Improved Oil Recovery in Fluvial Dominated Deltaic Reservoirs of Kansas - Near-Term

**Quarterly Report
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IMPROVED OIL RECOVERY ☐
IN FLUVIAL DOMINATED DELTAIC RESERVOIRS OF KANSAS - NEAR-TERM

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"U.S./DOE PATENT CLEARANCE IS NOT REQUIRED

Objectives

The objective of this project is to address waterflood problems of the type found in Morrow sandstone reservoirs in southwestern Kansas and in Cherokee Group reservoirs in southeastern Kansas. Two demonstration sites operated by different independent oil operators are involved in this project. The Stewart Field is located in Finney County, Kansas and is operated by PetroSantander, Inc. The Nelson Lease is located in Allen County, Kansas, in the N.E. Savonburg Field and is operated by James E. Russell Petroleum, Inc.

General topics to be addressed are 1) reservoir management and performance evaluation, 2) waterflood optimization, and 3) the demonstration of recovery processes involving off-the-shelf technologies which can be used to enhance waterflood recovery, increase reserves, and reduce the abandonment rate of these reservoir types.

In the Stewart Project, the reservoir management portion of the project conducted during Budget Period 1 involved performance evaluation. This included 1) reservoir characterization and the development of a reservoir database, 2) volumetric analysis to evaluate production performance, 3) reservoir modeling, 4) laboratory work, 5) identification of operational problems, 6) identification of unrecovered mobile oil and estimation of recovery factors, and 7) identification of the most efficient and economical recovery process.

To accomplish these objectives the initial budget period was subdivided into three major tasks. The tasks were 1) geological and engineering analysis, 2) laboratory testing, and 3) unitization. Due to the presence of different operators within the field, it was necessary to unitize the field in order to demonstrate a field-wide improved recovery process. This work was completed and the project moved into Budget Period 2.

Budget Period 2 objectives consisted of the design, construction, and operation of a field-wide waterflood utilizing state-of-the-art, off-the-shelf technologies in an attempt to optimize secondary oil recovery. To accomplish these objectives the second budget period was subdivided into five major tasks. The tasks were 1) design and construction of a waterflood plant, 2) design and construction of a water injection system, 3) design and construction of tank battery consolidation and gathering system, 4) initiation of waterflood operations and reservoir management, and 5) technology transfer. Tasks 1-3 have been completed and water injection began in October 1995.

In the Savonburg Project, the reservoir management portion involves performance evaluation. This work included 1) reservoir characterization and the development of a reservoir database, 2) identification of operational problems, 3) identification of near wellbore problems such as plugging caused from poor water quality, 4) identification of unrecovered mobile oil and estimation of recovery factors, and 5) preliminary identification of the most efficient and economical recovery process i.e., polymer augmented waterflooding or infill drilling (vertical or horizontal wells).

To accomplish this work the initial budget period was subdivided into four major tasks. The tasks included 1) geological and engineering analysis, 2) waterplant optimization, 3) wellbore cleanup and pattern changes, and 4) field operations. This work was completed and the project has moved into Budget Period 2.

The Budget Period 2 objectives consisted of continual optimization of this mature waterflood in an attempt to optimize secondary and tertiary oil recovery. To accomplish these objectives the second budget period is subdivided into six major tasks. The tasks were 1) waterplant development, 2) profile modification treatments, 3) pattern changes, new wells and wellbore cleanups, 4) reservoir development (polymer flooding), 5) field operations, and 6) technology transfer.

Summary of Technical Progress

Stewart Field Project

Task II.1 - Design/Construct Waterflood Plant

Summary of work in last quarter

Installed a horizontal injection pump to increase the injection capacity from approximately 9,900 to 15,000 BWPD. Current injection rate is 10,200 BWPD.

Summary of planned work for next quarter

Review water supply sources for additional water with lower corrosivity.

Task II.2 - Design/Construct Injection System

Summary of work in last quarter

In March, three additional wells were converted to injection to improve the sweep efficiency in several areas of the waterflood. These include the following wells:

<u>Well</u>	<u>Comment</u>
Haag Estate No. 2	Was shut-in, currently injecting 500 BWPD.
Bulger 7-5	Was producing 4 BOPD, currently injecting 250 BWPD.
Bulger 7-10	Was producing < 1 BOPD, currently injection 250 BWPD.

Summary of planned work for next quarter

None planned.

Task II.3 - Design/Construct Battery Consolidation and Gathering System

Summary of work in last quarter

None.

Summary of planned work for next quarter

None planned.

Task II.4 - Waterflood Operations and Reservoir Management

Summary of work in last quarter

Water supply well had significant downtime during March due to motor and cable burnout's. This resulted in 9 days of downtime.

Ongoing pump changes and speeding up pumping units were performed during the quarter on several wells. These changes are made as a result of the well testing program that identifies wells with production problems, rising fluid levels, abnormal production trends and low pump efficiencies. The changes that were made are a continued effort to maximize oil production and keep all the wells near a pumped off condition.

A pressure build-up test was performed on the Mackey No. 1 that indicated positive skin damage. An acid treatment was performed that resulted in a minor increase in production. Further evaluation will be conducted on a more aggressive treatment during the next quarter.

The computer model developed at the Tertiary Oil Recovery Project at the University of Kansas has been revised to history match waterflood production and injection. This model will be used to simulate different scenarios to assist in reservoir management decisions in an attempt to maximize waterflood oil recovery.

