Increasing Heavy Oil Reserves in the Wilmington Oil Field Through Advanced Reservoir Characterization and Thermal Production Technologies

**Quarterly Report
October 1 - December 31, 1997**

**By:
Scott Hara**

Work Performed Under Contract No.: DE-FC22-95BC14939

For
U.S. Department of Energy
Office of Fossil Energy
Federal Energy Technology Center
P.O. Box 880
Morgantown, West Virginia 26507-0880

By
City of Long Beach
Department of Oil Properties
Long Beach, California 90801

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PACKAGE CONTENTS

**1 COPY "QUARTERLY TECHNICAL PROGRESS REPORT" FOR
THE PERIOD OCTOBER 1 - DECEMBER 31, 1997**

Class III Mid-term Project - Wilmington Field

1 FLOPPY DISK OF REPORT IN THE FORMAT REQUIRED FOR QUARTERLY
REPORTS IN ADOBE ACROBAT

March 3, 1998

AAD Document Control
U. S. Department of Energy
Pittsburgh Energy Technology Center
Wallace Road, Building 921
P. O. Box 10940, MS 921-143
Pittsburgh, PA 15236-0940
Contact: Mr. Keith Miles

Subject: Quarterly Technical Progress Report - Class III Mid-Term Project, "Increasing Heavy Oil Reserves in the Wilmington Oil Field Through Advanced Reservoir Characterization and Thermal Production Technologies", DE-FC22-95BC14939.

Dear Keith:

As required by the "Federal Assistance Reporting Checklist", enclosed is a Quarterly Technical Progress Report covering the subject project for the period October 1 to December 31, 1997 submitted by Tidelands Oil Production Company and the City of Long Beach Department of Oil Properties. The associated floppy disk for the Quarterly Report in Adobe Acrobat format is also enclosed.

We still owe you the second Annual Report for the period April 1, 1996 to March 31, 1997 which is taking longer than anticipated to complete. It looks like we will be completing the second annual report soon and immediately following it up with the third annual report.

For simplicity in reading the report, Tidelands Oil Production Company will be referred to as "Tidelands", the City of Long Beach Department of Oil Properties will be referred to as "City", the University of Southern California will be referred to as "USC", and David K. Davies and Associates, Inc. will be referred to as "DKD". If you require any other information or have any questions please feel free to call me at 562-436-9918 ext.351.

Sincerely,

Scott Hara
Chief Production Engineer

PSH:DOE\STCM1297.FRM

INCREASING HEAVY OIL RESERVES IN THE WILMINGTON OIL FIELD THROUGH ADVANCED RESERVOIR CHARACTERIZATION AND THERMAL PRODUCTION TECHNOLOGIES

Cooperative Agreement No.: DE-FC22-95BC14939--12

Contractor Names: City of Long Beach Department of Oil Properties (City) and Tidelands Oil Production Company (Tidelands), Long Beach, CA.

Date of Report: March 3, 1998

Award Date: March 30, 1995

Anticipated Completion Date: March 29, 1999

DOE Award: \$4,245,517 (Cum Actual thru 1996)
\$1,928,369 (1997 Projected)
\$588,248 (1997 YTD Actual)

Principal Investigator: Scott Hara - Tidelands

Program Manager: Dan Ferguson - National Petroleum Technology Office

Reporting Period: October 1, 1997 to December 31, 1997

Objectives

The project involves improving thermal recovery techniques in a slope and basin clastic (SBC) reservoir in the Wilmington field, Los Angeles Co., Calif. using advanced reservoir characterization and thermal production technologies.

The existing steamflood in the Tar zone of Fault Block (FB) II-A has been relatively inefficient because of several producibility problems which are common in SBC reservoirs. Inadequate characterization of the heterogeneous turbidite sands, high permeability thief zones, low gravity oil, and nonuniform distribution of remaining oil have all contributed to poor sweep efficiency, high steam-oil ratios, and early steam breakthrough. Operational problems related to steam breakthrough, high reservoir pressure, and unconsolidated formation sands have caused premature well and downhole equipment failures. In aggregate, these reservoir and operational constraints have resulted in increased operating costs and decreased recoverable reserves. The advanced technologies to be applied include:

- (1) Develop three-dimensional (3-D) deterministic and stochastic geologic models.
- (2) Develop 3-D deterministic and stochastic thermal reservoir simulation models to aid in reservoir management and subsequent development work.
- (3) Develop computerized 3-D visualizations of the geologic and reservoir simulation models to aid in analysis.
- (4) Perform detailed study on the geochemical interactions between the steam and the formation rock and fluids.
- (5) Pilot steam injection and production via four new horizontal wells (2 producers and 2 injectors).
- (6) Hot water alternating steam (WAS) drive pilot in the existing steam drive area to improve thermal efficiency.
- (7) Installing a 2100 foot insulated, subsurface harbor channel crossing to supply steam to an island location.
- (8) Test a novel alkaline steam completion technique to control well sanding problems and fluid entry profiles.
- (9) Advanced reservoir management through computer-aided access to production and geologic data to integrate reservoir characterization, engineering, monitoring, and evaluation.

