

IMPROVED OIL RECOVERY
IN FLUVIAL DOMINATED DELTAIC RESERVOIRS OF KANSAS - NEAR-TERM

Cooperative Agreement Number DE-FC22-93BC14957

The University of Kansas Center for Research, Inc.

April 15, 1997

Budget Period #1 Duration from 06/18/93 - 03/31/95

Budget Period #2 Duration from 04/01/95 - 12/31/98

DOE Award \$ 2,007,446

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Reporting Period 01/01/97 - 03/31/97
(15th Quarterly Report)

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Objectives

The objective of this project is to address waterflood problems of the type found in Morrow sandstone reservoirs in southwestern Kansas and 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 North American Resources Company. 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.

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 was 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

No major work.

Summary of planned work for next quarter

None planned at this time, but will make adaptations as necessary.

Task II.2 - Design/Construct Injection System

Summary of work in last quarter

No major work.

Summary of planned work for next quarter

No additional construction work planned at this time.

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

Summary of work in last quarter

No major work.

Summary of planned work for next quarter

Make adaptations as needed for an efficient cost effective operation.

Task II.4 - Waterflood Operations and Reservoir Management

Summary of work in last quarter

Upgraded artificial lift equipment on the following wells:

Mackey #4 - installed 456 pumping unit with 144" stroke length

Meyer 10-2 - installed low profile 320 pumping unit and 2" bottomhole pump

Sherman #2 - installed low profile 320 pumping unit and 2" bottomhole pump
Haag Estate #3 - installed 228 pumping unit with 74" stroke length
Scott 4-7 - installed low profile 160 pumping unit with 74" stroke length

The bottomhole pump upgrades and increasing strokes per minute on pumping units were performed as a result of the well testing program which assists in identifying wells with production problems such as: rising fluid levels, abnormal production trends, and low pump efficiencies. The artificial lift upgrades were performed to handle increasing fluid production and lower the producing fluid level to a near pumped off condition.

Two additional pumping unit changes were made on the Scott 4-1 and Sherman 3-2, where it was necessary to install low profile units to accommodate new overhead farm sprinkler systems.

Continued monitoring production, injection and water supply volumes and pressures. Ongoing testing of producing wells with test trailers and fluid level guns continues. Oil production increased approximately 200 BOPD and 250 BWPD during the quarter due to waterflood response. This brings the total increase to approximately 1250 BOPD and 750 BWPD. A total of 19 of the 33 producing wells have shown a response due to the water injection. Increasing water oil ratios to varying degrees have been observed at 10 of the producing wells that have seen a response. Ongoing allocation of injection volumes in injection wells continues based on response in producers and injectors. Cumulative water injected in the Stewart Field since flood startup is 2,652,796 BW as of 3-31-97. Daily production and injection rates for the field are displayed on the attached plot.

Performed well servicing as necessary (pump changes, minor well work, etc.) A workover on the Sherman 3-1 injection well was performed to repair a leaking on-off tool. A 4 day static fluid level was taken while this well was down which indicated a bottomhole pressure of 1000 psi.

Summary of planned work for next quarter

Run one or two injection well falloff tests and obtain static shut-in fluid levels on producers. Continue to monitor for response at the producing wells with well tests and fluid levels. Update the reservoir model and simulate when applicable. Monitor water treatment program. Upgrade pumping equipment as required.

Drill one replacement well for the Haag Estate #1 (well has been temporarily abandoned since 1994) and drill one infill well (Pauls 9-5) in the NE NW NE of Section 9.

Task II.5 - Technology Transfer

Summary of work in last quarter

Continued to publicize information on the Stewart Field's increasing oil production. Presentations on the Stewart Field project were made at the API Chapter meeting in Great Bend, Kansas on 1-8-97 and Society of Independent Professional Earth Scientists (SIPES) meeting in Wichita, Kansas on 2-19-97.

A paper titled "Implementation and Monitoring of the Stewart Field Waterflood" was presented and will be published as part of the proceedings for the Twelfth Oil Recovery Conference