Continued to monitor production and injection rates, water supply volumes, and injection pressures. Continued the ongoing testing of producing wells with test trailers and fluid level instruments. Ongoing allocation of the injection volumes in the injection wells were performed based on response in producers and injectors. Cumulative water injection through March is 5,185,703 bbls. Average daily production and injection rates for the field are displayed on the plot included with this report.

Summary of planned work for next quarter

Continue to monitor for response at producing wells with well tests and fluid levels. Update the reservoir computer model and simulate when applicable. Upgrade pumping equipment as necessary. Several increasing fluid levels will be addressed with larger pumping equipment and evaluation of additional progressive cavity pumps will be conducted.

Evaluation of three infill drilling locations will be conducted. These locations include south of the Pauls 9-1, southwest of the Meyer 10-4, and south/southeast of the Mackey #4.

Task II.5 - Technology Transfer

Summary of work in last quarter

Continued to publicize information on the success of the Stewart Field waterflood. Operators throughout the region continue to visit the field to view the state-of-the-art waterflood installation and computerized monitoring system.

Summary of planned work for next quarter

Continue to publicize information on the success of the Stewart Field waterflood.

Stewart Waterflood Average Daily Totals

Summary of Technical Progress

Savonburg Field Project

Task II.1 - Water Plant Development

Summary of work in last quarter

In January a series of various water treatment methods utilizing the air flotation unit (AFU) was initiated. Initially, all water-treating chemicals were removed, utilizing only the air injection. In February, a new water aeration compressor was installed and the slop tank and suction tanks were cleaned. Early in March the operator began adding bleach to the water. Two weeks later FLW-162, a flotation aid chemical was started and a chemical breaker was added to the stream on the last day of March.

Summary of work planned for next quarter

The water treatment program will continue until all scenarios have had a sufficient time to be tested. A hydroclone will be added for solids removal.

Task II.2 - Profile Modification Treatments

Summary of work in last quarter

No channelblock treatments were performed during this quarter.

A pressure falloff test was attempted on well O-1, but was aborted due to equipment malfunction.

Temperature surveys were performed on wells RW-8 and RW-3. Mechanical integrity tests were performed on wells RW-8 and RW-11.

Summary of work planned for next quarter

As soon as weather conditions allow wells RW-1, RW-3, RW-6 and RW-7 will have temperature surveys.

An attempt will be made to isolate the B3 zone in injection well HW-18.

Task II.3 - Pattern Changes and Wellbore Cleanup

Summary of work in last quarter

The following wells were serviced during the last quarter; H-16 (four times), H-20 (twice), K-54 (twice), H-30 (twice), H-22 (twice), K-44, K-10 and K-45. Service was required to repair pumps or replace joints of 1" pump string that developed leaks.

Another attempt to recover the junk in H-27 was unsuccessful.

Wells H-9 and KW-51 were plugged and abandoned in February.
Summary of planned work for next quarter

Wells will be tested, cleaned and worked on as needed.

Task II.4 - Reservoir Development (Polymer Flooding)

Summary of work in last quarter

Waiting on a decision to implement polymer flooding.

Summary of work for next quarter

Waiting on a decision to implement polymer flooding.

Task II.5 - Field Operations

Summary of work in last quarter

Normal field operations have included: 1) monitoring wells on a daily basis, 2) repairing waterplant, piping, and wells as required, 3) collecting daily rate and pressure data, and 4) solving any other daily field operational problem that might occur.

<u>Month</u>	<u>Oil Production</u>
October 1993	26.4 B/D
November 1993	30.7 B/D
December 1993	32.0 B/D
January 1994	30.8 B/D
February 1994	30.9 B/D
March 1994	30.3 B/D
April 1994	29.1 B/D
May 1994	28.5 B/D
June 1994	30.3 B/D
July 1994	28.9 B/D
August 1994	24.6 B/D
October 1994	23.0 B/D
November 1994	25.7 B/D
December 1994	27.8 B/D
January 1995	27.0 B/D
February 1995	25.3 B/D
March 1995	22.4 B/D
April 1995	22.4 B/D
May 1995	25.0 B/D
June 1995	23.9 B/D

July 1995	26.8 B/D
August 1995	25.2 B/D
September 1995	24.8 B/D
October 1995	24.4 B/D
November 1995	24.4 B/D
December 1995	26.3 B/D
January 1996	28.0 B/D
February 1996	29.2 B/D
March 1996	27.2 B/D
April 1996	26.7 B/D
May 1996	26.6 B/D
June 1996	24.9 B/D
July 1996	25.4 B/D
August 1996	26.5 B/D
September 1996	26.1 B/D
October 1996	27.1 B/D
November 1996	26.4 B/D
December 1996	27.8 B/D
January 1997	26.9 B/D
February 1997	26.9 B/D
March 1997	27.5 B/D
April 1997	26.3 B/D
May 1997	25.5 B/D
June 1997	24.6 B/D
July 1997	23.5 B/D
August 1997	24.3 B/D
September 1997	23.8 B/D
October 1997	22.9 B/D
November 1997	23.5 B/D
December 1997	21.7 B/D
January 1998	19.0 B/D
February 1998	18.3 B/D
March 1998	18.9 B/D

Summary of planned work for next quarter

Field operations will be continued.

Task II.6 - Technology Transfer

Summary of work in last quarter

Monthly meetings were conducted with personnel from the James Russell Petroleum, Inc., the Tertiary Oil Recovery Project and the Petroleum Technology Transfer Council attending.

Summary of planned work for next quarter

The field will be visited by other operators from the are.