Summary of Technical Progress

This is the eleventh quarterly technical progress report for the project. Through December 1997, project work related to data preparation, basic reservoir engineering, deterministic 3-D geologic modeling, well drilling and completion, and surface facilities has

been completed. Estimated costs are on budget for the work performed to date. Technical accomplishments during the quarter include analyzing the high temperature coreflood work completed last quarter, evaluating the deterministic reservoir simulation modeling of the primary and waterflood phases in the Tar II-A zone, a successful pilot study on the use of produced fluid salinity data to monitor steamflood performance and improve reservoir characterization, expansion of hot waterflood injection volumes by boosting water volumes to the maximum through the Harbor Cogeneration Plant (average steam quality reduced), and presentation of two major papers at the 1997 SPE Annual Technical Conference on the steam injection sand consolidation well completion technique and on the rock-log correlation model. Work is continuing on the stochastic geologic and reservoir simulation models, tracking the reservoir tracers injected into the hot waterflood pilot injectors, performing more high temperature core work, developing a stochastic thermal reservoir simulation model of the Fault Block II-A Tar Zone, and reservoir surveillance of the pilot horizontal well steamflood and pilot hot waterflood.

● **Compilation and Analysis of Existing Data**

A computer database of production and injection data and previous reservoir studies was compiled for the FB II-A Tar zone. Digitized and normalized log data were completed for 171 wells (over 600 wells penetrate the Tar zone in the fault block). The digitized logs include the electric or induction and the spontaneous potential (SP) and/or gamma ray (GR). The log data from the 171 wells are distributed throughout the fault block and provide the base case log file for developing the 3-D stochastic geologic and reservoir simulation models. Another 100 logs will be digitized and normalized to use as "confirmation" logs for the stochastic modeling. Conventional cores throughout the zone were obtained from the previous operator in nine of the 171 wells which were used to correlate the formation rock and log data.

● **Advanced Reservoir Characterization**

The basic reservoir engineering technical work, including an SPE technical paper¹¹ and several draft reports covering various aspects of the study, has been completed. Work completed includes an analysis of the primary and waterflood recoveries, permeability estimates from performance data, comparing water injection profile surveys to the allocated injection volumes for each sub-zone, determining the quality of the new and old well logs, determining the vertical communication between sands, and evaluating the aquifer and solution gas. The draft reports are entitled "Application of Basic Reservoir Engineering Techniques to the Tar Zone Fault Block IIA, Wilmington, CA"; "Study of Pre-1960 Well Logs in Fault Block IIA, WilmingtonField"; and "Study of Water Injection Surveys, Tar Zone Fault Block II, Wilmington Field".

SPE paper #38309¹¹, presented in June 1997, is entitled "Conceptual Model of FB IIA, Wilmington Field, from Field Performance Data" which explains a new empirically-based yardstick for calculating original oil in place using gas production and PVT data from the Tar IIA Zone and draws upon the basic reservoir engineering work described in the draft reports. The paper also describes how a cum-derivative plot of water cut data for a number of producers identified five distinguishable water breakthroughs covering the T, D1 and D2 sands and how a Spearman Rank correlation method was used to correlate producer-injector relationships which will be used later for conditional simulation of stochastic geologic images.

Historical problems with oil, gas, and water production allocations to each well and to each zone completed in the wells caused uncertainty in the material balance calculations and projected remaining reserves. As a check, the original oil in place (OOIP) was calculated two ways. The first way used conventional volumetric techniques (log and core data) to define the formation porosity, reservoir net oil sand thickness and areal limits, fluid saturations and oil characteristics which resulted in 92 million stock tank barrels of oil (MMSTBO). The second way was by dividing the cumulative gas production by the total of the original solution gas-oil ratio times the fraction of the total reservoir pressure drop during primary production divided by the original reservoir pressure. Water influx from the aquifer accounted for about 60% of the voidage created by primary production, but reservoir pressure still dropped to about 265 psi from 1110 psi original. Old reports indicated that PVT data compared favorably with Standings' correlations, therefore, Standings' correlations were used to derive the initial solution gas-oil ratio at the original reservoir pressure for the FB II-A Tar zone oil. An initial solution gas-oil ratio of 97 scf/stbo and cumulative gas production of 7.2 BCF yields an OOIP of 97 MMSTBO which is acceptably close to the material balance calculation considering the uncertainty of the gas production figures.

