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

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Objectives

The objective of this project is to address waterflood problems of the type found in Cherokee Group reservoirs in southeastern Kansas and in Morrow sandstone reservoirs in southwestern Kansas. Two demonstration sites operated by different independent oil operators are involved in the project. The Nelson Lease (an existing waterflood) is located in Allen County, Kansas in the N.E. Savonburg Field and is operated by James E. Russell Petroleum, Inc. The Stewart Field (on latter stage of primary production) is located in Finney County, Kansas and is operated by North American Resources Company.

General topics to be addressed will be 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.

The reservoir management portion of the project will involve performance evaluation and will include such work as 1) reservoir characterization and the development of a reservoir database, 2) identification of operational problems, 3) identification of near wellbore problems, 4) identification of unrecovered mobile oil and estimation of recovery factors, and 5) identification of the most efficient and economical recovery process.

The waterflood optimization portion of the project involves only the Nelson Lease. It will be based on the performance evaluation and will involve 1) design and implementation of a water cleanup system for the waterflood, 2) application of well remedial work such as polymer gel treatments to improve vertical sweep efficiency, and 3) changes in waterflood patterns to increase sweep efficiency.

Finally, it is planned to implement an improved recovery process on both field demonstration sites.

Summary of Technical Progress

Savonburg Field Project

Task II.1 - Water Plant Development

Summary of work in last quarter

The water plant is working satisfactorily, however there are a few problems including, 1) probe controls in both the raw water and clear water tanks were not functioning properly which also makes transfer of water difficult, 2) barium sulfate is still precipitating out, 3) capacity of the single bag filter is inadequate, and 4) power downtimes occurred due to the extreme weather.

The probes were replaced with floating ball devices, which appear to be operating satisfactorily. The transfer pump was replaced with one using a larger motor. It was then determined that the capacity of the 2" transfer line had been reduced by scaling. The transfer pump was switched back to the 4" diameter transfer line and the bleach injection was restarted at that point. A larger overload unit was installed for the transfer pump. The Murphy Hi-Low control for the injection pump was replaced.

The removal of suspended oil and solids have been successful, however the dissolved barium has caused a problem by the formation of a barium sulfate scale. The resulting scale is more difficult to remove due to the absence of oil and other solids which in the past made the scale soft and removable. Progress is being made in reducing the barium content of the produced water before combinations of the

make up water. A Texsteam pump and mix tank were set for a floc test. The objective was to floc and remove barium from the water stream. Various combinations of soda ash, sodium sulfate, and alum have been mixed and proportioned into the raw water for this test. The barium ion is being monitored daily while the test continues. Cleanup of injection wells has indicated no appreciable deposits in the injection wellbores from the injected brine.

Since injection rates have been increased, additional downtime was caused by exceeding the capacity of the single bag filter. An additional bag filter was placed in parallel with the existing filter. A meter was installed in the water transfer line to better monitor and control the water flow.

Downtime was caused by storms blowing fuses in the water transfer pump. Greater power problems were experienced on the producing system. Some problems resulted from the storms blowing individual well drops loose on our secondary system. Most problems resulted from single-phasing of the power source. Phase sensing motor protectors are being installed. A meeting was set up with the power supplier, United Electric Cooperative. The purpose was to urge them toward providing a more reliable and economic power supply.

Summary of planned work for next quarter

The waterplant will be continually monitored and optimized as problems arise. We believe the greatest opportunity lies in the area of metering, monitoring, and controlling the water streams leading into and out of the flotation unit. It has been difficult to maintain constant flotation efficiency at the unit. This is caused by a variation in the percentage of produced and make-up water that is being treated over time. When this mix changes, the constituents of the combined water stream also change, necessitating a variation in the chemical treatment. This problem could be solved by automatically monitoring the water mix and adjusting the chemical feed accordingly. This development would certainly make the technology useable by most operators and applicable over a wide range of conditions.

Task II.2 - Profile Modification Treatments

Summary of work in last quarter

No treatments were conducted.

Summary of planned work for next quarter

We plan to conduct at least three polymer gel treatments in the next quarter.

Task II.3 - Pattern Changes and Wellbore Cleanup

Summary of work in last quarter

In the month of April -

A packer was set in Well No. K-39 so that injector No. KW-47 could be reactivated. Well No. KW-7 was washed, jetted, acidized and placed back on injection. Utilizing the pump truck and the wash pipe, full-scale jetting and acid jobs were performed on Wells (RW-3, RW-6, and RW-8). Coil tubing acid jobs were done on Wells (KW-9, KW-11, and RW-13). A lubricator acid-cleaning job was performed on Well KW-51.

