

PROJECT facts

Petroleum Exploration
and Production

02/2004

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

GREEN RIVER FORMATION WATER FLOOD DEMONSTRATION

Waterflooding high paraffin content reservoirs

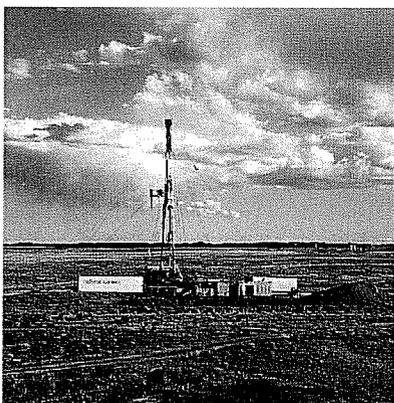
PARTNERS

Inland Resources, Inc.
Denver, CO
Lomax Exploration Co.
Denver, CO
University of Utah
Salt Lake City, UT

MAIN SITE

Monument Butte Field
Duchesne and Uintah, Cos.
Uinta Basin, UT

DE-FC22-93BC14958



Well site showing the typical terrain of Monument Butte Field.

Background/Problem

The Monument Butte waterflood project, which started in 1992 and completed in 1996 by Lomax Petroleum, was one of the major success stories of the Class I Fluvial-Deltaic program. Waterflooding technology was not commonly used in the Uinta Basin due to the low permeability, heterogeneity and high paraffin content (12%) of the lacustrine reservoirs. Primary production from the Eocene age, Green River formation in Monument Butte field averaged only 5% of original oil in place (OOIP). Lomax Petroleum was bought by Inland Resources as the project successfully demonstrated how to waterflood a high paraffin oil reservoir. Inland Resources completed the DOE project in 1996.

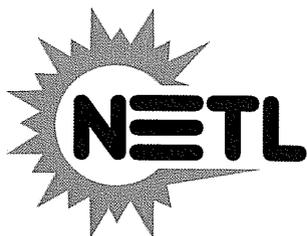
In 2003 NETL began reviewing the field demonstrations of the Class projects to determine the long term benefits of DOE funding. Inland Resources expressed great satisfaction with the original DOE Class I project and credited the expansion of the pilot from a 2-section Monument Butte Unit to the entire 125,000 acre field to technology developed under DOE's funding. DOE's return on investment has an average annual rate of 33% from 1992 to 2003.

Project Description/Accomplishments

The objectives of the project were to identify the recovery mechanisms operating in the waterflood, to evaluate the success of the Monument Butte Unit waterflood and extend the waterflood to Travis and Boundary Units.

Reservoir characterization of Monument Butte reservoirs provided key information, which resulted in a successful waterflood. Core analysis identified the most laterally continuous and lithologically homogeneous zones. The ability to isolate and waterflood a single zone, making use of fracture orientation data, rather than targeting multiple zones significantly increased production and improved economic efficiency. Reservoir simulation models based on core and log analysis identified the need to quickly pressurize the reservoir by waterflooding to move the waxy crude into the wellbore.

The successful waterflooding technology was expanded to the Travis and Boundary Units with an estimated ultimate recovery of 20% OOIP from secondary recovery. The first use of FMI logs in northern Utah proved valuable in identifying zones for perforation and data for geologic modeling. One of the keys to waterflooding the reservoir was the importance of using fresh water for injection. Oil recovery from Monument Butte Unit increased from 300 BOPD to 2000 BOPD, and the number of wells increased from 20 to 60 during the project. Independent operators in neighboring leases picked up the technology and initiated eleven new waterflood projects in the Uinta Basin. Reservoir life was extended by over 10 years.



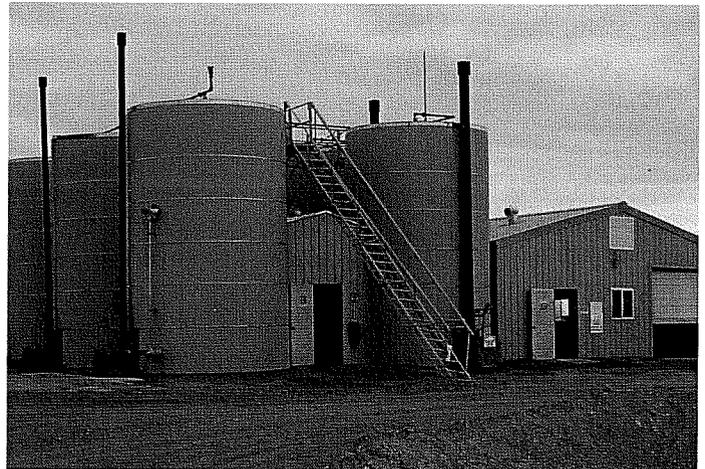
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Benefits/Impacts

Since the end of the DOE project in 1996 Inland Resources has continued to expand the waterflood technologies. Current production is at 6,000 barrels of oil and 11 million cubic ft of gas per day. Cumulative production of 25 million barrels of oil and 70 billion cubic feet of gas has reached 20% of OOIP and continues to rise. The strategy developed from the DOE project is to drill wells on a 5-spot pattern. All wells are put on production and after 18 months, the center producer is converted to a water injector. As of May 2003, 740 wells are on production and Inland plans to drill an additional 1,000 wells on 40-acre spacing over the next 4 to 5 years. Inland Resources controls over 125,000 acres, the vast majority of Monument Butte field. The original DOE project has expanded from 2 sections to cover over 60 sections. Currently, the drilling rate averages 5 days per well to a depth of 5,000 to 6,000 ft. To meet both environmental regulations and to maintain year round production each producer has its own surface facilities including 800 bbl oil storage tanks and 400 bbl water storage tanks and each injector has a heated wellhead. Hydrocyclones have been installed to remove particulate matter prior to water injection. Fresh water for injection remains a critical factor in expansion of the field in the arid Uinta Basin. At present, Inland is injecting 18,000 bbl of water per day (including 4,000 bbl of produced water) in 5-spot patterns. Decline curves of Monument Butte field prove the technical success of the waterflood technology, as a positive response is shown with each new waterflood cycle.

The financial benefits in the Uinta Basin are demonstrated by increased royalties, state and federal taxes and increased employment. Inland Resources employs over 100 people. Three large independent operators, Petrocliffe, Questar and Berry Petroleum have acquired leases in the area and continue to expand the



Main water injection facility showing a series of water separation tanks and the building housing the hydrocyclone.

waterflood technologies across the Uinta Basin. Inland Resources has installed a gas stripping plant that enables the company to meet pipeline specifications and environmental regulations for selling oil and gas liquids. The gas liquids recovered from the plant provide an additional \$150,000 per month profit. Paraffin is also sold as a by-product of oil and gas liquids production. The life of the Monument Butte reservoir has been extended from a short period on primary to 10 to 20 years on secondary production. The economic success of the project can be inferred from the aggressive expansion by Inland Resources and from other area operators using the waterflood technology developed.

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TOTAL ESTIMATED COST

\$4.4 million

COST SHARING

DOE - \$1.8 million
Non-DOE - \$2.6 million

WEBSITE

www.netl.doe.gov