CV101 | 98 | 38 | 72 | 526 | 440 | 3.0 | 2.5 | 1272 | 2.93 | 12.5 | 0.5 | 16.0 | N* | 35 | 50 | 0.70 |
| 49 | CV136 | 134 | 197 | 41 | 292 | 682 | 5.4 | 3.3 | 874 | 1.94 | 7.5 | 0.5 | 11.0 | N | 66 | 140 | 0.47 |
| 50 | CV106 | 114 | 197 | 37 | 304 | 727 | 4.4 | 3.3 | 953 | 2.22 | 8.0 | 0.1 | 8.2 | Y | 43 | 201 | 0.21 |
| 51 | CV107 | 95 | 62 | 60 | 395 | 248 | 1.7 | 2.6 | 1260 | 1.45 | 6.5 | 1.0 | 16.0 | Y | 51 | 45 | 1.14 |
| 52 | CV108 | 60 | 16 | 79 | 644 | 198 | 2.7 | | 1308 | 2.32 | 12.0 | 4.0 | 16.0 | Y | 50 | 12 | 4.15 |
| 53 | CV135 | 102 | 176 | 37 | 328 | 614 | 6.2 | | 1012 | 2.09 | 14.7 | 0.1 | 3.0 | Y | 62 | 33 | 1.90 |
| 54 | CV113 | 113 | 106 | 52 | 352 | 58 | 0.8 | | 1168 | 0.25 | 12.0 | 0.1 | 13.0 | N* | 36 | 230 | 0.16 |
| 55 | CV114 | 59 | 36 | 62 | 411 | 276 | 4.3 | | 1316 | 2.65 | 11.5 | 6.0 | 13.0 | N* | 19 | 36 | 0.53 |
| 56 | CV115 | 11 | 8 | 58 | 1242 | 65 | 2.5 | | 975 | 3.12 | 0.1 | 0.1 | 15.0 | N | 12 | 5 | 2.40 |
| 57 | CV134 | 67 | 104 | 39 | 432 | 247 | 5.8 | | 793 | 1.36 | 15.0 | 0.1 | 3.0 | N* | 17 | 5 | 3.40 |
| 58 | CV133 | 41 | 300 | 12 | 474 | 42 | 0.8 | | 1106 | 0.12 | 13.5 | 0.1 | 10.5 | N* | 14 | 44 | 0.32 |
| 59 | CV120 | 62 | 33 | 65 | 321 | 509 | 33.0 | | 953 | 4.88 | 13.0 | 8.0 | 14.0 | N* | 22 | 5 | 4.40 |
| 60 | CV121 | 18 | 11 | 61 | 362 | 45 | 3.6 | | 1136 | 1.42 | 12.0 | 0.1 | 0.1 | N* | 7 | 5 | 1.40 |
| | | 59.3 | 667.6 | 17.8 | 405.6 | 846.2 | 8.0 | | 981.3 | 1.6 | 5.3 | 0.7 | 5.5 | | | | |

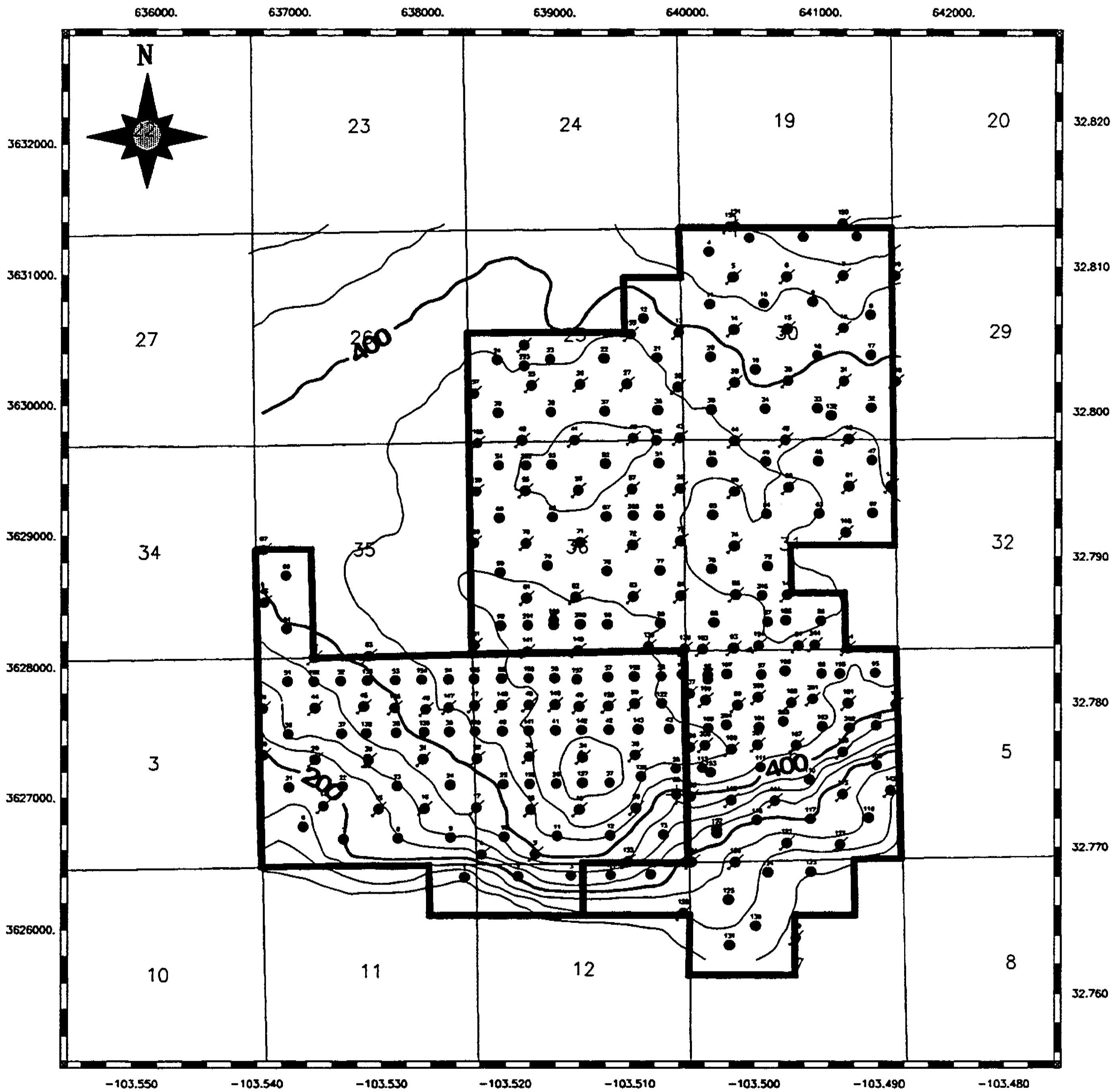



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| GRAYBURG DOLOMITE STRUCTURE, FT. SUBSEA | | |
| FIGURE A-1 | | |
| C.I. = 50 | | Scale 1:46263.88 |
| Taylor, Sharon | | 22, 1996 |

Scale 1:46263.88

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.2 0.4 0.6 0.8 1. kilometers

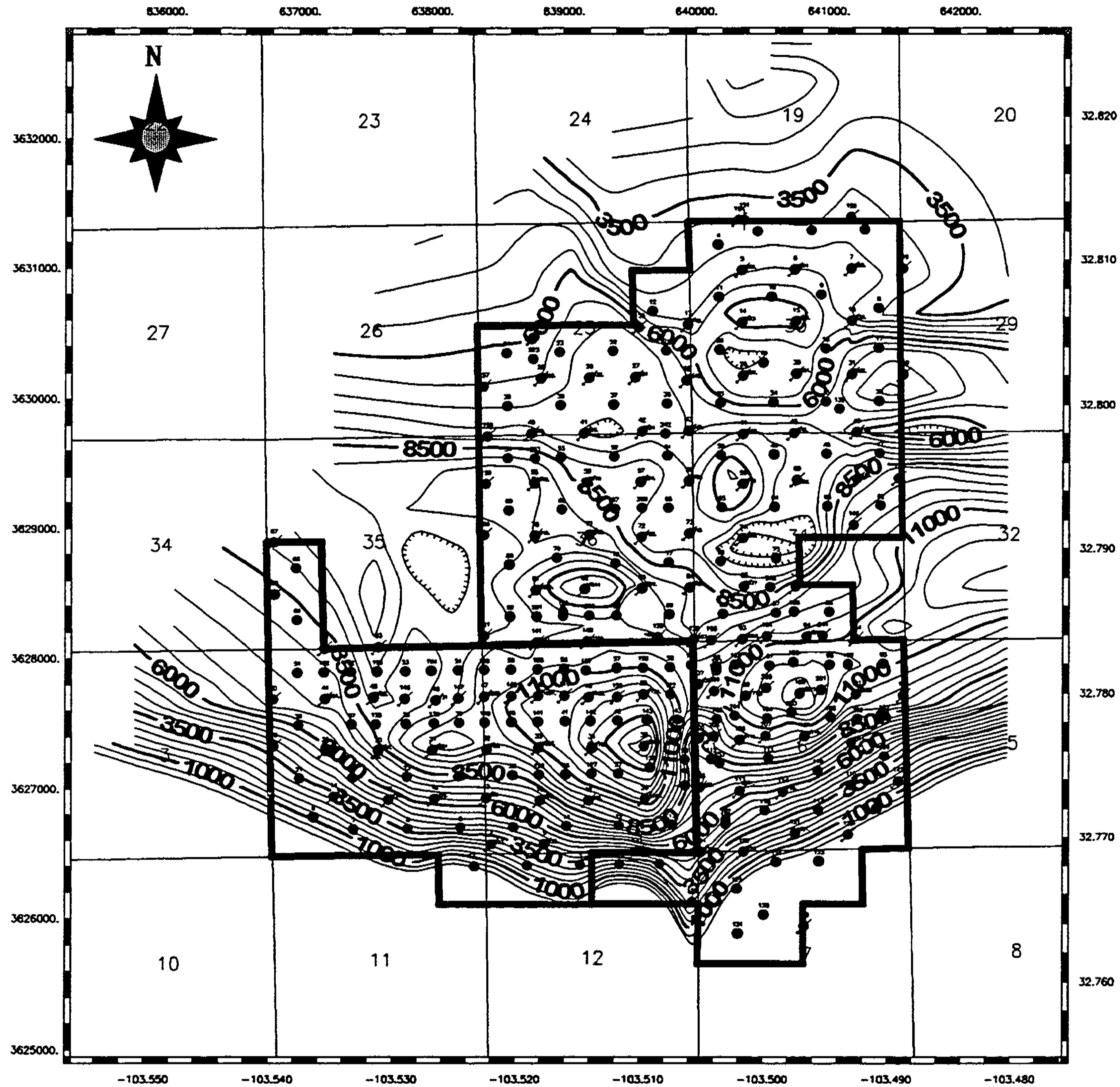



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| GROSS PAY, FT. ABOVE -735 SUBSEA | | |
| FIGURE A-2 | | |
| C.I. = 50 | | Scale 1:45433.59 |
| Taylor, Sharon | | 7/22/96 |

Scale 1:45433.59

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

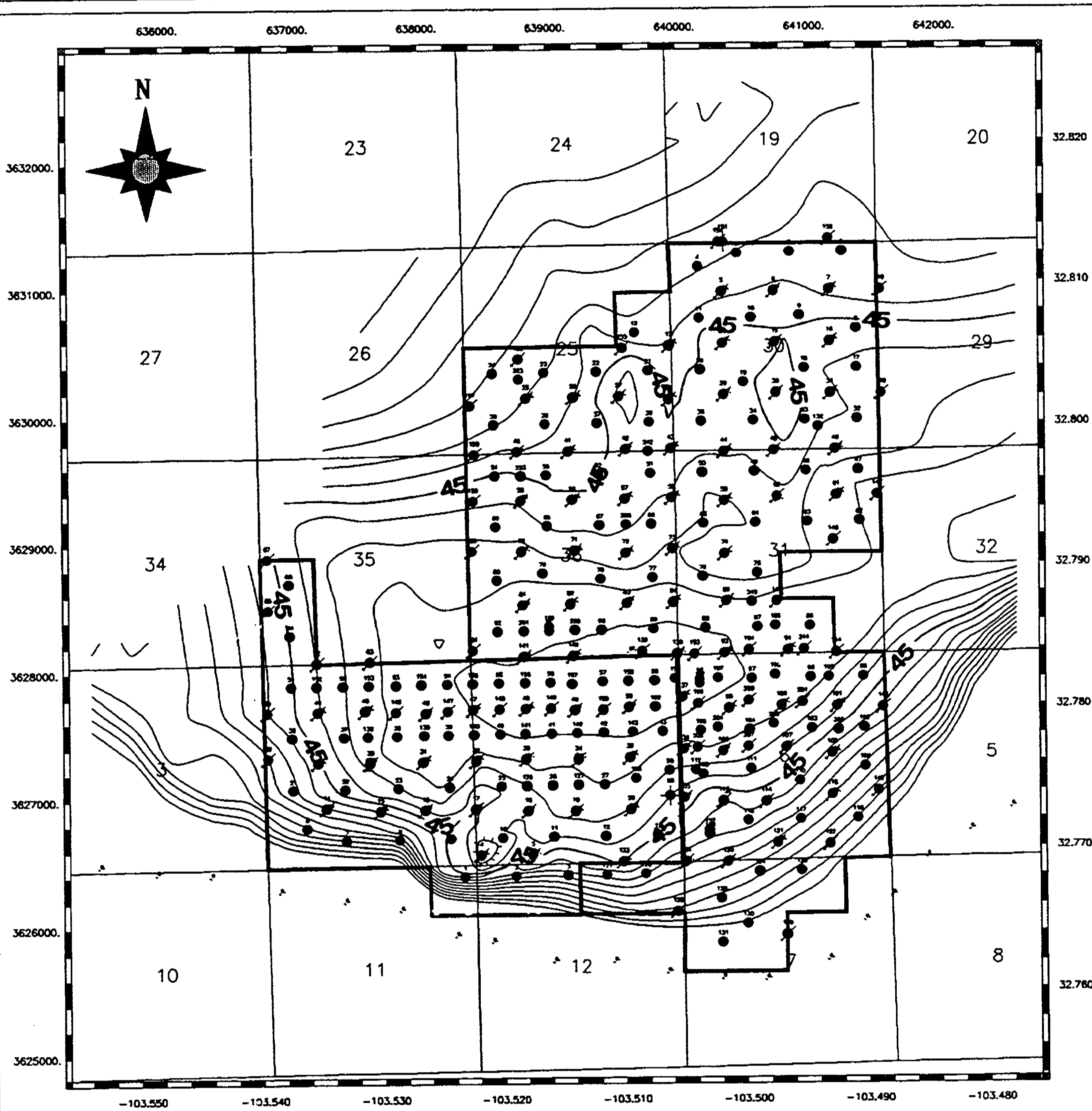



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| TOTAL PORE VOLUME, MRVB | | |
| FIGURE A-3 | | |
| C.I. = 500 | | Scale 1:46993.29 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:46993.29