An SPE presentation (and future paper) was given on a parametric study comparing projected steam drive recoveries from vertical wells and horizontal wells using the steam-assisted gravity drainage technique. Study results using the TETRADTM thermal reservoir simulator program, a product of Dyad 88 Software Inc., are being cross-checked with the CMG STARSTM program. The study results compared recovery from both types of well completions as a function of reservoir properties, crude oil characteristics, and injection strategies and provided guidelines and correlations for predictive purposes in developing the stochastic reservoir simulation model on the STARS program. The paper should be completed next quarter¹⁵.

Reservoir tracers were bulk injected on February 14, 1997 into two hot water-alternating-steam pilot injectors which are now injecting hot water. The tracer program includes two tracers, ammonium thiocyanate (AT) was injected into the "T" sub-zone in Well 2AT-32 and lithium chloride (LC) was injected into the "D" sub-zone in Well 2AT-33. No tracer response has been recorded through December. This means either the injected

water is evenly distributing areally, the tracers are being absorbed by the formation rocks more than anticipated, the tracers are breaking down under the high reservoir temperatures, or that we missed sampling the tracers. Given our high sampling frequency and reservoir heterogeneity, we believe the middle two reasons are more probable. While some breakthroughs are suspected, additional tests are underway to delineate the range of AT and LC background levels compared to the concentration increases observed in the samples. We are evaluating new lab procedures to identify AT and LC components in the previous test samples. The tracers will follow the liquid phase of the injected fluids rather than the steam phase and were selected based on their supposed stability in high temperatures, minimum absorption rate, and being non-radioactive. Computer software has been developed to map formation permeability in 3-D from production and injection data. The software has been tested using a compositional model at a major research company in California.

A 3-D deterministic geologic model was completed which is being used to develop the 3-D stochastic geologic model and was used for drilling the observation and horizontal wells^{1,2,3,4,6,8,14}. The deterministic model correlates eighteen sand tops in the Tar zone. A rock-log model was developed which identified five distinct rock types in the gross Tar zone interval. Two SPE papers were presented in June and October on the development of a rock-log model to identify permeability trends in the reservoir^{5,19,23}. All existing cores were visually inspected and the core and log data were evaluated to develop a core-based log model, a porosity-permeability model and a rock-log model. These models will provide the rock and reservoir data for the stochastic geologic model in locations where no well log data exists. The rock types were selected based on broad, but distinct differences in reservoir characteristics so that realistic grid block sizes could be created for the reservoir simulation model. Developing a multitude of rock types for every small difference in reservoir characteristics would make simulation modeling impractical. The rock-log model will be continually refined as new geologic, geostatistic, and core information becomes available.

In an effort to find a better, more cost-effective core analysis procedure, lab work has been performed to determine the difference in air and liquid permeability data using "routine Dean Stark analysis" on unconsolidated sands when measured under minimum confinement stress and under overburden pressures. This data will be compared to several core samples that were tested for permeability under overburden pressures after miscibly removing the oil. The tests should offer insight about the accuracy of "routine" core analysis and help calibrate the "routine" data obtained in the past.

Other deterministic geologic draft reports that have been completed include "Stratigraphic Equivalents of the Wilmington Field 'Tar Zone' in the Subsurface Los Angeles Basin, California"; and "Barrier Characteristics of the Geologic Faults". The first report provides information regarding which reservoirs in the Los Angeles Basin are analogous to the Tar zone in the Wilmington field. A separate basin model will be

generated with specific emphasis on the relative timing of sediment deposition and compaction, structural deformation and hydrocarbon migration. Backstripping, decompaction and structural restoration will be performed to create a time-defined history of sedimentation and deformation of the area. The second report analyzes the possibility of fluid movement across faults using production and injection data and capillary transition and oil-water contact data^{2,8}. This analysis is being used in the basic reservoir engineering and reservoir simulation modeling.

On the stochastic geologic model, a three stage conditioning process was used for identifying the reservoir heterogeneities within the Tar Zone turbidites, including the development of 3-D equiprobable images of the sequence stratigraphy based on log and core data, detailed characterization of individual flow units to demonstrate the heterogeneities associated with the deposition of turbidites, and analyzing logging-while-drilling and measurement-while-drilling data from the west-to-east bearing horizontal wells to determine lateral extent of the flow units. This process identified the existence of a north-south gradient of sand quality, the presence of a major north-east to southwest channel sand cutting through the upper "T" sands, and the existence of previously unmapped faults⁸.

A sand sequence analysis of the geologic column in the Tar Zone is being conducted to map local effects requiring special correlation studies during the conceptual modeling phase. Of particular interest is that log normalization and environmental correction work can significantly affect log character with regard to variogram modeling. Several logs from wells with associated core data had to be re-digitized and re-normalized to provide a consistent base for rock-log typing. In addition, a detailed depth shifting evaluation of the logs and associated cores was performed by comparing the spherically focused short resistivity logs at 5 in./100 ft scale with the core photos and previous core descriptions of grain size analysis and environment of deposition.