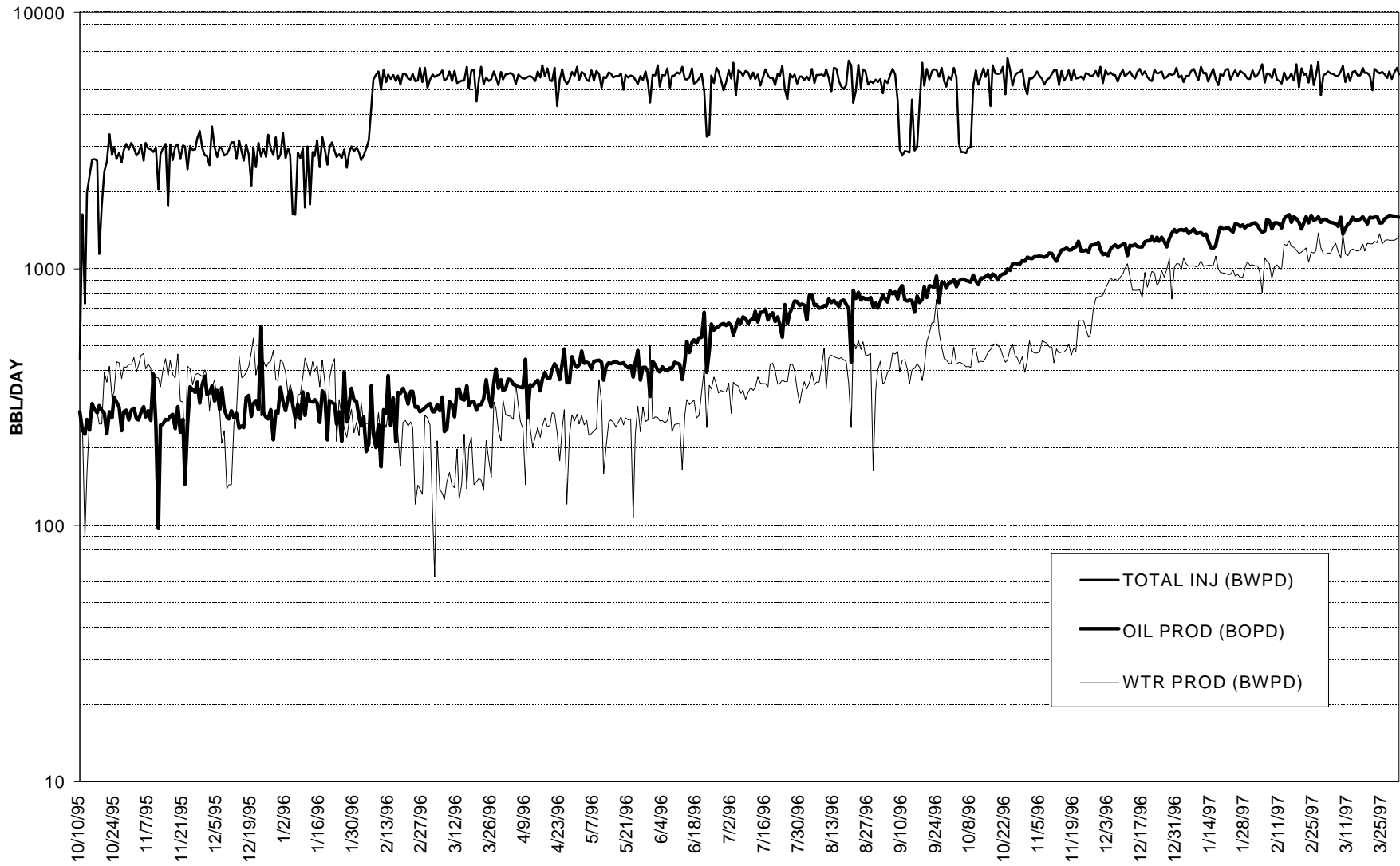
held March 19-20, 1997 in Wichita, Kansas.

Operators throughout the area 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 Stewart Field's increasing oil production.

STEWART WATERFLOOD DAILY TOTALS



Summary of Technical Progress

Savonburg Field Project

Task II.1 - Water Plant Development

Summary of work in last quarter

Development work and testing on the flotation unit continues. Another Venturi device for bubble generation was installed and tested. The Unit is now operating satisfactorily with two of the Venturi devices. The addition point for flotation aid polymer was changed to the suction of the transfer pump for better mixing. Several items of plant maintenance were accomplished, 1) oil was changed in the main injection pump, 2) seals were replaced in the transfer pump, and 3) the circulating pump motor was changed.

Cleaning and calibration of the chemical pumps continues to be a major item.

An additional point for the #661 barium scale inhibitor was changed from the gunbarrel to the AFU discharge.

A team of chemists from National Petrochem met with us and performed on-site testing February 26, 1997. The D-Sperce-C chemical was replaced by National Petrochem #223, a quaternary amine. Evaluation of the changes will be made over the next few weeks.

Summary of planned work for next quarter

The water plant will be continually monitored and optimized as problems arise.

Task II.2 - Profile Modification Treatments

Summary of work in last quarter

No profile modification treatments were conducted during this quarter.

Summary of work planned for next quarter

We plan to conduct various gel polymer treatments in the next quarter. An additional treatment will be conducted on H-29. Before designing the treatments we will conduct some preliminary fluid balance calculations to confirm problems.

Task II.3 - Pattern Changes and Wellbore Cleanup

Summary of work in last quarter

In January 1997, the following wells were serviced: H-15, H-17, and H-22 (Twice).

In February 1997, RW-20 had a pressure fall-off test and temperature survey conducted. The pressure fall-off test indicates that the skin effect around the wellbore is zero. During the temperature survey, the differential portion failed, but the gradient curve indicated water leaving the wellbore at the perforated interval. Following the tests, the well has returned to its previous low injectivity behavior. The following wells were serviced: H-3, H-17, H-22, and K-44. All servicing was caused by holes in the 1" pump strings.

Summary of planned work for next quarter

Wells will be continuously cleaned and worked on as needed.

Task II.4 - Reservoir Development (Polymer Flooding)

Summary of work in last quarter

Waiting for a decision to implement polymer flood.

Summary of work for next quarter

Waiting for a decision to implement polymer flood.

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 problems 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	29.0 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

Summary of planned work for next quarter

Field operations will be continued.

Task II.6 - Technology Transfer

Summary of work in last quarter

Two papers were presented at the Twelfth Oil Recovery Conference on March 19-20, 1997 in Wichita, Kansas. The titles were "Savonburg Project Progress Report" and "Problems in the use of Air Flotation for Cleaning Produced Water". Operators visiting throughout the area.

Summary of planned work for next quarter

The field will be visited by operators throughout the area.