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

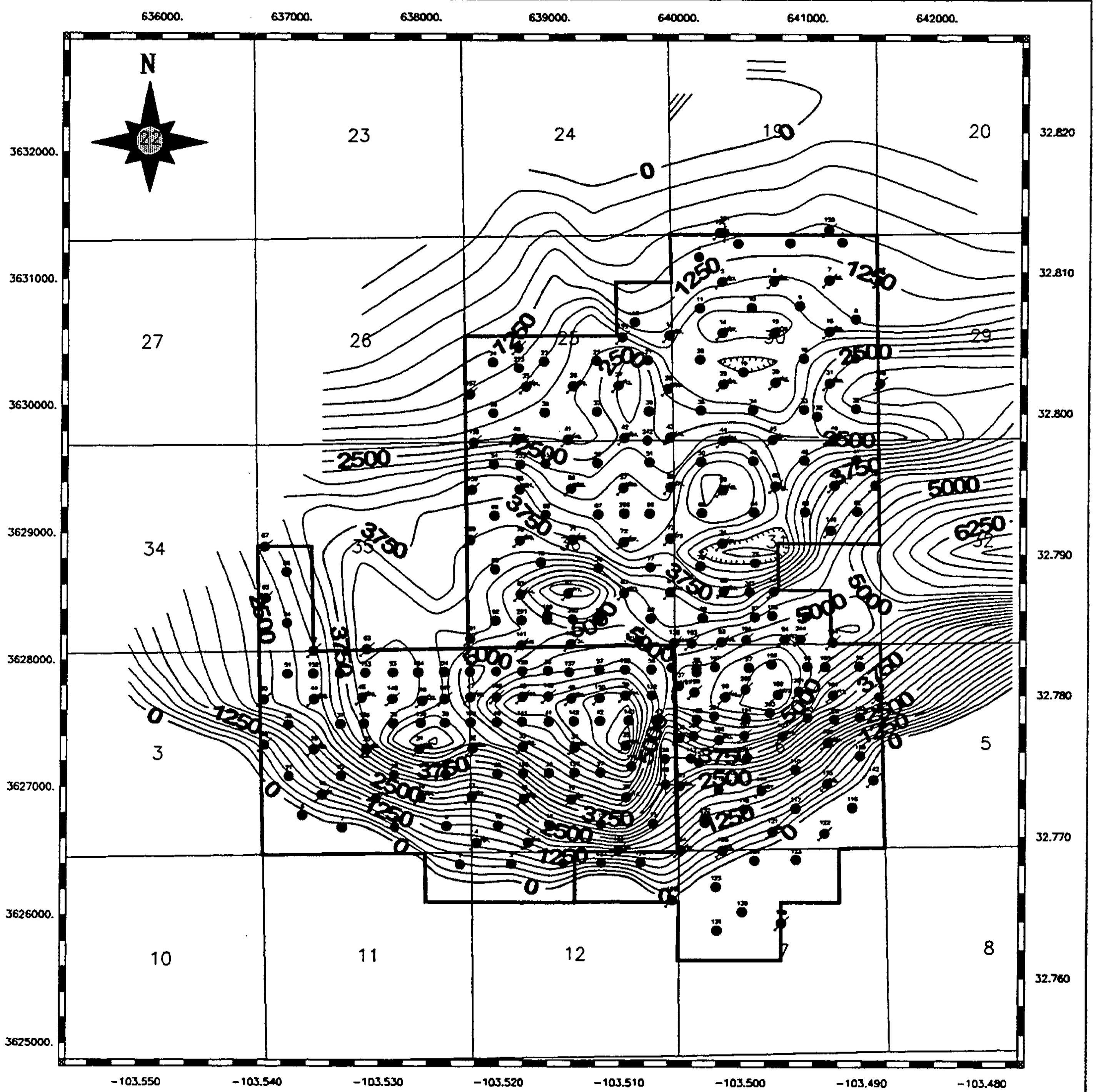



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| AVG. SWI OF GROSS PAY, % <br> FIGURE A-4 | | |
| C.I. = 5 | | Scale 1:46642.35 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:46642.35

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

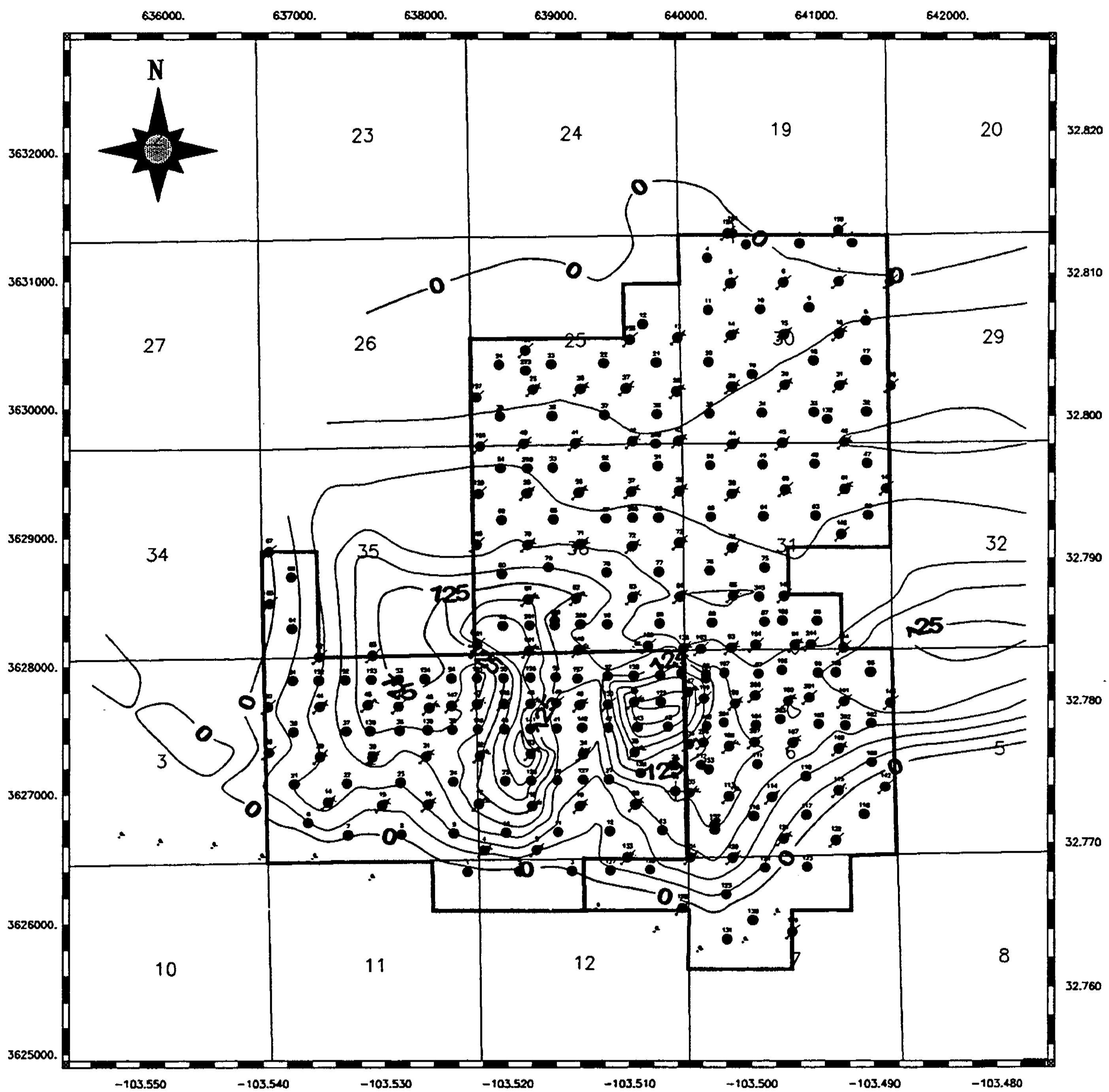



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| OOIP, MSTB<br>FIGURE A-5 | | |
| C.I. = 250 | | Scale 1:45387.43 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:45387.43

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

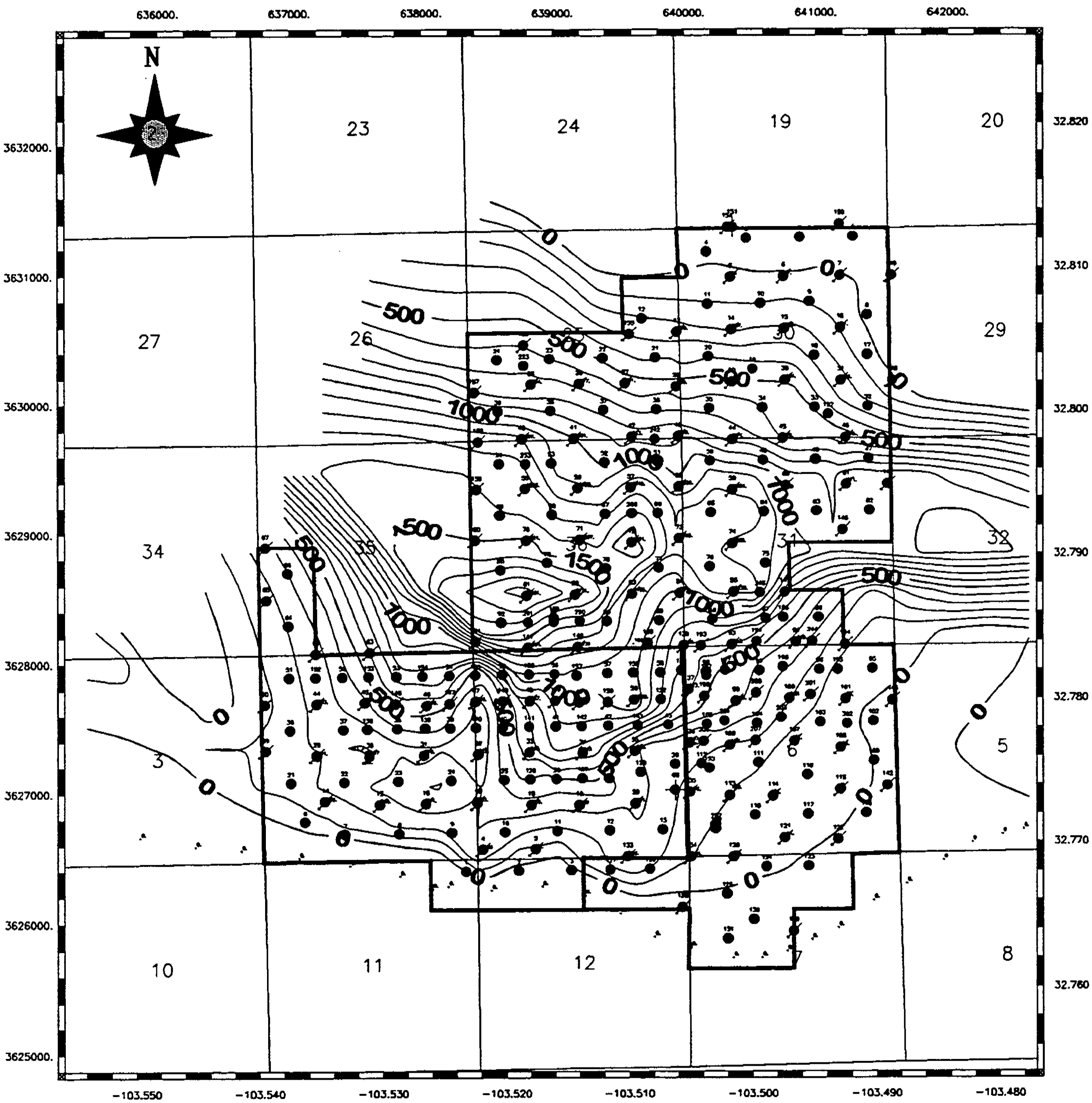



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| 1994 AVG. OIL RATE, BOPD<br>FIGURE A-6 | | |
| C.I. = 25 | | Scale 1:46037.37 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:46037.37