The neural network analyzer is continuously being upgraded to analyze the similarities of various zones and sub-zones in terms of sequence stratigraphy using gamma ray, spontaneous potential, neutron, and resistivity logs and to improve signal compression through linear transform techniques such as DCT, Fourier Transform, and DST. In an effort to improve the training process of the pattern recognition phase of the neural network model, procedures such as Self-Organize and Adaptive Resonance Theory and K-means were studied. Work also continued on development of submarine fan facies models. Sample stochastic grid block models are test run on FB II-A logs using the 3-D Earth-Vision™ visualization software to ensure compatibility.

A license has been obtained to use the GOCAD++ geostatistical software program which will integrate the deterministic geologic model and the detailed sand sequence analysis work to provide stochastic images of the geologic model that will be used in the stochastic reservoir simulation model. GOCAD was developed and is maintained by the

National School of Geology in Nancy, France. The program is supported by an international consortium of oil and oil service companies and research institutes.

● Reservoir Simulation

The STARS™ thermal reservoir simulation program by the Computer Modelling Group (CMG) of Calgary and the R10,000 Onyx RE2 work station by Silicon Graphics Incorporated (SGI) were selected for the reservoir simulation modeling which began in October 1996. History matches covering the primary depletion and waterflood periods have been completed utilizing both the CMG IMEX™ black oil simulator program and STARS for history match verification purposes. Current effort is focused on finding reasonable waterflood history matches which are consistent with the formation compaction which occurred during primary production and with the oil saturation calculations from the open-hole induction logs from the 1980's vintage steam drive wells.

Two dynamic reservoir processes are affecting the history matches and must be studied further, plastic deformation of the rock and gas liberation. The project team developed a rock compaction algorithm that can mimic the local and dynamic features of rock compaction and rebound as a function of reservoir pressure. The project team and CMG incorporated the algorithm into an alpha version (97.20) of STARS 97.00 and into the new STARS 98.00 version this quarter.

● Reservoir Management

Four horizontal wells (two steam injectors and two producers) were drilled in late 1995 with measured depths of 4380-4820 ft and lateral sections of 1700-2075 ft in the target "D1" sands at true vertical depths ranging from 2410-2660 ft. All of the wells were completed over the last 600 ft of the horizontal section and given cyclic steam stimulation jobs in 1996 to consolidate the formation sands around the perforated completions and to stimulate initial oil production. The two injection wells, 2AT-61 and 2AT-63, were selectively completed with 11 quarter inch limited entry perforations per well and the two production wells, UP-955 and UP-956, were selectively completed with 48 and 36 quarter inch perforations, respectively, to provide more productivity and test the perforating limits of the sand consolidation process^{18,22}. The four wells initially would accept only low rates of about 300-500 barrels of cold water equivalent steam per day (BCWESPD) at 1300 psi injection pressure and 900 psi reservoir pressure which would increase to the desired rate of 1500 BCWESPD per well gradually over two months (process accelerated in two wells by breaking down the perforations with high pressure water).

Injection wells 2AT-61 and 2AT-63 were given cyclic steam stimulation jobs (146,000 and 186,000 bbls steam, respectively) during the first half of 1996, produced for

a short time at 1200 - 1500 BPD gross/well (41-60 BOPD), and converted to permanent injection in November 1996 and January 1997, respectively, at rates consistently ranging from 1650-1750 BCWESPD each. Production wells UP-955 and UP-956 were given cyclic steam stimulation jobs (114,000 and 183,000 bbls steam, respectively) during the second half of 1996. UP-955 was placed on production in November 1996 and reached cyclic peaks of 1450 BPD gross and 80 BOPD before declining to 20 BOPD by the end of the First Quarter 1997. Steam drive response began in April and production continually increased through September 1997 to 2000 BPD gross / 180 BOPD and stabilized at 1900 BPD gross / 150 BOPD by the end of 1997. UP-956 was placed on production in January 1997 and reached cyclic peaks of 1900 BPD gross and 200 BPD oil in April. Oil production declined to a low of 85 BOPD in June when it started responding to steam drive. September production rates stabilized at 1600 BPD gross / 130 BPD oil through year end. The oil and gross rates for both wells are low compared to projected rates of 2100 BPD gross and 300 BPD oil per well. Both wells have high fluid levels greater than 1000 feet over the pump so more productive capacity is available. The strategy is to accelerate steam drive response but avoid premature steam breakthrough. Fluid temperatures have risen in UP-955 to 285° F and in UP-956 to 347°F at an injection to gross production ratio of 1.0. Steam injection will be reduced next quarter to approach the current minimum required IP ratio of 0.85 BCWESPD/BPD gross (to prevent surface subsidence) to allow the producers to pump down their fluid levels and reduce injection costs. Of note is that all four horizontal wells have had no sand fill during well pulling operations, indicating successful sand consolidation jobs.