Well H-5 was pulled and the pump repaired. The well was later washed, jetted and acidized. A packer and 1" tubing string were installed and the well was converted to injection service. Well RW-2 was reactivated and injection begun on April 6, 1995. Steel line T.D. measurement was taken on numerous wells to check the need for clean-out.

Producing wells H-16, H-22, K-41, and K-54 were pulled and serviced during the month.

In the month of May -

Injection well remedial work was limited to well RW-9. This well received a coil tubing acid treatment which was then displaced with the pump truck. A lateral line was laid to H-14 to prepare for its conversion to an injection well. Steel line measurements were taken to check T.D. on Wells RW-9, RW-12, H-12, and HW-31. Two separate step-rate tests were conducted on Well KW-51.

Producing wells (H-3, H-10, H-13, H-21, and K-54) were pulled and serviced during the month. H-21 had a large pumping unit and a long-stroke pump installed. The speed was increased on H-17 and K-44 in response to increased fluid.

In the month of June -

H-14 was converted to an injection well. H-41, H-13 were pulled and repaired. Step-rate and fall-off tests were conducted on RW-7. K-50 was reactivated and worked over.

Summary of planned work for next quarter

We will clean appropriate wells for better injectivity into the B3 zone.

Task II.4 - Reservoir Development (Polymer Flooding)

Summary of work in last quarter

Equipment to inject polymer was placed on location. The equipment was tested for reliability.

A drilling location was determined and is presented in Figure 1.

Summary of planned work for next quarter

Start injection of polymer and drill at least one well.

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. Monthly average production rates follow.

<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

Summary of planned work for next quarter

Continue Field Operations

Task II.6 Technology Transfer

WORKSHOP ON A DEMONSTRATION PROJECT IN THE SAVONBURG FIELD IN EASTERN KANSAS

A one-day workshop titled "Exploitation of Mature Reservoirs - Results on Savonburg Project" will be held at Allen County Community College in Iola, Kansas, August 9, 1995. The workshop will be co-sponsored by the North Mid-Continent Regional Lead Organization which is part of the Petroleum Technology Transfer Council (PTTC) and Allen County Community College. The workshop will be aimed primarily at operators, engineers, geologists, and oil field investors who own mature reservoirs under waterflood in central and eastern Kansas.

Topics to be covered include:

- 1) Geological and Engineering Analysis: This will include a the geological and engineering study with a special section on the use of Stratamodel in reservoir characterization. Stratamodel is a 3-D visualization tool to envision a reservoir model.
- 2) Waterplant Optimization: Plant modification utilizing air flotation with results to date.
- 3) Field Testing: Pressure fall-off testing and the use of tests to determine fluid flow in reservoirs.
- 4) Methods of wellbore cleanup with results to date on wells in the Savonburg Field.
- 5) Gel polymer treatments.
- 6) Reservoir development which includes pattern changes, polymer flooding and possible results from drilling in-fill wells.

Registration is being coordinated by John Masterson at Allen County Community College, Allen County, Kansas (31) 365-5116 Ext #211.

Stewart Field Project

Task II.1 - Design/Construct Waterflood Plant

Summary of work in last quarter

Selected waterflood injection plant fabrication and design, and ordered the waterflood injection plant. The plant is designed for a maximum of 10,000 BWPD at 2000 psi.

Summary of planned work for next quarter

Secure the land for the central facility site and install the waterflood injection plant.

Task II.2 - Design/Construct Injection System

Summary of work in last quarter

Re-completed an existing wellbore and tested the Topeka formation for water supply quantity and quality.

Finalized the injection system design, selected manufacturer, and ordered 4" fiberglass pipe for injection lines.

Summary of planned work for next quarter

Complete an additional Topeka water supply well and equip both water supply wells with electric submersible pumps.

Install injection lines and convert 6 producing wells to injection wells.

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

Summary of work in last quarter

Revised the design to accommodate one central tank battery location. Ordered fiberglass gathering lines, central battery tanks, and heater treater.

Summary of planned work for next quarter

Secure land for central facility site, construct central tank battery, and install gathering lines.

Task II.4 - Waterflood Operations and Reservoir Management

Summary of work in last quarter

Hired a production foreman to supervise waterflood construction and operations. Designed and equipped 2 well test trailers and field tested the trailers for accuracy of test data.

Summary of planned work for next quarter

Hire company pumper, implement waterflood operations, finalize field data capture system plan, and plan reservoir data collection schedule.

Task II.5 - Technology Transfer

Summary of work in last quarter

A paper titled, "Stewart Morrow Field - DOE Class 1 Project", was presented at the TORP Oil Recovery Conference and will be published in the conference proceedings.