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

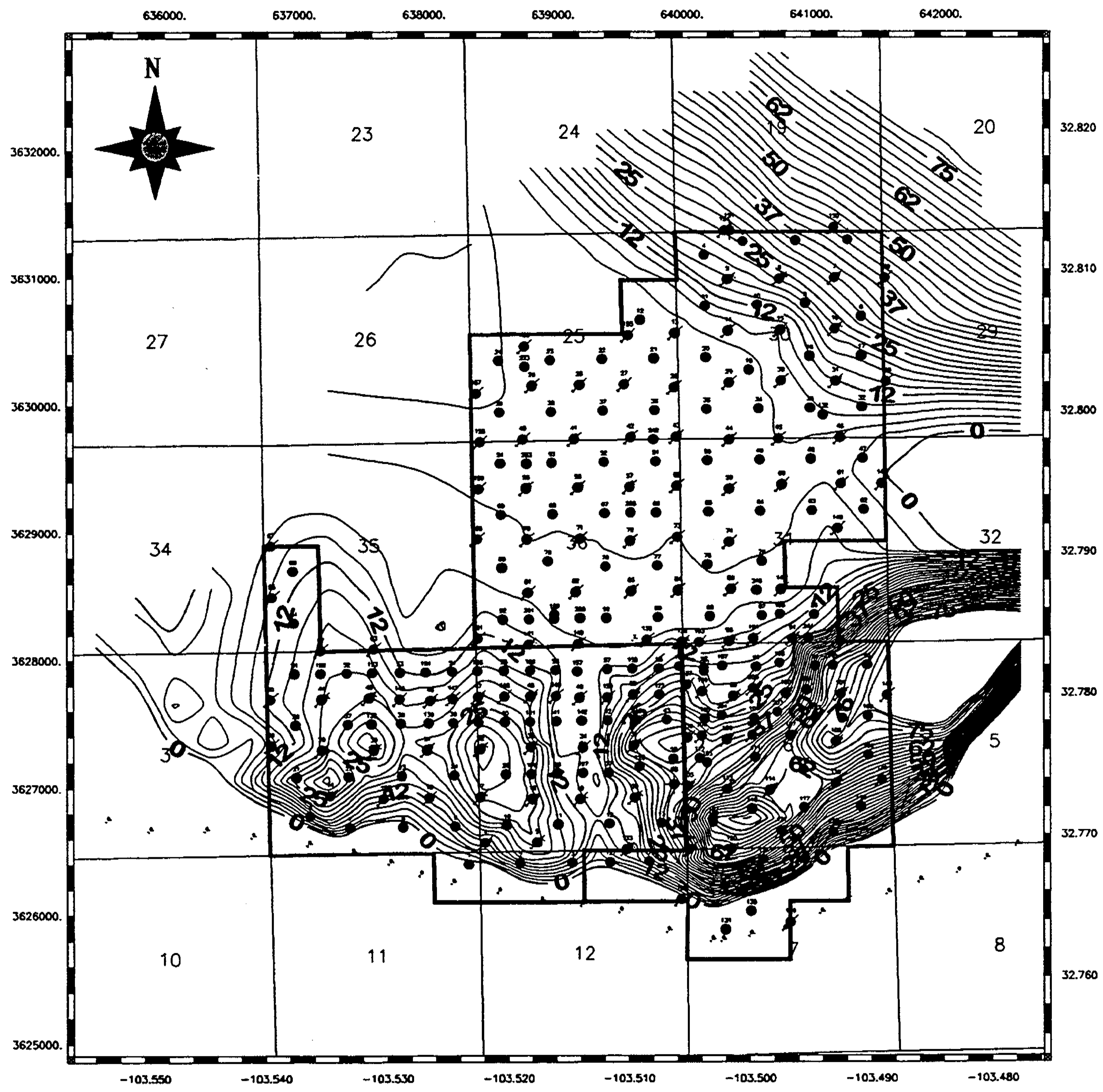



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| 1994 AVG. H20 RATE, BWPD<br>FIGURE A-7 | | |
| C.I. = 100 | | Scale 1:44483.71 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:44483.71

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers




TEXACO EXPLORATION & PRODUCTION, INC.

1994 AVG. OIL CUT, %

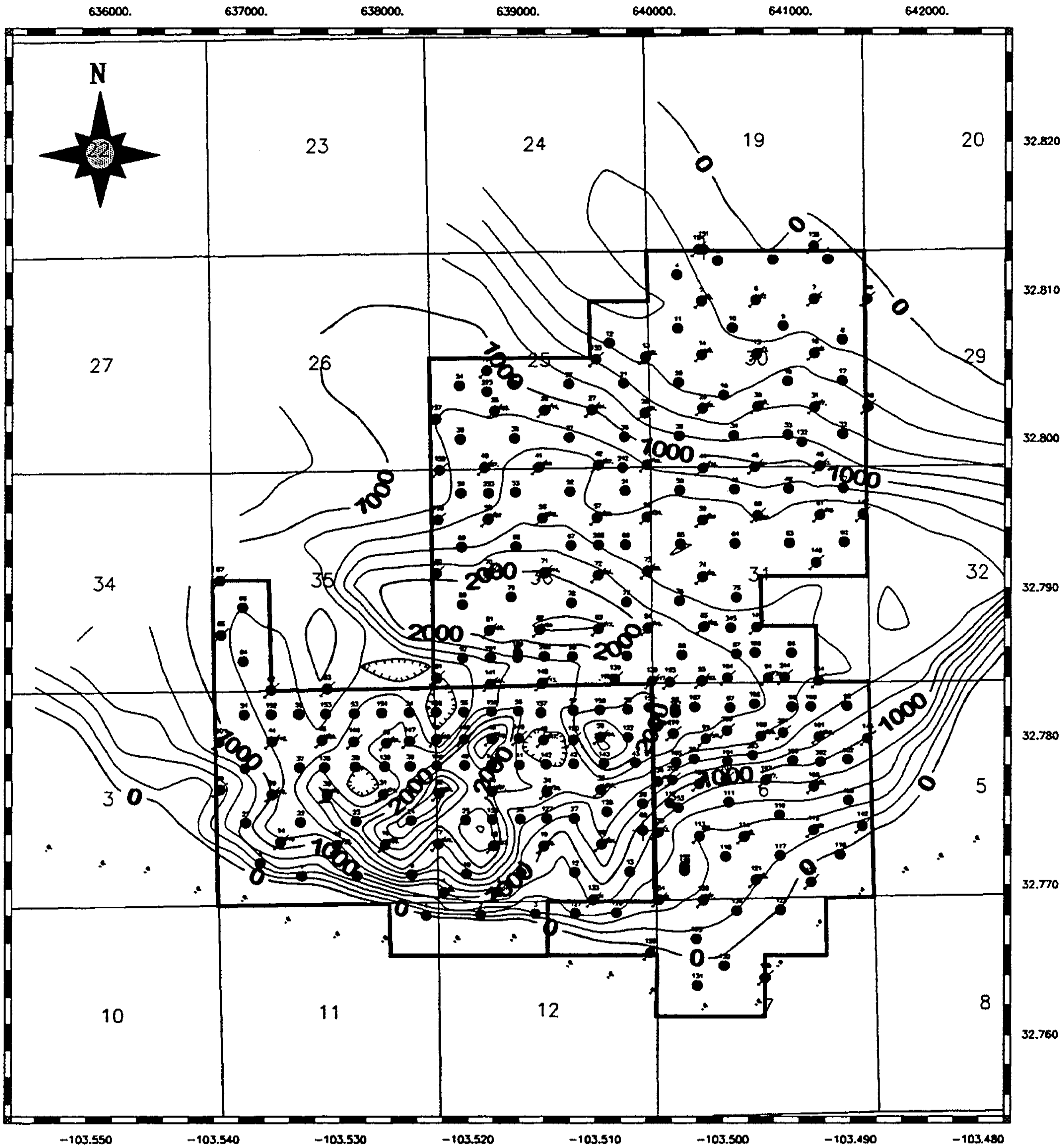
FIGURE A-8

| | | |
|---|---|---|
| C.I. = 2.5 | | Scale 1:46601.89 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:46601.89

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

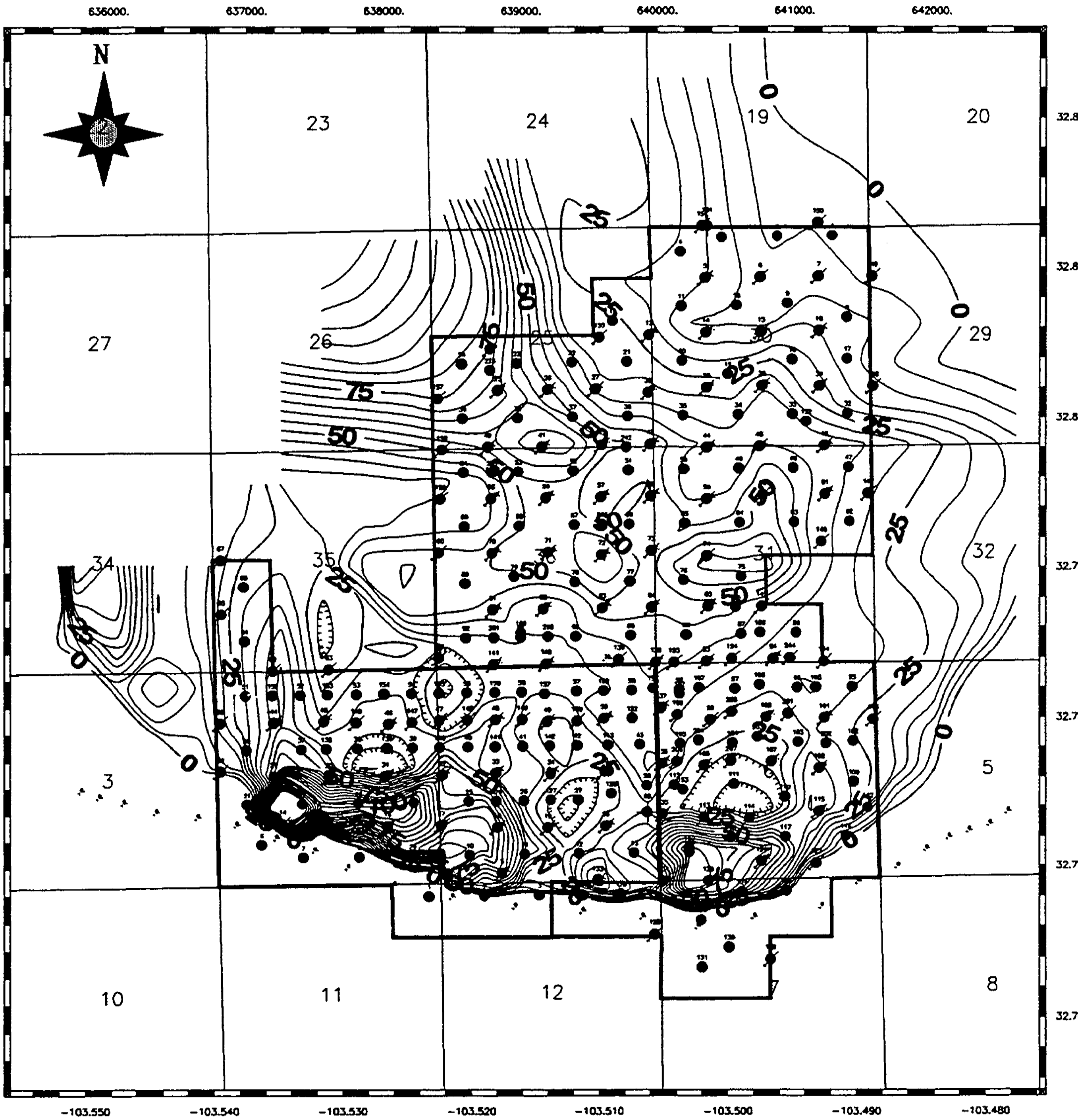



| TEXACO EXPLORATION & PRODUCITON, INC. | | |
|---|---|---|
| CUM. OIL RECOVERY, MSTB (01/01/95) | | |
| FIGURE A-9 | | |
| C.I. = 200 | | Scale 1:44597.59 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:44597.59