The 2100 ft steam transmission line under the Cerritos Channel was placed in service in mid-December 1995 and has performed very well with no problems to date⁹.

The pilot hot waterflood has now been expanded to eleven injection wells injecting 8000 BPD of 500°F water at approximately half the BTU energy input of the cold water equivalent volume of steam. The four original steam injection wells (wells 2AT-32, 2AT-33, 2AT-40, and 2AT-41) were converted to hot water injection from March 1995 to February 1996. Hot water injection rates ranged from 500-3000 BWPD during this period. Steam injection was resumed from February to November 1996 and hot water injection resumed in November at 4400 BWPD. Four additional steam injectors (wells 2AT-36, 2AT-37, 2AT-44, and 2AT-45) were converted to hot waterflood injection in February 1997 and three more were added in October (wells 2AT-38, 2AT-46, and 2AT-47). To date, we have not noticed any oil production decline from the pattern producers which is unusual following initiation of hot waterflood operations. This could be attributed to the very mature nature of the steamflood which no longer requires the same rate of heat input to move the oil and to the high reservoir pressures (700-900 psi) which have limited steam chest formation to areas with temperatures greater than 503-532° F. The increased hot water injection volumes are from increasing water volumes to the maximum to the Harbor Cogeneration Plant and receiving more overall steam at a lower quality. Reservoir tracers were injected into wells 2AT-32 ("T" sand) and 2AT-33 ("D" sand) on February 14, 1997 as described

in the Reservoir Characterization section.

A successful pilot study was completed on the use of salinity data from produced water samples to monitor steamflood performance and improve reservoir characterization. The study was performed as a Master's thesis project by a Petroleum Engineering student from USC. The pilot showed that injected hot water preferentially went in a northeast - southwest direction which followed the presumed direction of sand deposition based on our geologic model and was perpendicular to formation dip which would normally be the direction (downdip) that hot water would be expected to travel. Because water salinity data is so inexpensive to obtain (about \$10-12 a sample), this is a very cost-effective tool for reservoir surveillance and the plan is expand the program.

High temperature coreflood work was performed to determine residual oil saturations from waterflooding and steamflooding, changes in porosity and permeability, and geochemical alterations of the formation rocks and fluids. Initial analysis indicates that the coreflood samples were plugged with foreign substances to be determined and did not show any evidence of rock alterations. These findings are troubling and will be further analyzed during the next quarter. The coreflood results showed that plain waterflooding is a very efficient recovery mechanism that can recover over 60% of the original oil in place (OOIP) where swept. The steam can recover over 90% of the OOIP where swept. Further evaluation of the lab results is being conducted. The tested cores are currently being examined for rock alterations.

High temperature core work began for measuring rock compaction due to steamflooding. The objective is to determine whether high temperatures will induce overall rock compaction or expansion and what operating methods are available to mitigate either effect. This aspect of the core work was added to the original proposal to perform steam coreflood tests and measure the geochemical effects of high temperature steam on the reservoir rocks and fluids. All of the special core work above will be used in the thermal reservoir simulation model.

● Operational Management

Detailed thin section, scanning electron microscope, and x-ray diffraction work on wellbore fill samples from the existing steam drive wells showed several types of scale including calcites, dolomites, barites, anhydrites, and magnesium-silicates. A study of the cores, produced fluids, and injection water has been completed that determined the mineralogy and source of the scales and how to prevent their occurrence²⁵.

The project team is continuing to find new ways to reduce steamflood operating costs. The gas produced from the Fault Block II-A Tar zone has high concentrations of H₂S, CO₂, and mercaptans which makes the gas non-commercial and costly to dispose.

An improved H₂S caustic scrubber has been jointly developed by engineers from T. J. Cross Engineers and Tidelands Oil Production Company for stripping the H₂S from steamflood-related produced gas streams at less than half the previous cost. This new scrubber process, called Lo-CoSTSM, improves the caustic mixing system and uses a more effective caustic substitute called SulfaTreatTM in the latter scrubber stages for removing low H₂S concentrations which results in significantly lower caustic usage¹². A state-of-the-art 50 MMBTU/hr steam generator has been designed and installed which can use the low BTU non-commercial gas streams as generator fuel to supply useful steam which has allowed the economic expansion of thermal recovery operations on the Fault Block V Tar zone¹³. Operating cost reductions through vendor alliances and special electrical rates are in progress. Electrical power deregulation and innovative electricity rate schedules provide several means for resourceful operators to negotiate lower power costs. Power cost reduction projects can be tailored to be especially effective in allowing marginal wells to stay on production or to provide incentives to return idle wells to production¹⁶.