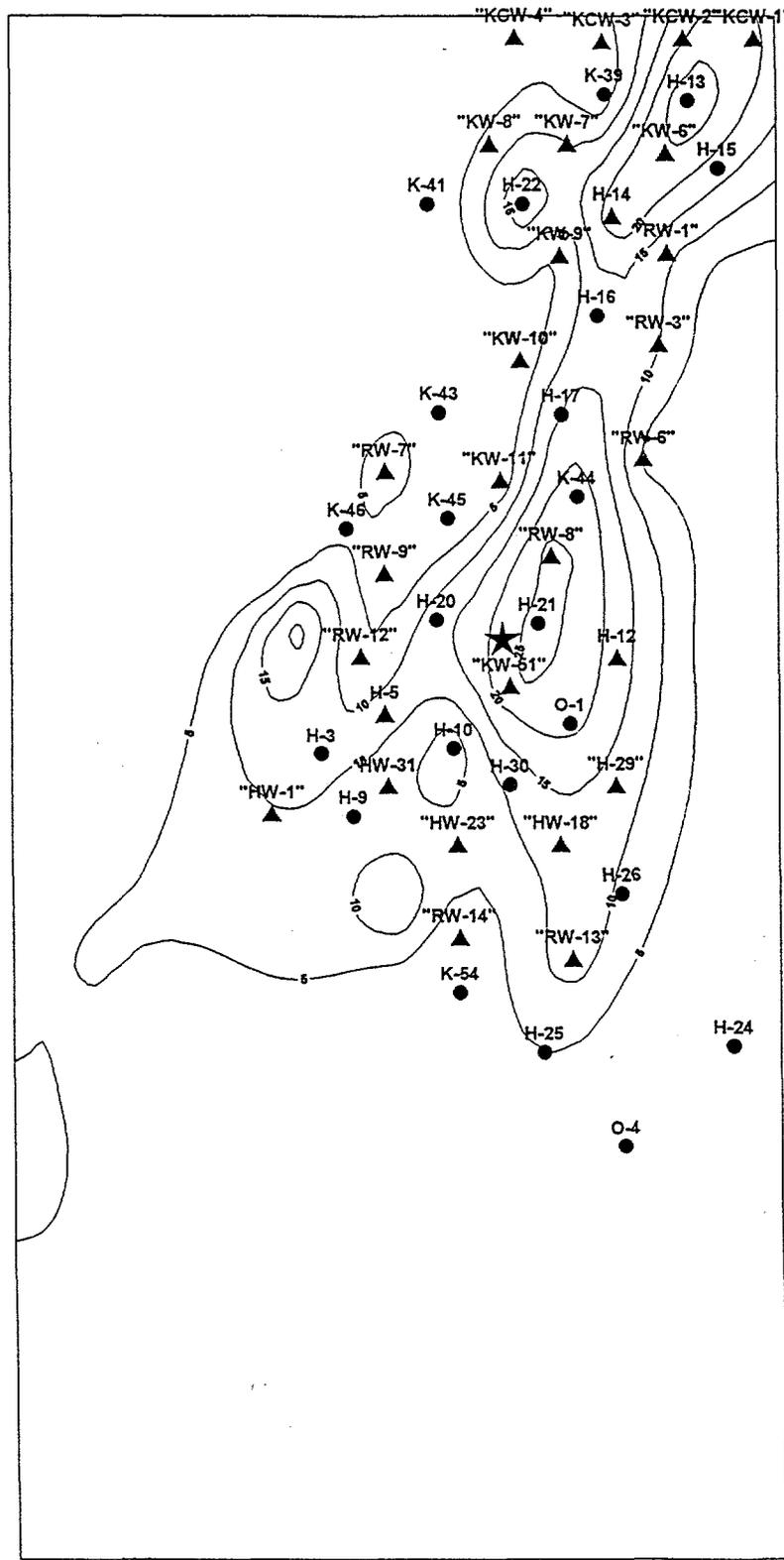
The Stewart Field project was awarded the "Best Advanced Recovery Project" in the Midcontinent by Hart's Oil and Gas World and was runner-up as the "Best Field Improvement Project".

Summary of planned work for next quarter

Project information will be presented as a poster session at the SPE Forum Series titled, "Multidisciplined Analysis and Solutions to Rejuvenating Old or Marginal Fields", August 6-11 in Snowmass Village, Colorado.

Methodologies used on this project will be presented as a case study at a seminar titled, "Increasing Profitability in Marginal Oil Fields", August 24-25 at Barton County Community College in Great Bend, Kansas.

Savonburg Field (6/19/95)



Active Wells (B3 Net Isopach)