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

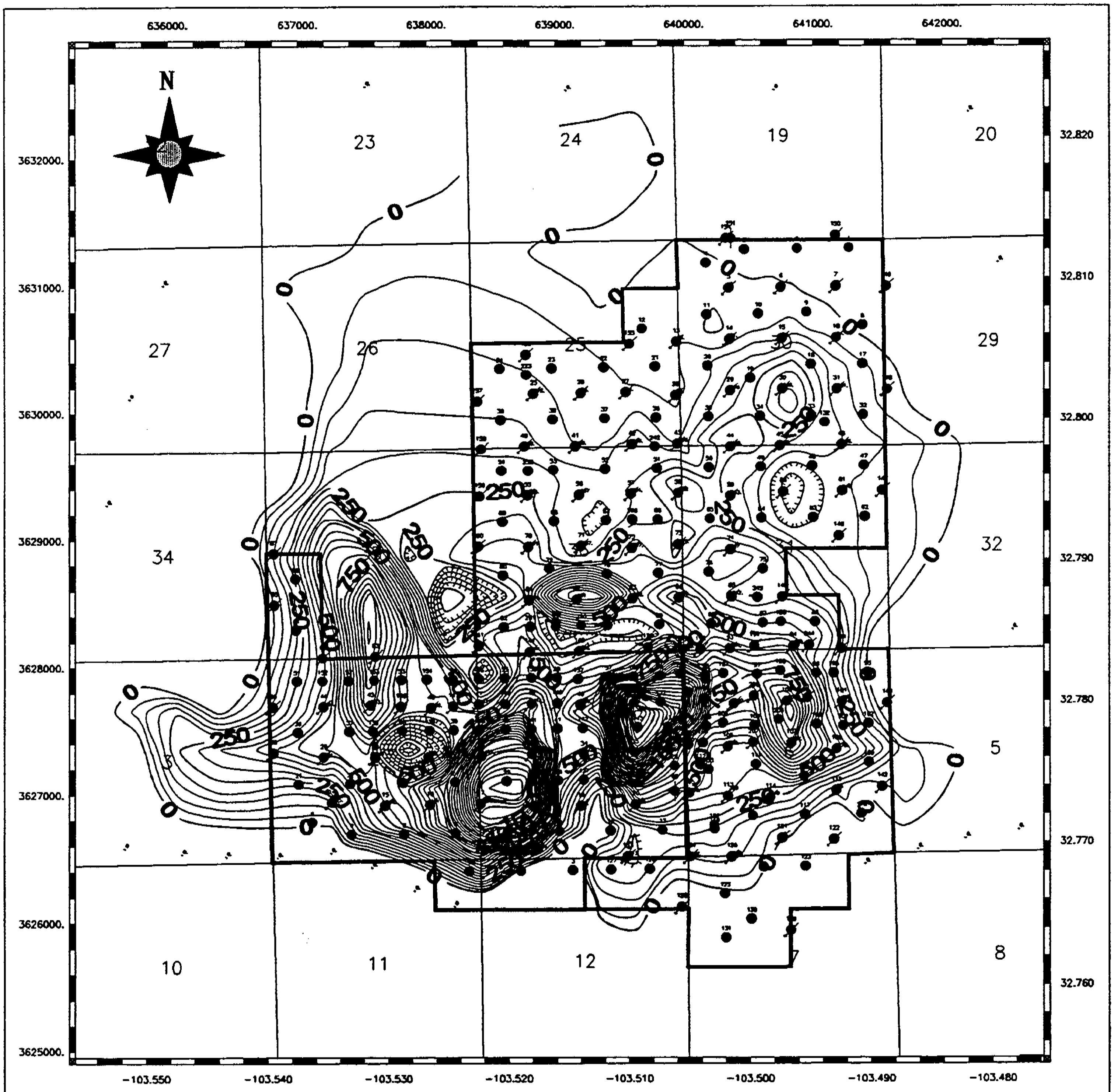



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| CUMMULATIVE OIL RECOVERY, %OOPI (01/01/95) FIGURE A-10 | | |
| C.I. = 5 | | Scale 1:44008.08 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:44008.08

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

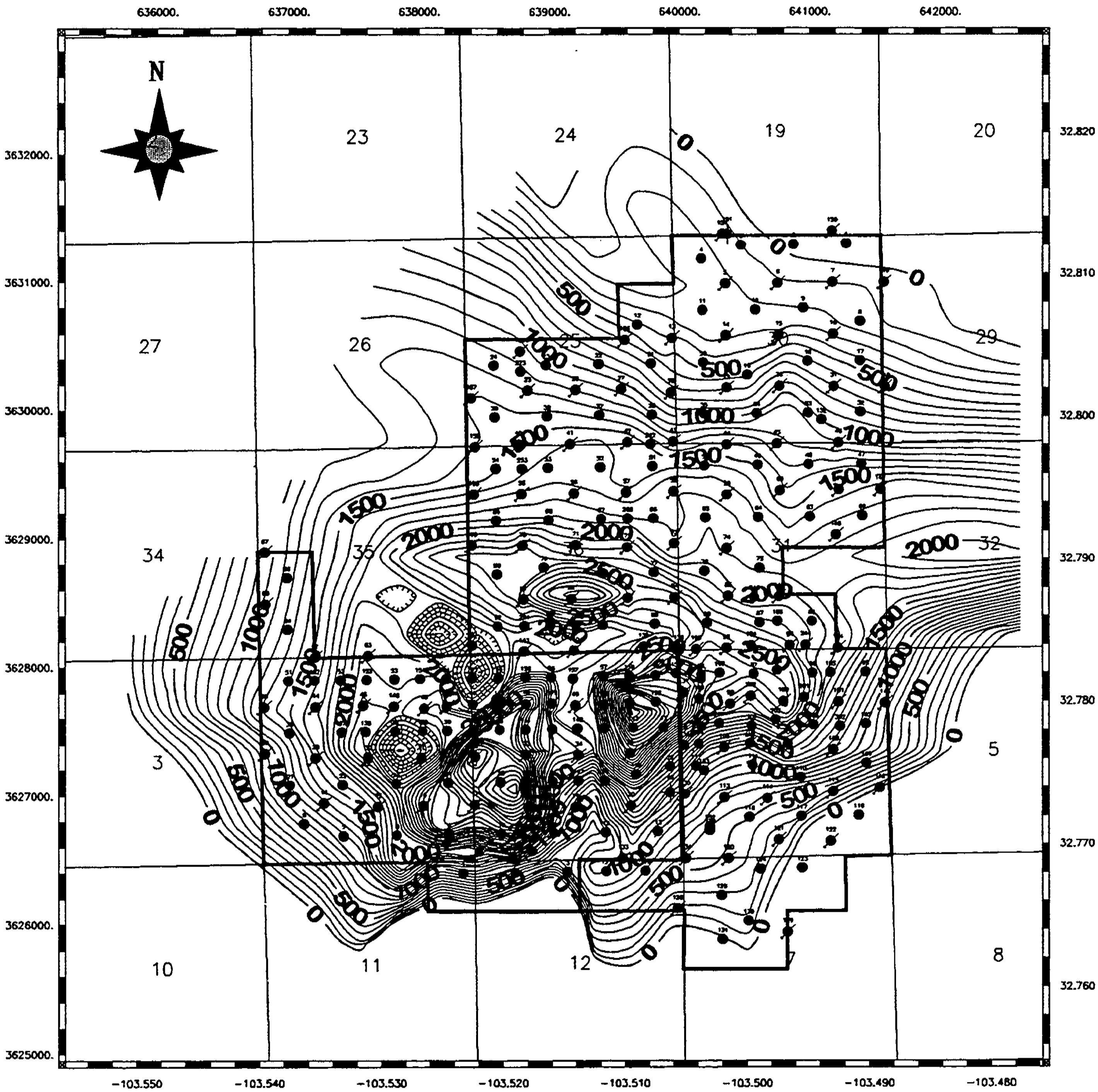



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| RSVS. (Q vs t)<br>Rsvs. MSTB (01/01/95)<br>FIGURE A-11 | | |
| C.I. = 50 | | Scale 1:43403.54 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:43403.54

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

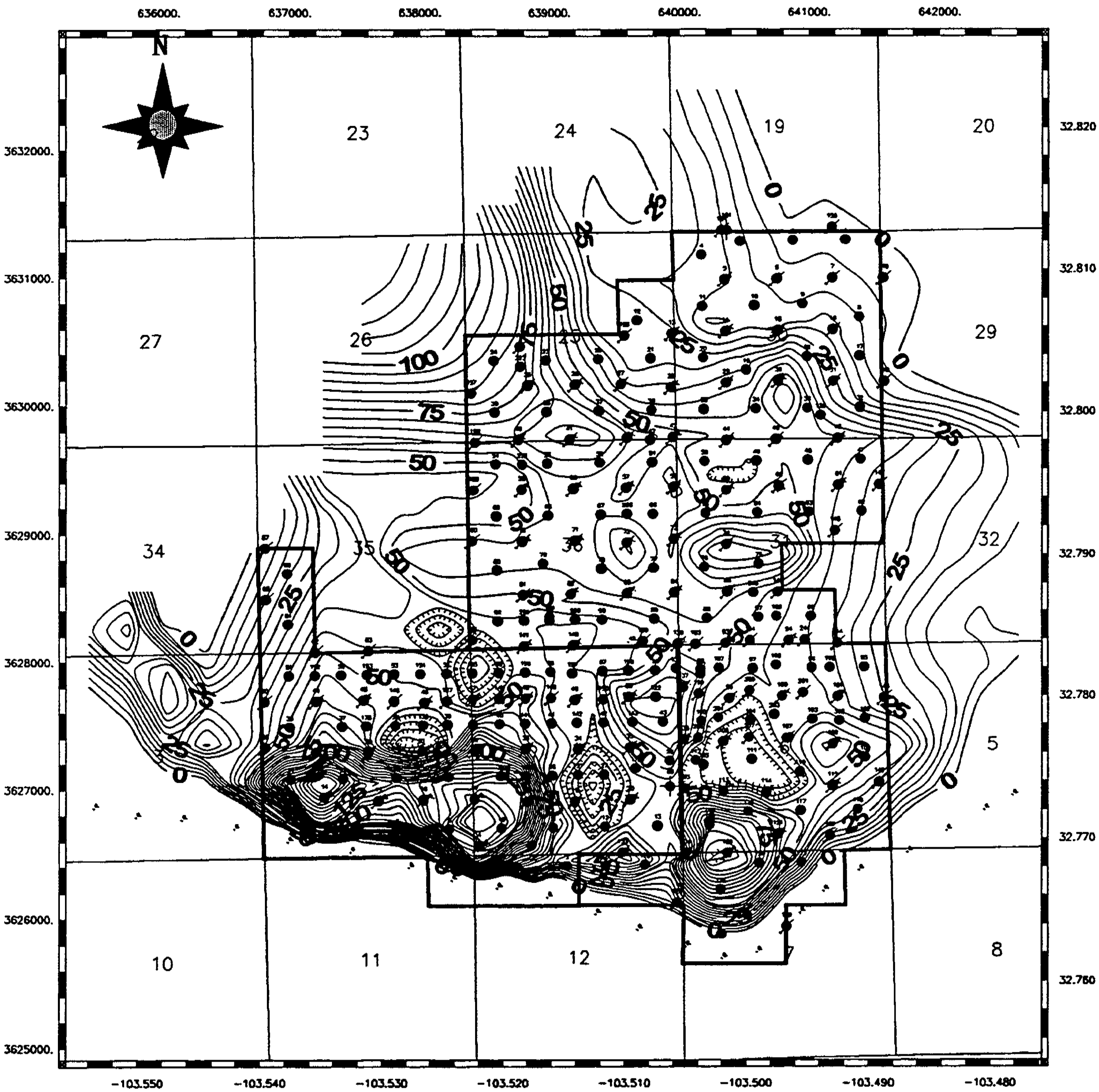



| TEXACO EXPLORATION & PRODUCTION, INC. | |
|---|---|
| RSVS. FORECAST (Q vs t)<br>Np, MSTB<br>FIGURE A-12 | |
| C.I. = 100 | Scale 1:45107.2 |
| Taylor, Sharon | 7/18/96 |

Scale 1:45107.2

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

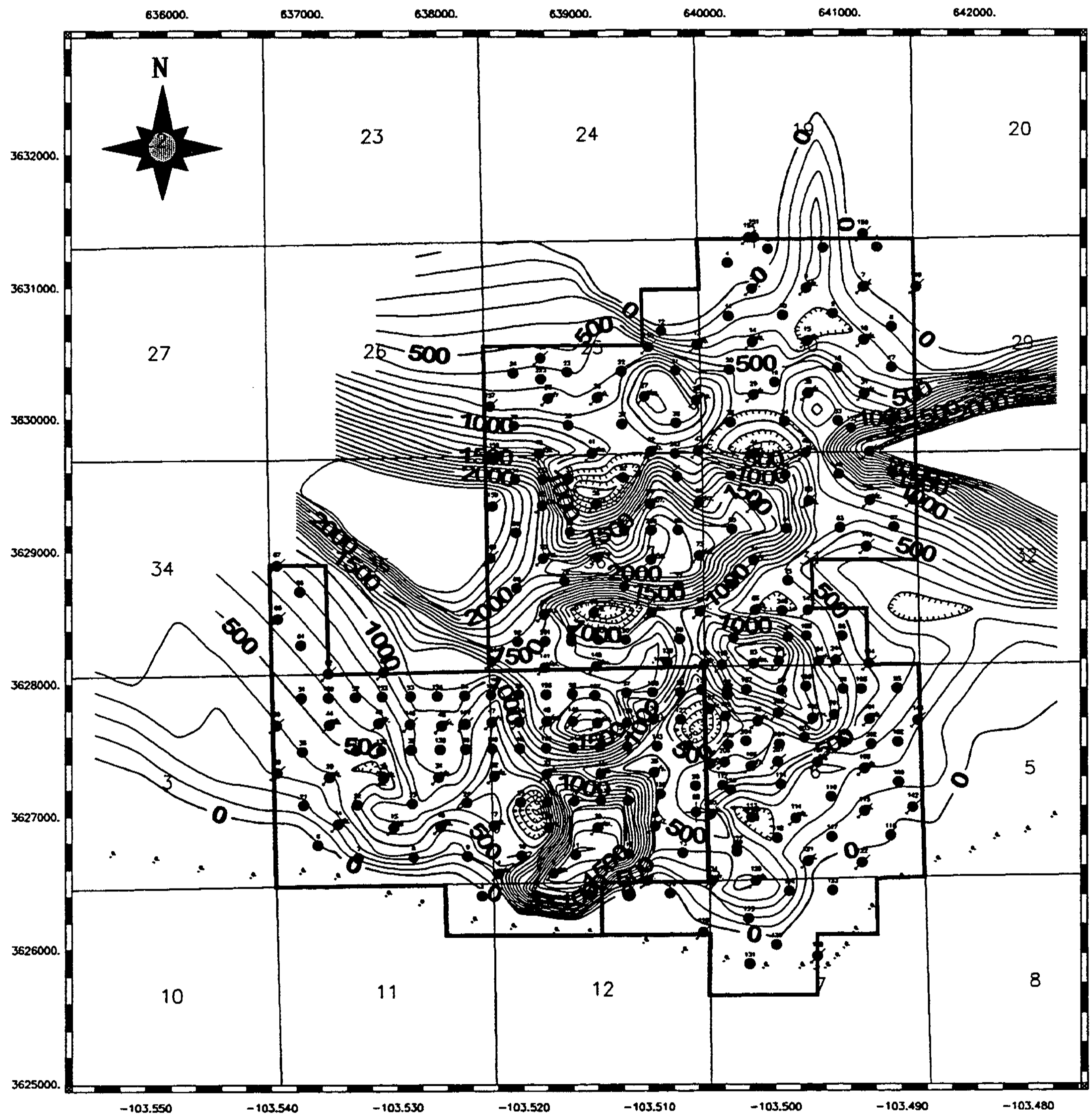



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| RSVS. FORECAST ( Q vs t)<br>Np, % OOIP<br>FIGURE A-13 | | |
| C.I. = 5 | | Scale 1:46363.22 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:46363.22

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers




TEXACO EXPLORATION & PRODUCTION, INC.