● Technical Transfer

During this quarter, the project team presented two papers at the 1997 SPE Annual Technical Conference in San Antonio from October 6-8 on the steam injection sand consolidation well completion technique and on the rock-log correlation model^{22,23}. The City of Long Beach and Tidelands wrote an article for the Summer 1997 edition of the U. S. DOE's *The Class Act* entitled "Horizontal Drilling for Thermal Recovery in the Wilmington Field, California"²⁶. USC, through the West Coast PTTC, organized a short course entitled "GOCAD++ Training" held on November 14 at USC and made a presentation during the course²⁷. Tidelands reprised the sand consolidation well completion presentation at the SPE Los Angeles Basin Section's New Technology and Environmental Forum meeting on November 19 at the Long Beach Petroleum Club²⁸. USC and the City of Long Beach, through the West Coast PTTC, organized a geologic short course and field trip on "Turbidite Reservoirs in California" on November 24 in Ventura, CA²⁹. Tidelands gave a short presentation of the two Wilmington Class III projects to Guido DeHoratiis of the DOE on December 4 in Tidelands' office³⁰. The American Association of Petroleum Geologists, in collaboration with Tidelands, is writing an article entitled "Increasing Reserves in a Mature Giant: Wilmington Field, Los Angeles Basin Part II: Improving Heavy Oil Production through Advanced Reservoir Characterization and Innovative Thermal Technologies" to be published in the April 1998 issue of *The AAPG Bulletin*³¹. DKD and Tidelands were invited to submit their SPE paper on the sand consolidation well completion to the 1998 Annual Meeting of the Petroleum Society of the Canadian Institute of Mining, Metallurgy and Petroleum to be held June 8-10 in Calgary, Alberta³². USC has submitted a paper entitled "A Simulation Study of Steamflooding in a Highly Stress-Sensitive Heavy Oil Formation" to be given at the 1998 UNITAR International Conference on Heavy Crude and Tar Sands in Beijing, China from October 27-31³³.

A home page is active on the Internet (<http://www.usc.edu/peteng/doe.html>) for the project. A CD-ROM of the project¹⁰ on IBM PC format will be distributed free upon request to Scott Hara, Tidelands Oil Production Company, phone - (562) 436-9918, email - tidelands@laspe.org.

References and Notes

1. Clarke, D., City of Long Beach, Phillips, C., Tidelands Oil Production Company, An, L., University of Southern California: "Horizontal Wells in a Clastic Oil Field with Intraformational Compaction", Poster Session presentation at the 1997 AAPG Annual Meeting in Dallas, TX, 7-9 April.
2. An, L., Ershaghi, I., University of Southern California, Clarke, D., City of Long Beach, Phillips, C., Tidelands Oil Production Company: "Sealing Behavior of Normal Faults in Fault Block II, Wilmington Oil Field, California", Poster Session presentation at the 1997 AAPG Annual Meeting in Dallas, TX, 7-9 April.
3. Dynamic Graphics, Inc., Phillips, C., Tidelands Oil Production Company: "EarthVision Software Solutions for Structurally Consistent 3-D Geologic Modeling, 3-D Well Placement Planning", Advertisement Mailer sent to 1997 AAPG Annual Meeting (7-9 April) attendees which offers copy of September 1996 article from The American Oil and Gas Reporter entitled "3-D Modeling, Horizontal Drilling...Give New Life to Aging Fields" by Clarke, Phillips, An. Wilmington DOE projects featured in Dynamic Graphics' exhibit booth at convention and in Internet homepages (info@dgi.com and www.dgi.com/topko.html).
4. Schwalm, J., Perry, J., Dynamic Graphics, Inc.: "3-D Geologic Modeling: Theory and Application", 1/2 day workshop sponsored by PTTC at USC campus, Los Angeles, CA, 2 May 1997 and in Ventura, Bakersfield, and Sacramento from 15-17 Sept 1997. Presentation used 3-D deterministic geologic model from this project to explain fundamentals of 3-D geologic modeling.
5. Davies, D. K., Vessell, R. K., David K. Davies and Associates, Inc.: "Geological Controls on Permeability Distribution and Sand Distribution: Tar Zone, Fault Block IIA, Wilmington Field", Oral presentation at the 1997 AAPG Pacific Section Convention in Bakersfield, CA, 14-16 May.
6. Clarke, D., City of Long Beach, Phillips, C., Tidelands Oil Production Company, An, L., University of Southern California: "Tertiary Development of Heavy Oil Sands Through Thermal Recovery in the Wilmington Field, California: An Update and Some New Challenges", Oral presentation at the 1997 AAPG Pacific Section

Convention in Bakersfield, CA, 14-16 May.