1994 AVG. H20 INJ. RATE (BWPD)

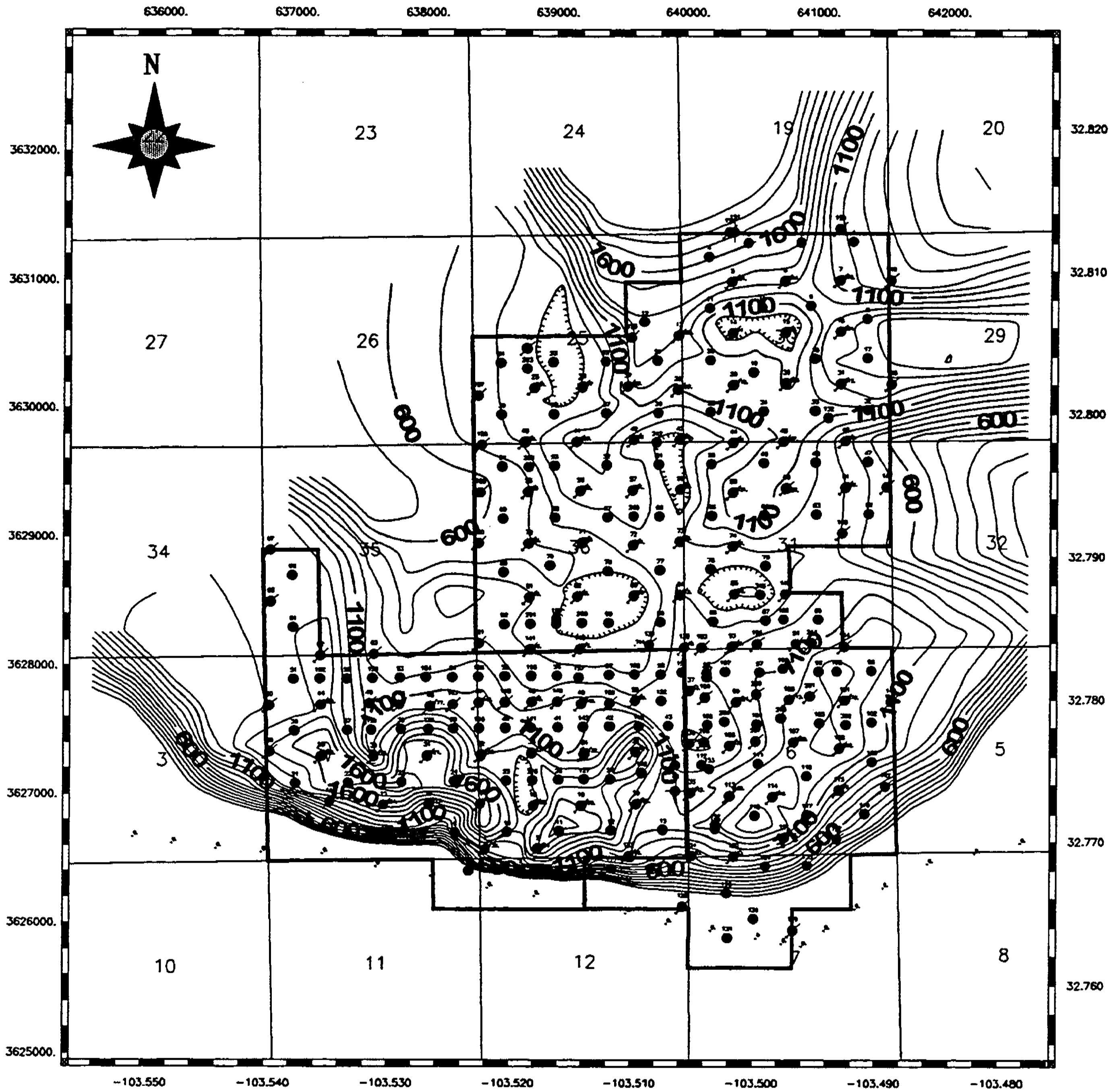
FIGURE A-14

| C.I. = 100 | | Scale 1:44766.38 |
|---|---|---|
| Taylor, Sharon | | 7/18/96 |

Scale 1:44766.38

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

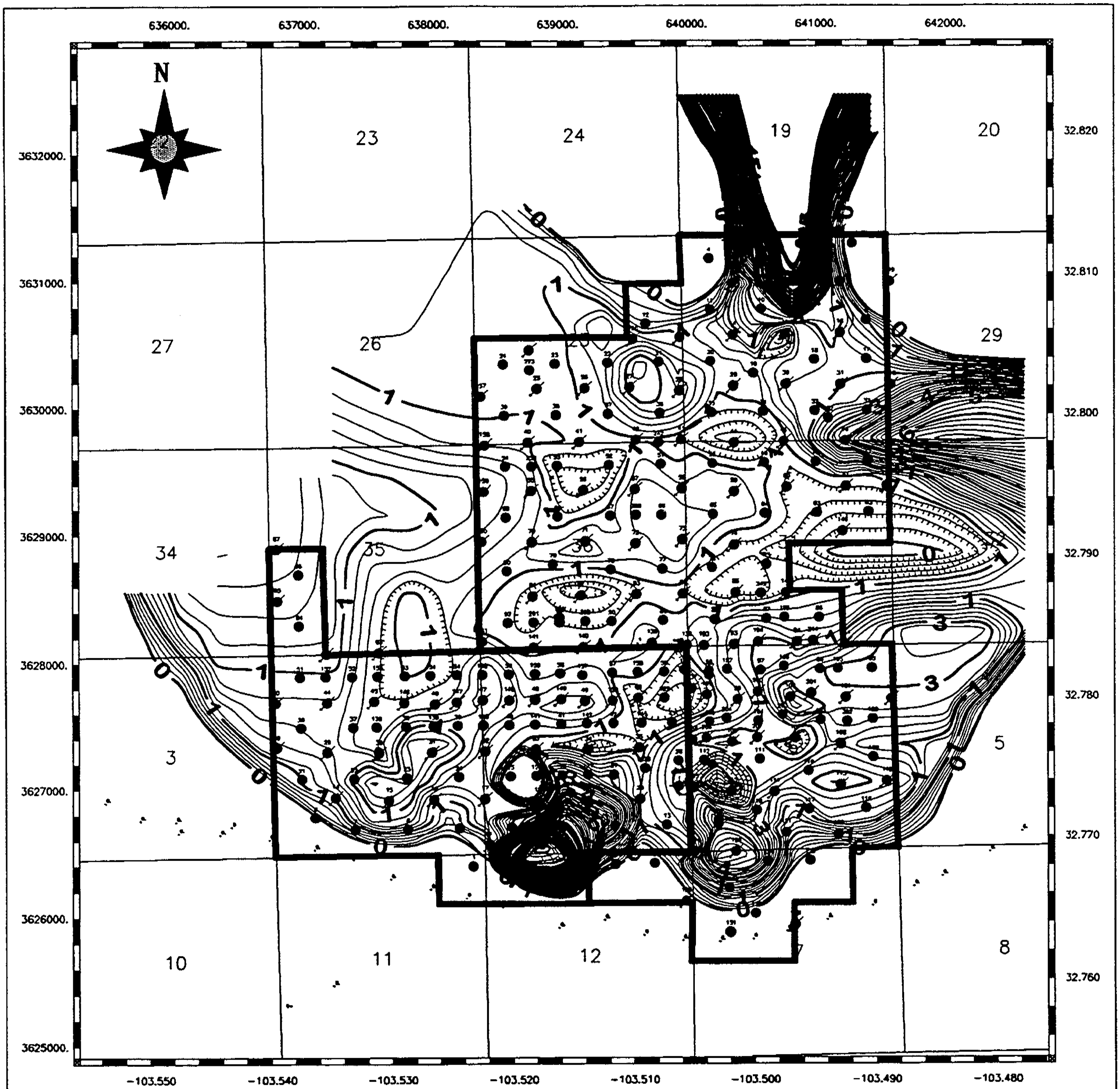



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| 1994 AVG. SURF. H20 INJ. PRESS., PSIG<br>FIGURE A-15 | | |
| C.I. = 100 | | Scale 1:46897.56 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:46897.56

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

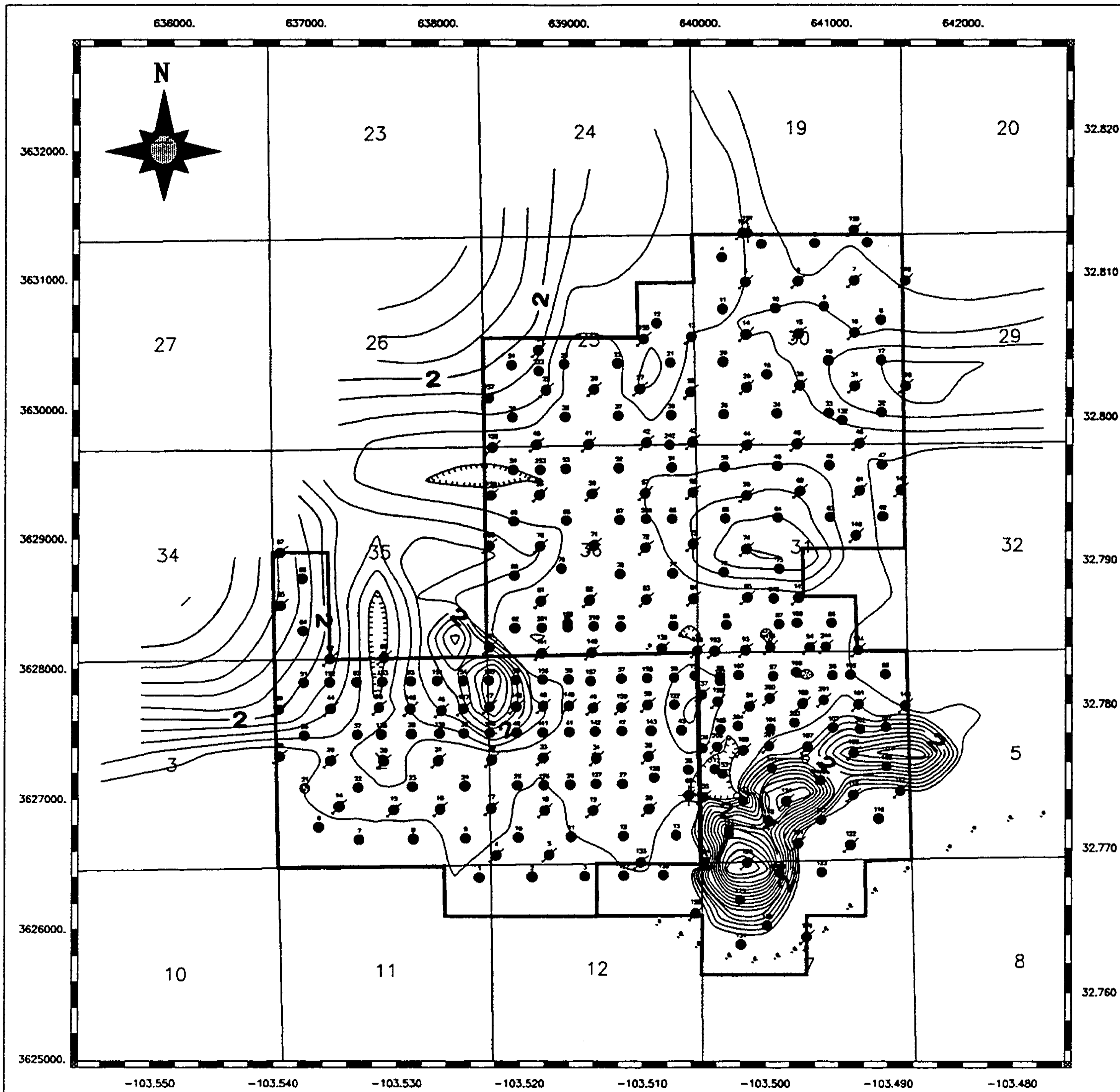



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| 1994 AVG. INJECTION WITHDRAWAL RATE | | |
| FIGURE A-16 | | |
| C.I. = 0.2 | | Scale 1:44888.29 |
| Taylor, Sharon | | 7/22/96 |