7. Hassibi, M., Ershaghi, I., University of Southern California: "Characterization of Lithological Log Responses in Turbidite Series using Neural Networks", Oral presentation at the 1997 AAPG Pacific Section Convention in Bakersfield, CA, 14-16 May.
8. An, L., University of Southern California, Clarke, D., City of Long Beach, Phillips, C., Tidelands Oil Production Company: "Reservoir Characterization Using Advanced 3-D Computer Modeling Technology: A Case Study of the Fault Block II in Wilmington Field, California", Electronic poster session at the 1997 AAPG Pacific Section Convention in Bakersfield, CA, 14-16 May.
9. Cassinis, R., Tidelands Oil Production Company, "2100-foot, 14-inch Steam Line Under a Ship Channel", SPE Paper No. 37530 presented at the 1997 SPE International Thermal Operations and Heavy Oil Symposium in Bakersfield, CA, 10-12 February 1997.
10. Ershaghi, I., University of Southern California, Kapelke, M., Tidelands Oil Production Company: CD-ROM of this DOE project presented at 1997 SPE Western Regional Meeting in Long Beach, CA, 25-27 June. Copies of CD-ROM still available.
11. Ershaghi, I., Handy, L. L., Akkutlu, I. Y., University of Southern California, Mondragon III, J.J., Tidelands Oil Production Company: "Conceptual Model of FB IIA, Wilmington Field, from Field Performance Data", SPE Paper No. 38309 to be presented at the 1997 SPE Western Regional Meeting in Long Beach, CA, 25-27 June.
12. Cassinis, R., Tidelands Oil Production Company: "Improved H₂S Caustic Scrubber", SPE Paper No. 38273 to be presented at the 1997 SPE Western Regional Meeting in Long Beach, CA, 25-27 June.
13. Whitaker, W., Tidelands Oil Production Company: "7-ppm NO_x 50 MMBtu/hr Oilfield Steam Generator Operating on Low-Btu Produced Gas", SPE Paper No. 38277 to be presented at the 1997 SPE Western Regional Meeting in Long Beach, CA, 25-27 June.
14. Phillips, C.C., Hara, P. S., Tidelands Oil Production Company: "Three-Dimensional Geological Modeling as a Cost-Effective Tool for Horizontal Drilling", SPE Gem Presentation No. WR GEM No. 6 to be presented at the 1997 SPE Western Regional Meeting in Long Beach, CA, 25-27 June.

15. Ershaghi, I., Amili, P., University of Southern California: "Correlations for Prediction of Steamflood Oil Recovery in Steam-Assisted Gravity-Drainage Process Using Horizontal Injectors and Producers", SPE Paper No. 38297 to be presented at the 1997 SPE Western Regional Meeting in Long Beach, CA, 25-27 June.
16. Fickes, R., Tidelands Oil Production Company: "Enhancing the Profitability of Marginal Wells Through Vendor Alliances and Special Electrical Rates for Marginal Wells", SPE Gem Presentation No. WR GEM 27 to be presented at the 1997 SPE Western Regional Meeting in Long Beach, CA, 25-27 June.
17. Walker, F. S., Tidelands Oil Production Company: "Locating and Producing Bypassed Oil: A DOE Project Update", SPE Paper No. 38283 to be presented at the 1997 SPE Western Regional Meeting in Long Beach, CA, 25-27 June. This DOE waterflood project for Wilmington describes new application of well completion technology using steam to consolidate sand developed in this project.
18. Mondragon III, J. J., Hara, P. S., Tidelands Oil Production Company: "Novel Sand Consolidation Completion Technique Using Alkaline-Steam Injection in the Tar Zone, Wilmington Field", SPE Gem Presentation No. WR GEM 29 to be presented at the 1997 SPE Western Regional Meeting in Long Beach, CA, 25-27 June.
19. Davies, D. K., Vessell, R. K., David K. Davies and Associates, Inc.: "Improved Prediction of Permeability and Reservoir Quality Through Integrated Analysis of Pore Geometry and Openhole Logs: Tar Zone, Wilmington Field, California", SPE Paper No. 38262 to be presented at the 1997 SPE Western Regional Meeting in Long Beach, CA, 25-27 June.
20. Clarke, D., City of Long Beach, Phillips, C. C., Tidelands Oil Production Company, Ottot, G., Thums Long Beach Company: Field trip entitled "A Visit to the Giants of the Los Angeles Basin, Geology and Urban Operations in the L. A. Basin". A guidebook is to be provided consisting of fourteen papers on geologic and operational aspects related to slope and basin clastic reservoirs in the Los Angeles Basin. The field trip is to be given at the 1997 SPE Western Regional Meeting in Long Beach, CA, 25-27 June and is reprised from the field trip for the 1996 Annual Meeting of the American Association of Petroleum Geologists (AAPG) in San Diego.
21. Kapelke, M., Tidelands Oil Production Company: "How To Work With the DOE" and "Multimedia and Technical Transfer", National Petroleum Technology Resource Center sponsored by the DOE to be presented at the 1997 SPE Western Regional Meeting in Long Beach, CA, 25-27 June.
22. Davies, D., David K. Davies and Associates, Mondragon, J., Hara, S., Tidelands Oil Production Company: "A Novel Low Cost Well Completion Technique Using Steam

For Formations With Unconsolidated Sands, Wilmington Field, California", SPE Paper No. 38793 to be presented at the 1997 SPE Annual Technical Conference in San Antonio, TX, 5-8 October.