Scale 1:44888.29

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

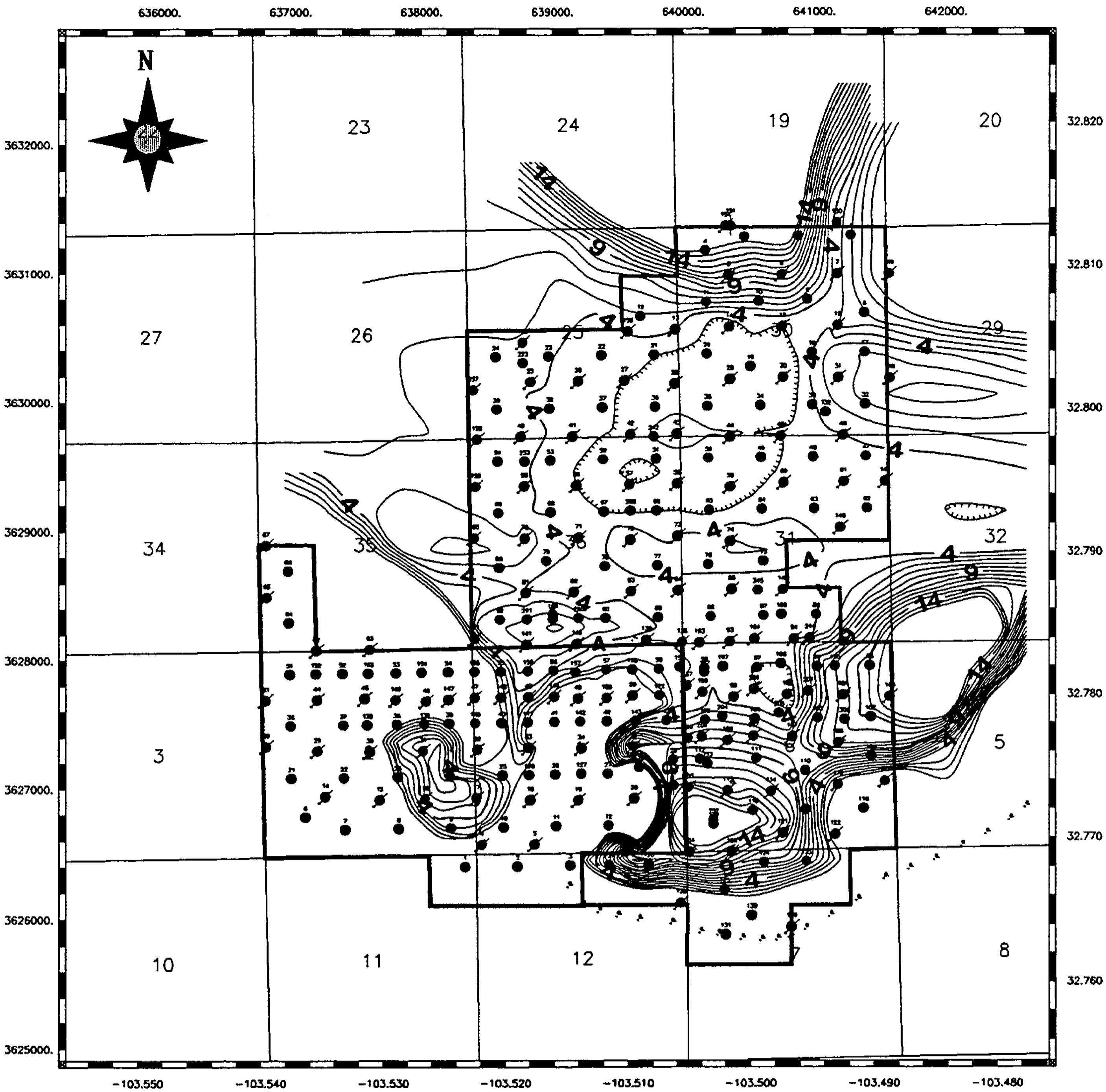



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| INITIAL WF BREAKTHROUGH, YRS FROM START | | |
| FIGURE A-17 | | |
| C.I. = 0.5 | | Scale 1:44230.35 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:44230.35

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

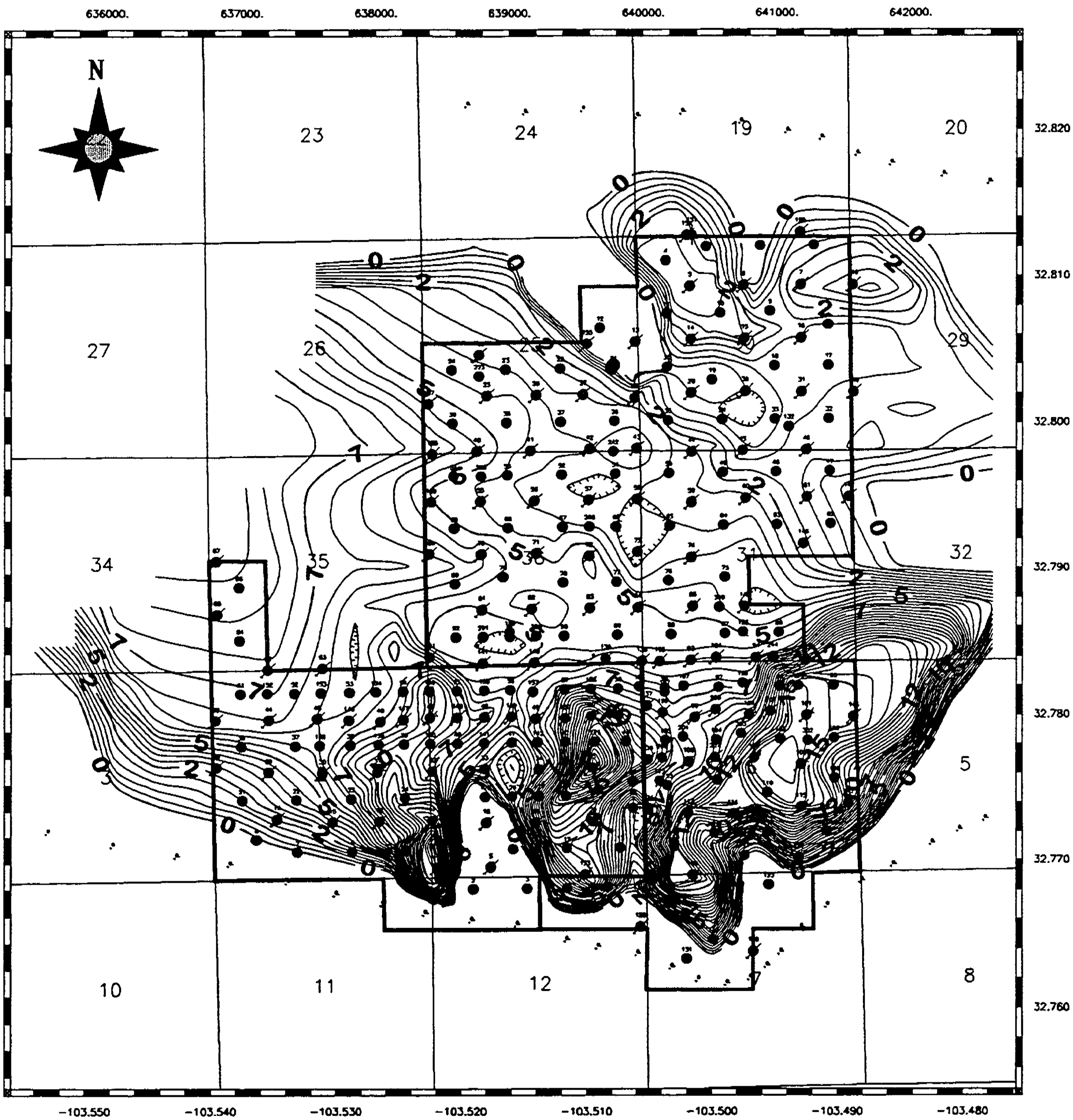



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| WF PEAK OIL RESPONSE, YRS. FROM START<br>FIGURE A-18 | | |
| C.I. = 1 | | Scale 1:45628.04 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:45628.04

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

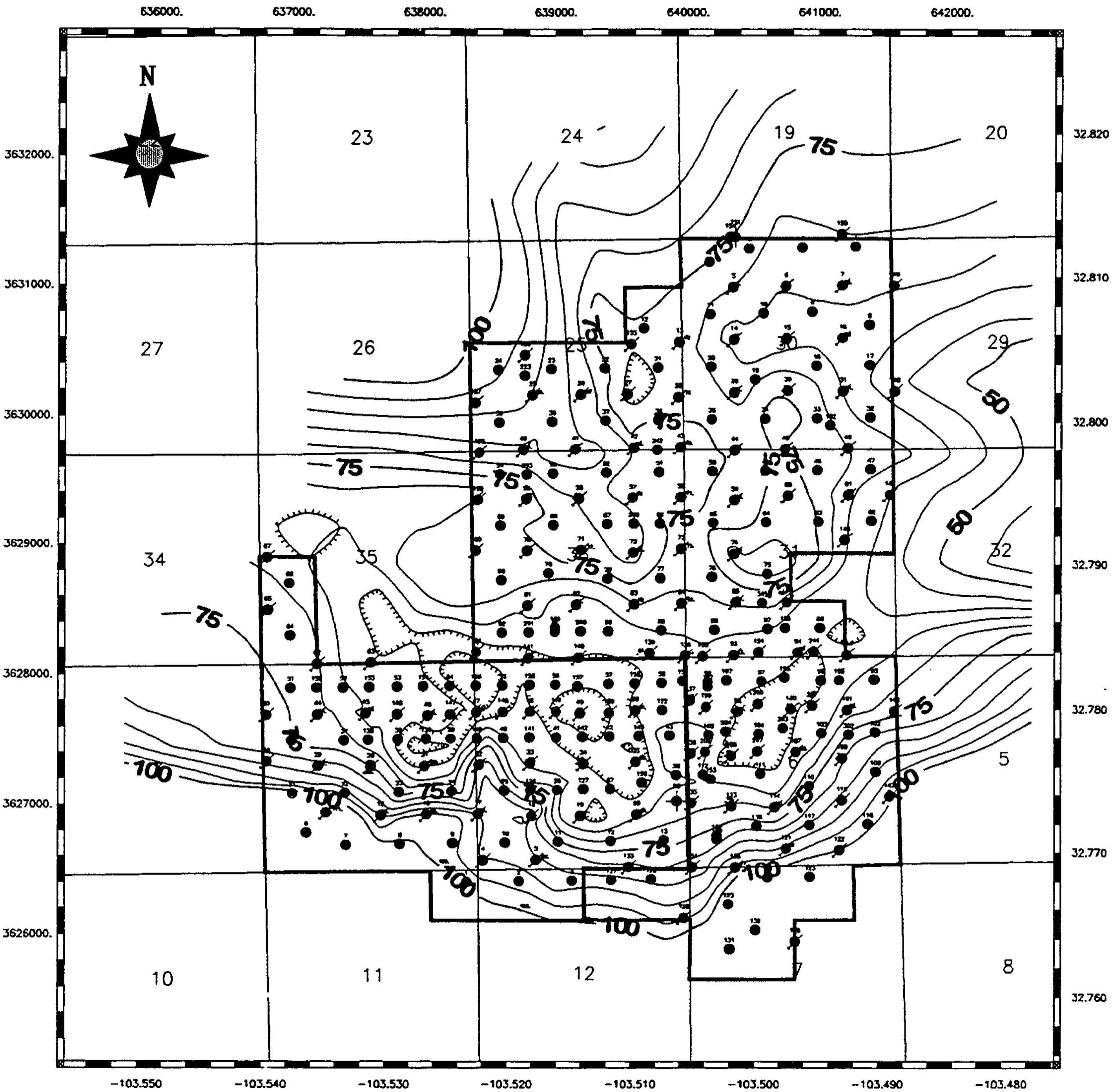



| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| 50% H20 BREAKTHROUGH, YRS. FROM START | | |
| FIGURE A-19 | | |
| C.I. = 0.5 | | Scale 1:44885.79 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:44885.79

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers




| TEXACO EXPLORATION & PRODUCTION, INC. | | |
|---|---|---|
| GROSS PAY AVG. SW, % (01/01/95) | | |
| FIGURE A-20 | | |
| C.I. = 5 | | Scale 1:45261.5 |
| Taylor, Sharon | | 7/18/96 |