23. Davies, D., Aumon, J., Vessel R., David K. Davies and Associates: "Improved Prediction of Reservoir Behavior through Integration of Quantitative Geological and Petrophysical Data", SPE Paper No. 38914 to be presented at the 1997 SPE Annual Technical Conference in San Antonio, TX, 5-8 October.
24. Ershaghi, I., Du, C., An, L., University of Southern California: "A Three Stage Conditioning Process for Scrutinizing Stochastic Representation of a Turbidite Sequence in a Densely Drilled Formation", SPE Paper No. 38681 to be presented at the 1997 SPE Annual Technical Conference in San Antonio, TX, 5-8 October.
25. Davies, D. K., et al: Nature, Origin, Treatment and Control of Well-bore Scales in an Active Steamflood, Wilmington Field, California, SPE Paper No. 35418 presented at the SPE/DOE Improved Oil Recovery Symposium in Tulsa, OK, 21-24 April 1996.
26. Clarke, D., City of Long Beach, Phillips, C., Tidelands Oil Production Company: "Horizontal Drilling for Thermal Recovery in the Wilmington Field, California", Article for Summer 1997 edition of U. S. DOE The Class Act.
27. Du, C., University of Southern California, West Coast PTTC staff, organized short course entitled "GOCAD++ Training" and made a presentation during the course, November 14, 1997 at USC campus.
28. Hara, S., Tidelands Oil Production Company, reprised sand consolidation well completion presentation - SPE paper 38793, SPE Los Angeles Basin Section New Technology and Environmental Forum meeting, November 19, 1997, Long Beach Petroleum Club.
29. Ershaghi, I., University of Southern California, Clarke, D., City of Long Beach, West Coast PTTC staff: Organized geologic short course and field trip on "Turbidite Reservoirs in California", November 24, 1997, Ventura, CA.
30. Tidelands Oil Production Company gave a short presentation of the two Wilmington Class III projects to Guido DeHoratiis of the DOE on December 4, 1997 in Tidelands' office.
31. Montgomery, S., American Association of Petroleum Geologists, Phillips, C., Hara, S., Tidelands Oil Production Company: "Increasing Reserves in a Mature Giant: Wilmington Field, Los Angeles Basin Part II: Improving Heavy Oil Production

through Advanced Reservoir Characterization and Innovative Thermal Technologies", Article to be published in the April 1998 issue of *The AAPG Bulletin*.

32. Davies, D., David K. Davies and Associates, Mondragon, J., Hara, S., Tidelands Oil Production Company: "A Novel Low Cost Well Completion Technique Using Steam For Formations With Unconsolidated Sands, Wilmington Field, California", SPE Paper No. 38793 invited to be presented at the 1998 Annual Meeting of the Petroleum Society of the Canadian Institute of Mining, Metallurgy and Petroleum, June 8-10, Calgary, Alberta.
33. Yang, Z., University of Southern California: "A Simulation Study of Steamflooding in a Highly Stress-Sensitive Heavy Oil Formation", Paper submitted to the 1998 UNITAR International Conference on Heavy Crude and Tar Sands in Beijing, China from October 27-31.

March 3, 1998

Mr. Dan Ferguson
Project Manager
U. S. Department of Energy
National Petroleum Technology Office
P. O. Box 3628
Tulsa, OK 74101

Subject: Quarterly and Annual Technical Progress Reports - Class III Mid-Term Project, "Increasing Heavy Oil Reserves in the Wilmington Oil Field Through Advanced Reservoir Characterization and Thermal Production Technologies", DE-FC22-95BC14939.

Dear Dan:

Attached is a copy of our Quarterly Technical Progress Report dated October 1 - December 31, 1997 and the associated floppy disk with the text in Adobe Acrobat. We sent the required copy and disk to Pittsburgh today.

For your information, we are still actively working on the second Annual Report for the period March 30, 1996 - March 29, 1997. As you know, the entire project team was very heavily involved in technical transfer activities related to this project from September 1996 through this past quarter as referenced in this and previous Quarterly reports. It looks like we will complete the second Annual Report and then immediately work on the third Annual Report, which is due at the end of April. The second Annual Report will include all of the papers and exhibits presented through June of 1997. We reported earlier that we had completed the first draft of the report, however, it turned out that the first draft I received from my project team members was very rough and requires major rewrites.

We realize that we are very late but I am allocating as much time as I can to finishing it. I have been spending a lot of time working on it and I will keep you abreast of my progress.

Sincerely,

Scott Hara
Chief Production Engineer

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