Scale 1:45261.5

0.2 0. 0.2 0.4 0.6 0.8 1. miles

0.2 0. 0.20.40.60.8 1. kilometers

## *** APPENDIX "B" ***

# TABLE B-1

```
c Core Input File for VIP-COMP without Array Data (142 pgs.)
C ---------------------------------------------------
INIT
TITLE1
CENTRAL VACUUM
TITLE2
SITE SPECIFIC
TITLE3
HUFF N PUFF RUNS
DATE 30 12 1993
PLOT
MAP
GIBBS
PRINT NONE
PRINT INIT ALL
C PRINT COMP ALL
C
C ---------------------------------------------------
C   STRATAMODEL GRID SYSTEM
C ---------------------------------------------------
NX NY  NZ  NCOMP
22 26  12   9
LGR
 CARTREF W99
 2 2 12 12 1 12
 1
 1
 12*1
 ENDREF
 CARTREF W93
 1 1 1 1  1 12
 1
 1
 12*1
 ENDREF
 CARTREF W100
 12 12 12 12 1 12
 1
 1
 12*1
 ENDREF
 CARTREF W94
 13 13 1 1  1 12
 1
 1
 12*1
 ENDREF
 RADZREF W97
   7 6 1 12
   5 1 0.33 RMIN 7
   12*1
   13*.5
   13*.5
 ENDREF
ENDLGR
C ---------------------------------------------------
C
C ---------------------------------------------------
C
C ---------------------------------------------------
C   PHYSICAL PROPERTIES CONSTANTS
C ---------------------------------------------------
DWB  BWI  VW   CW     CR   TRES TS  PS
1.00 1.000 .75 3.200E-6 3.200E-6 105 60 14.65
C
KROINT
C
HCPVTAB 50
C
C
```

```
 NONEQ
C
C
TABLES
C ----------------------------------------
C   EQUILIBRIUM TABLE
C ----------------------------------------
C
 IEQUIL  PINIT   DEPTH  PCWOC  WOC  PCGOC  GOC  PSAT
  1   1620    700   21.0   840  0.0   200   790
C
C
C ----------------------------------------
C   PVT DATA – EOS PARAMETERS
C ----------------------------------------
C
C
EOS ZJRK
COMPONENTS
 CO2 C1N2 C2 C3 C4 C5C6 HVY1 HVY2 HVY3
PROPERTIES F   PSIA
COMP  MW   TC   PC   ZC  ACENTRIC OMEGAA  OMEGAB  PCHOR >
     NBP  GRVL   TREF
CO2    44.01   87.90 1070.90 .2742 .2225 .4019551 .0806553  49.6 >
    -261.0  .3000  60.0
C1N2   16.49 -120.93 661.30 .2888 .0135 .4244240 .0865580  69.7 >
    -109.3  .8150  60.0
C2     30.07   90.10 707.80 .2850 .0978 .4274800 .0866400 111.0 >
    -127.5  .3560  60.0
C3     44.10  206.00 616.30 .2810 .1541 .4274800 .0866400 151.0 >
    -43.7   .5080  60.0
C4     58.12  302.84 548.70 .2748 .1999 .4274230 .0866250 191.0 >
     29.2   .5820  60.0
C5C6   78.22  411.70 466.60 .2665 .2680 .4277090 .0864750 248.3 >
     119.3  .6440  60.0
HVY1  133.10  665.04 381.10 .3299 .4139 .4012600 .0866600 428.2 >
     327.6  .7770  60.0
HVY2  251.34  920.57 258.50 .2959 .7674 .4012600 .0866600 754.2 >
     595.6  .8521  60.0
HVY3  466.61 1215.37 177.40 .1498 1.5095 .3283300 .0703300 1528.4 >
     937.1  .9225  60.0
DJK C1N2
   CO2      .0700000
   C2      .0000000
   C3      .0000000
   HVY1      .0414000
DJK C2
   CO2      .0700000
DJK C3
   CO2      .0700000
   C2      .0000000
DJK C4
   CO2      .0700000
   C2      .0100000
   C3      .0100000
   HVY1      .0000000
   C1N2      .0196000
DJK C5C6
   CO2      .0700000
   C2      .0100000
   C3      .0100000
   HVY1      .0000000
   C1N2      .0219000
   C4      .0000000
DJK HVY1
   CO2      .1513587
   C2      .0100000
   C3      .0100000
DJK HVY2
   CO2      .0726924
   C2      .0100000
```

```
   C3        .0100000
   HVY1       .0000000
   C1N2       .0520000
   C4        .0000000
   C5C6       .0000000
DJK HVY3
   CO2        .1097270
   C2        .0100000
   C3        .0100000
   HVY1       .0000000
   C1N2       .0649000
   C4        .0000000
   C5C6       .0000000
   HVY2       .0000000
C
ENDEOS
C
OILMF 1
0.0203 0.1419 0.0983 0.0980 0.0838 0.0904 0.2721 .1529 .0423
GASMF 1
X    X    X    X    X    X    X
C ----------------------------------------
C   WATER SATURATION TABLE
C ----------------------------------------
SWT  1
  SW      KRW     KROW      PCWO
0.2000    0.0000  1.0000    5.0
0.3000    0.1000  0.3000
0.4000    0.2000  0.0800
0.5000    0.3000  0.0200
0.6000    0.4000  0.0050
0.6500    0.4500  0.0020
0.7000    0.5000  0.0000
1.0000    1.0000  0.0000    0.0000
C
C ----------------------------------------
C   GAS SATURATION TABLE
C ----------------------------------------
SGT  1
C SGTR 0.30
C With hysteresis
C
  SG      KRG      KROG     PCGO
0.0000    0.0000   1.0000   0.0000
0.0300    0.0000   0.9400   8.0000
0.1000    00.0180  0.72     10.000
0.2000    00.0400  0.339    12.00
0.3000    00.0650  0.1757    14.00
0.4000    00.0850  0.0756   16.000
0.4500    00.1000  0.0509   17.
0.5000    00.1150  0.0265   18.00
0.6000    00.1370  0.0050   20.0000
0.6150    00.1420  0.0000   20.30
0.6500    00.1600  0.0000   21.000
0.7000    00.1800  0.0000   22.0000
0.7500    00.2000  0.0000   120.0000
0.8000    00.2200  0.0000   200.000
C
C ----------------------------------------
C   ARRAY DATA
C ----------------------------------------
C
C  ---------------
C  IN ANOTHER FILE
C  ---------------
C
STOP
END
C ----------------------------------------
C ----END OF CORE PART, START OF EXEC-------------
C ----------------------------------------
```

**C Exec Input File for VIP-COMP Simulation**

```
C ------------------------------------------------
RUN
DIM NPRFMX NPRFTOT NWMAX
   12  336   28
IMPES
RESTART 0 3
IMPGRID
W93 IMPLICIT
W97 IMPLICIT
W99 IMPLICIT
W100 IMPLICIT
W94 IMPLICIT
ENDIMPGRID
START
GIBBS
OUTPUT P SO
SSSUM FIELD TAB TIME DATE QGP QOP QWP QGI QWI CGP COP CWP CGI CWI TPVP
PRINT WELLS REGIONS SSSUM TIME
C ----TIMESTEP CONTROL------------------------------
C SWITCH DTMIN  DTMAX  DPMAX  DSMAX  DVMAX  DZMAX
DT -1  0.0001  100   300
IMPSTAB .7
C     ITNMIN ITNMAX  DPLIM  DSWLIM  DVLIM  DZL1M
ITNLIM   1     22
TCUT 20 20
TOLR  .005 .0005 RELTOL
CBLITZ
C -----------------------------------------
C -------WELL DATA-------------------------------------
C -----------------------------------------
WELL N  NAME        IW  JW  GRID
  1  CVU195      22   7  ROOT
  2  CVU96       17   6  ROOT
  3  CVU196      12   6  ROOT
  4  CVU97       X    X  W97
  5  CVU197      1    7  ROOT
  13  CVU99      1    1  W99
  14  CVU200     7   11  ROOT
  15  CVU100     1    1  W100
  16  CVU201     17  12  ROOT
  17  CVU101     22  12  ROOT
  6  CVU204      1   16  ROOT
  7  CVU104      6   16  ROOT
  8  CVU203      11  16  ROOT
  9  CVU103      17  16  ROOT
  10  CVU302     22  16  ROOT
  18  CVU106     1   20  ROOT
  19  CVU207     6   20  ROOT
  20  CVU107     12  20  ROOT
  21  CVU108     21  21  ROOT
  11  CVU110     15  26  ROOT
  12  CVU111     6   24  ROOT
  22  CVU93      1    1  W93
  23  CVU194     7    1  ROOT
  24  CVU94      1    1  W94
  25  CVU244     17   1  ROOT
  26  CVU144     22   1  ROOT
  27  CVU97I     X    X  W97
  28  CVU97P     X    X  W97
INJ  W  STD 13 -17 18 -26
PROD  O STD  1 -5  6 -10 11 12 28
INJ  G  STD  27
YINJ  27
C COMPOSITION OF GAS
1.0 0.00  0 0 0 0 0 0 0
C
FPERF
WELL         IW  JW  DTOP   DBOT  SKIN   GRID
  1         22   7  365   700   -1    ROOT
  2         17   6  355   700   -1    ROOT
```

```
 3        12   6  344  700  -1   ROOT
 4        X    X  342  700  -1   W97
 5        1    7  332  700  -1   ROOT
 13       1    1  325  700  -4   W99
 14       7   11  328  700  -4   ROOT
 15       1    1  329  700  -4   W100
 16       17  12  342  700  -4   ROOT
 17       22  12  358  700  -4   ROOT
 6        1   16  318  700  -1   ROOT
 7        6   16  313  700  -1   ROOT
 8        11  16  318  700  -1   ROOT
 9        17  16  340  700  -1   ROOT
 10       22  16  356  700  -1   ROOT
 18       1   20  314  700  -4   ROOT
 19       6   20  300  700  -4   ROOT
 20       12  20  319  700  -4   ROOT
 21       21  21  367  700  -4   ROOT
 11       15  26  314  700  -1   ROOT
 12       6   24  390  700  -1   ROOT
 22       1   1   319  700  -4   W93
 23       7   1   367  700  -4   ROOT
 24       1   1   314  700  -1   W94
 25       17  1   390  700  -1   ROOT
 26       22  1   390  700  -1   ROOT
 27       X   X   342  700  -1   W97
 28       X   X   342  700  -1   W97
WI  13 -26
14*10.0
C
WI  4 27
2*6.0
C
QMAX 13 -26
 14*0
QMAX 1 -12
 12*0
PROD LIQUID 4
QMAX  4
  625.0
QMAX 27
 0
QMAX 28
 0
ACTIVATE ALL
C
C
C
C ------------------------------------------------
C PRODUCTION - INJECTION DATA
C ------------------------------------------------
DATE  01 01 1994
C SWITCH DTMIN  DTMAX  DPMAX  DSMAX  DVMAX  DZMAX
DT -1   0.0001  10    300
OVER  ISAT
1 22 1 26 1 12 =7
GLIMIT LIMIT 1 -12
12*1000
BHP 4
100
700
PROD LIQUID 4
QMAX  4
  625.0
QMAX 13 15 22 24
4*450
BHP 13 -26
14*1700
14*700
DATE  01 06 1995
QMAX  4
0.0
```

```
BHP 27
2000
700
QMAX 27
2000.0
C SWITCH DTMIN  DTMAX  DPMAX  DSMAX  DVMAX  DZMAX
DT -1   0.0001  1     300
OUTPUT   SO SG
PRINT ARRAYS TNEXT
DATE  04 06 1995
OUTPUT  SO SG
PRINT ARRAYS TNEXT
DATE  07 06 1995
OUTPUT  SO SG
PRINT ARRAYS TNEXT
DATE  10 06 1995
OUTPUT  SO SG
PRINT ARRAYS TNEXT
DATE  15 06 1995
OUTPUT  SO SG
PRINT ARRAYS TNEXT
DATE  20 06 1995
PRINT ARRAYS TNEXT
DATE  25 06 1995
QMAX 27
0.0
DATE  15 07 1995
PROD LIQUID 4
QMAX   4
 800
C 625
DATE  16 07 1995
DATE  18 07 1995
DATE  21 07 1995
DATE  24 07 1995
DATE  27 07 1995
DATE  30 07 1995
QMAX 4
625
C SWITCH DTMIN  DTMAX  DPMAX  DSMAX  DVMAX  DZMAX
DT -1   0.0001  10    300
DATE  01 08 1995
DATE  15 08 1995
DATE  01 09 1995
DATE  15 09 1995
DATE  01 10 1995
DATE  15 10 1995
DATE  01 11 1995
DATE  01 12 1995
DATE  01 01 1996
DATE  01 02 1996
DATE  01 03 1996
DATE  01 04 1996
DATE  01 05 1996
DATE  01 06 1996
DATE  01 07 1996
DATE  01 08 1996
STOP
END
```

# VIP-COMP Simulation Output Data in Summary Format

| Time days | Gas Prod Rate mcf/d | Oil Prod Rate stb/d | Water Prod Rate bbl/d | Gas Inj Rate mcf/d | Water Inj Rate bbl/d | Gas Prod Cum mmscf | Oil Prod Cum mstb | Water Prod Cum mstb | Gas Inj Cum mmscf | Water Inj Cum mstb |
|---|---|---|---|---|---|---|---|---|---|---|
| 518 | 20.492367 | 47.453844 | 577.54616 | 0.00E+00 | 628.19091 | 6.5172 | 15.072048 | 308.67795 | 0 | 285.51543 |
| 521 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2000 | 624.55306 | 6.5172 | 15.072048 | 308.67795 | 6 | 287.39734 |
| 524 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2000 | 598.1171 | 6.5172 | 15.072048 | 308.67795 | 12 | 289.23329 |
| 527 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2000 | 552.87095 | 6.5172 | 15.072048 | 308.67795 | 18 | 290.95233 |
| 532 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2000 | 462.76331 | 6.5172 | 15.072048 | 308.67795 | 28 | 293.46383 |
| 537 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2000 | 371.9645 | 6.5172 | 15.072048 | 308.67795 | 38 | 295.51262 |
| 542 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2000 | 287.30592 | 6.5172 | 15.072048 | 308.67795 | 48 | 297.11564 |
| 562 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 154.20021 | 6.5172 | 15.072048 | 308.67795 | 48 | 300.96248 |
| 563 | 1000 | 1.7825831 | 36.069967 | 0.00E+00 | 152.72448 | 7.5172 | 15.073831 | 308.71402 | 48 | 301.11521 |
| 565 | 1000 | 7.6093495 | 61.566299 | 0.00E+00 | 151.72593 | 9.5172 | 15.085921 | 308.8233 | 48 | 301.41877 |
| 568 | 1000 | 21.951968 | 234.05686 | 0.00E+00 | 156.99111 | 12.5172 | 15.13509 | 309.27855 | 48 | 301.8826 |
| 571 | 1000 | 315.21171 | 484.0992 | 0.00E+00 | 169.66909 | 15.5172 | 15.57128 | 310.60818 | 48 | 302.3753 |
| 574 | 811.88789 | 334.40204 | 465.59796 | 0.00E+00 | 188.77078 | 18.041478 | 16.589803 | 311.98966 | 48 | 302.91854 |
| 577 | 1000 | 332.71195 | 453.88018 | 0.00E+00 | 211.3158 | 20.681664 | 17.550086 | 313.42333 | 48 | 303.52682 |
| 579 | 533.04121 | 265.03753 | 359.96247 | 0.00E+00 | 226.79206 | 21.729297 | 18.08445 | 314.13897 | 48 | 303.97267 |
| 593 | 296.34659 | 153.30916 | 471.69084 | 0.00E+00 | 321.96757 | 27.557453 | 20.584664 | 320.38875 | 48 | 308.06449 |
| 610 | 239.12183 | 116.81105 | 508.18895 | 0.00E+00 | 403.04524 | 31.702948 | 22.706044 | 328.89237 | 48 | 314.60661 |
| 624 | 174.43293 | 93.855379 | 531.14462 | 0.00E+00 | 453.27824 | 34.390542 | 24.088722 | 336.2597 | 48 | 320.78986 |
| 640 | 126.91222 | 79.289847 | 545.71015 | 0.00E+00 | 495.71019 | 36.55086 | 25.402509 | 344.94591 | 48 | 328.5666 |
| 654 | 108.01441 | 71.638731 | 553.36127 | 0.00E+00 | 523.22835 | 38.126399 | 26.434129 | 352.66429 | 48 | 335.80337 |
| 671 | 90.82886 | 62.527536 | 562.47246 | 0.00E+00 | 547.93786 | 39.740621 | 27.534167 | 362.18925 | 48 | 345.02146 |
| 701 | 72.043219 | 57.120552 | 567.87945 | 0.00E+00 | 578.38409 | 42.078718 | 29.305434 | 379.16798 | 48 | 362.09759 |
| 732 | 60.262557 | 53.160807 | 571.83919 | 0.00E+00 | 598.97659 | 44.054077 | 30.988483 | 396.85993 | 48 | 380.47263 |
| 763 | 53.17639 | 51.079661 | 573.92034 | 0.00E+00 | 612.85782 | 45.767836 | 32.589193 | 414.63422 | 48 | 399.34003 |
| 792 | 48.421887 | 49.79278 | 575.20722 | 0.00E+00 | 622.06276 | 47.220257 | 34.045673 | 431.30274 | 48 | 417.28938 |
| 823 | 45.492646 | 48.967716 | 576.03228 | 0.00E+00 | 629.06429 | 48.660981 | 35.567597 | 449.15582 | 48 | 436.72268 |
| 853 | 42.974719 | 48.483696 | 576.5163 | 0.00E+00 | 634.11291 | 49.973913 | 37.026231 | 466.44719 | 48 | 455.69894 |
| 884 | 40.883033 | 48.101086 | 576.89891 | 0.00E+00 | 637.97143 | 51.261924 | 38.521078 | 484.32734 | 48 | 475.43891 |
| 914 | 39.005856 | 47.540046 | 577.45995 | 0.00E+00 | 640.75925 | 52.450269 | 39.952749 | 501.64567 | 48 | 494.63569 |
| 945 | 37.515797 | 47.224208 | 577.77579 | 0.00E+00 | 642.87986 | 53.628632 | 41.420594 | 519.55282 | 48 | 514.54458 |

## *** APPENDIX "C" ***

# TABLE C-1

DOE/CVU CO2 Huff-n-Puff Test
Pre-demo./Injection/Soak/Production Testing

| Date | Oil STB/D | Water Bbl/D | Daily Avg. Total Gas Mcf/D | Est. HC Gas Mcf/D | Cum. CO2 Mcf/D | CO2 Inj. MMcf/D | Avg. Tbg. Press. psig | Choke Size x/64" | Est'd. Total Fluid STB/D | % CO2 in gas, % | Cum. CO2 Prod., % Total Inj'd. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10/1/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/2/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/3/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/4/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/5/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/6/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/7/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/8/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/9/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/10/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/11/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/12/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/13/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/14/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/15/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/16/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/17/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/18/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/19/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/20/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/21/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/22/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/23/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/24/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/25/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/26/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/27/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/28/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/29/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/30/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 10/31/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 11/1/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 11/2/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 11/3/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 11/4/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 11/5/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 11/6/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 11/7/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 11/8/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 11/9/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 11/10/95 | 68 | 745 | 27.2 | 27.2 | — | — | 30 | — | 827 | — | — |
| 11/11/95 | 0 | 0 | 0 | — | — | — | 0 | — | 0 | — | — |
| 11/12/95 | — | — | — | — | — | — | 0 | — | 0 | — | — |
| 11/13/95 | — | — | — | — | — | 1.82 | 400 | — | 0 | — | — |
| 11/14/95 | — | — | — | — | — | 1.06 | 510 | — | 0 | — | — |
| 11/15/95 | — | — | — | — | — | 2.18 | 542 | — | 0 | — | — |
| 11/16/95 | — | — | — | — | — | 2.30 | 647 | — | 0 | — | — |
| 11/17/95 | — | — | — | — | — | 2.30 | 683 | — | 0 | — | — |
| 11/18/95 | — | — | — | — | — | 2.54 | 662 | — | 0 | — | — |
| 11/19/95 | — | — | — | — | — | 2.67 | 744 | — | 0 | — | — |
| 11/20/95 | — | — | — | — | — | 2.30 | 650 | — | 0 | — | — |
| 11/21/95 | — | — | — | — | — | 2.61 | 548 | — | 0 | — | — |
| 11/22/95 | — | — | — | — | — | 2.91 | 607 | — | 0 | — | — |
| 11/23/95 | — | — | — | — | — | 1.67 | 616 | — | 0 | — | — |
| 11/24/95 | — | — | — | — | — | 1.46 | 561 | — | 0 | — | — |
| 11/25/95 | — | — | — | — | — | 1.78 | 633 | — | 0 | — | — |
| 11/26/95 | — | — | — | — | — | 2.20 | 678 | — | 0 | — | — |
| 11/27/95 | — | — | — | — | — | 1.99 | 685 | — | 0 | — | — |
| 11/28/95 | — | — | — | — | — | 1.88 | 676 | — | 0 | — | — |
| 11/29/95 | — | — | — | — | — | 1.99 | 678 | — | 0 | — | — |
| 11/30/95 | — | — | — | — | — | 1.99 | 684 | — | 0 | — | — |
| 12/1/95 | — | — | — | — | — | 1.78 | 665 | — | 0 | — | — |
| 12/2/95 | — | — | — | — | — | 1.67 | 649 | — | 0 | — | — |
| 12/3/95 | — | — | — | — | — | 1.88 | 675 | — | 0 | — | — |
| 12/4/95 | — | — | — | — | — | 1.36 | 580 | — | 0 | — | — |
| 12/5/95 | — | — | — | — | — | 0.31 | 462 | — | 0 | — | — |

## DOE/CVU $CO_2$ Huff-n-Puff Test

Pre-demo./Injection/Soak/Production Testing

| Date | Oil STB/D | Water Bbl/D | Daily Avg. Total Gas Mcf/D | Est. HC Gas Mcf/D | Cum. $CO_2$ Mcf/D | $CO_2$ Inj. MMcf/D | Avg. Tbg. Press. psig | Choke Size x/64" | Est'd. Total Fluid STB/D | % $CO_2$ in gas, % | Cum. $CO_2$ Prod., % Total Inj'd. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12/6/95 | — | — | — | — | — | 2.20 | 630 | — | 0 | — | — |
| 12/7/95 | — | — | — | — | — | 2.62 | 701 | — | 0 | — | — |
| 12/8/95 | — | — | — | — | — | 0.52 | 603 | — | 0 | — | — |
| 12/9/95 | — | — | — | — | — | — | 683 | — | 0 | — | — |
| 12/10/95 | — | — | — | — | — | — | 737 | — | 0 | — | — |
| 12/11/95 | — | — | — | — | — | — | 764 | — | 0 | — | — |
| 12/12/95 | — | — | — | — | — | — | 779 | — | 0 | — | — |
| 12/13/95 | — | — | — | — | — | — | 792 | — | 0 | — | — |
| 12/14/95 | — | — | — | — | — | — | 803 | — | 0 | — | — |
| 12/15/95 | — | — | — | — | — | — | 823 | — | 0 | — | — |
| 12/16/95 | — | — | — | — | — | — | 831 | — | 0 | — | — |
| 12/17/95 | — | — | — | — | — | — | 846 | — | 0 | — | — |
| 12/18/95 | — | — | — | — | — | — | 866 | — | 0 | — | — |
| 12/19/95 | — | — | — | — | — | — | 857 | — | 0 | — | — |
| 12/20/95 | — | — | — | — | — | — | 829 | — | 0 | — | — |
| 12/21/95 | — | — | — | — | — | — | 863 | — | 0 | — | — |
| 12/22/95 | — | — | — | — | — | — | 879 | — | 0 | — | — |
| 12/23/95 | — | — | — | — | — | — | 872 | — | 0 | — | — |
| 12/24/95 | — | — | — | — | — | — | 870 | — | 0 | — | — |
| 12/25/95 | — | — | — | — | — | — | 866 | — | 0 | — | — |
| 12/26/95 | — | — | — | — | — | — | 868 | — | 0 | — | — |
| 12/27/95 | 4 | 1 | 840 | 0 | 840 | — | 754 | 16 | 425 | 100.0% | 0.02 |
| 12/28/95 | 6 | 0 | 674 | 0 | 1514 | — | 778 | 16 | 343 | 100.0% | 0.03 |
| 12/29/95 | 0 | 0 | 872 | 0 | 2386 | — | 741 | 16 | 436 | 100.0% | 0.05 |
| 12/30/95 | 0 | 3 | 836 | 0 | 3222 | — | 656 | 16 | 421 | 100.0% | 0.07 |
| 12/31/95 | 6 | 3 | 836 | 0 | 4058 | — | 644 | 16 | 427 | 100.0% | 0.08 |
| 1/1/96 | 10 | 0 | 929 | 0 | 4987 | — | 652 | 16 | 474 | 100.0% | 0.10 |
| 1/2/96 | 7 | 0 | 952 | 0 | 5939 | — | 652 | 16 | 483 | 100.0% | 0.12 |
| 1/3/96 | 18 | 0 | 972 | 51 | 6860 | — | 632 | 16 | 505 | 94.8% | 0.14 |
| 1/4/96 | 37 | 0 | 895 | 47 | 7708 | — | 607 | 16 | 484 | 94.8% | 0.16 |
| 1/5/96 | 55 | 0 | 918 | 48 | 8578 | — | 617 | 17 | 514 | 94.8% | 0.18 |
| 1/6/96 | 35 | 0 | 445 | 27 | 8996 | — | 607 | 17 | 258 | 93.9% | 0.19 |
| 1/7/96 | 49 | 0 | 594 | 38 | 9552 | — | 631 | 17 | 346 | 93.7% | 0.20 |
| 1/8/96 | 70 | 8 | 884 | 56 | 10380 | — | 645 | 18 | 521 | 93.7% | 0.22 |
| 1/9/96 | | | 763 | 48 | 11095 | — | 563 | 18 | 382 | 93.7% | 0.23 |
| 1/10/96 | 40 | 0 | 393 | 25 | 11463 | — | 593 | 13 | 237 | 93.7% | 0.24 |
| 1/11/96 | 63 | 1 | 414 | 26 | 11851 | — | 613 | 14 | 271 | 93.7% | 0.25 |
| 1/12/96 | 70 | 6 | 434 | 28 | 12257 | — | 580 | 14 | 293 | 93.7% | 0.26 |
| 1/13/96 | 60 | 11 | 392 | 25 | 12624 | — | 599 | 14 | 267 | 93.7% | 0.26 |
| 1/14/96 | 59 | 8 | 388 | 25 | 12988 | — | 590 | 15 | 261 | 93.7% | 0.27 |
| 1/15/96 | 63 | 24 | 455 | 29 | 13414 | — | 554 | 14 | 315 | 93.7% | 0.28 |
| 1/16/96 | 65 | 32 | 388 | 39 | 13763 | — | 537 | 14 | 291 | 89.9% | 0.29 |
| 1/17/96 | — | — | — | — | 13763 | — | — | 14 | 0 | 89.9% | 0.29 |
| 1/18/96 | 57 | 32 | 293 | 30 | 14026 | — | 531 | 14 | 236 | 89.9% | 0.29 |

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