Recovery of More Oil-in-Place at Lower Production Costs While Creating a Beneficial Water Resource

DE-FC26-02NT15463

Goal
The project goal is to develop a reliable, economic means of removing excess produced water from San Ardo oilfield by converting it into a new water resource for potential beneficial use in agriculture, groundwater recharge, or other use.

Performers
Aera Energy LLC
Bakersfield, CA

Kennedy/Jenks Consultants
Irvine, CA

Results
The project was organized into three groups of activities. The first identified and finalized the requirements that must be met by the demonstration study; the second was to design, construct, and operate the demonstration plant; and the last summarized the findings and developed the cost and regulatory response for implementing a full-scale beneficial use of produced water project. A demonstration treatment plant constructed at Aera's operations in the San Ardo oilfield has shown that treated water quality objectives are achievable at expected water recovery rates. The treatment process utilized warm precipitation softening for hardness and silica removal, followed by reverse osmosis (RO) membranes for desalting. Additional treatment may be required to remove organic chemicals and ammonia present in the produced water. However, despite the success of the demonstration plant, significant obstacles remain to the development of a full-scale project. Currently identified potential end-uses of the treated water appear infeasible primarily because of the high cost of conveyance (pipeline) or water storage

Benefits
Finding another home for produced water provides a solution to the problem facing a significant number of U.S. fields, especially in California. This project attempts to develop a win-win solution by converting this "waste" to a much-needed municipal or agricultural water resource. The project objective is to develop a sustainable, economical treatment technology for removal of the produced water from oil production, which lowers oil production cost and allows more recovery of oil-in- place. Conversion of this treated produced water to a beneficial resource for use in groundwater recharge, irrigation water for agriculture, or wildlife habitat from surface discharge is the ultimate goal.

Background
Crude oil produced from Aera's operations in San Ardo oilfield in Monterey County, CA, requires significant heat from steam to reduce the oil's viscosity and increase overall recovery. Over time, the water cut for this production has gradually increased to 95 percent, and there are limited injection zones within the oilfield for disposal of this produced water. High reservoir pressures have resulted from reinjection of the water into Class II disposal wells within the oil-field, which in turn has resulted in reduced steam drive performance. Future oilfield development and crude oil recovery at this location may be dependent on economically dewatering the reservoir, thereby improving the steam performance.

The 1998 California Water Plan (DWR Bulletin 160-98, November 1998 edition) estimates that, at a 1995 level of development, by the year 2010 California will have a water shortage of 1.6 million acre-feet (12.4 billion barrels) in average water years and 5.1 million acre-feet (39.6 billion barrels) in drought years. The shortage forecasted for 2020 increases to 2.4 million acre-feet (18.6 billion barrels) in average water years and 6.2 million acre-feet (48.1 billion barrels) in drought years. Population growth is expected to drive the State's increased water demands.

In 2000, about 359 million barrels of produced water was reinjected into Class II disposal wells in California (California Department of Conservation, 2001). The top seven oil producing counties in California (Kern, Monterey, Santa Barbara, Los Angeles, Fresno, San Luis Obispo, and Ventura) generate 99.5% of this volume.

Over 50 million barrels per year of produced water is disposed of in Class II injection wells in Monterey County, 14% of the statewide total.

Summary
The project tasks break out as:

- Phase I, identification of end use options and regulatory requirements: Phase I of this study identified and investigated potential end uses for the treated water. Regulatory requirements for the treatment facility and the delivery, use, and storage of the water were identified and documented.

- Phase II, pilot operation of treated water quality evaluation: The nine-month pilot operation has been completed. The results indicated that the San Ardo produced water can be treated to meet all of the water quality criteria for various end use options.

Project researchers undertook the following studies:

- Ammonia removal using a cooling tower. The raw produced water contains about 20-30 mg/l of ammonia. The Placerita Canyon pilot study identified ion exchange treatment following a high pH reverse osmosis (RO) operation as the means to remove the majority of the ammonia from the water.
- Breakpoint chlorination: As an alternative to ion exchange process to remove ammonia, bench studies were conducted to evaluate ammonia removal using breakpoint chlorination.
- Evaluation of boron removal at lower pH. The conventional approach to boron removal in oilfield produced water is by operating the RO at an elevated pH (>10.5). At this pH, boron is ionized and rejected by the RO membrane. While this approach is very effective for boron removal, this will require a large amount of chemical addition, resulting in high operations and maintenance cost.
- Oxidation of organics by chlorine dioxide to reduce membrane fouling. Under this pilot study, another novel approach is being evaluated for oxidizing complex organic matter in the raw water to minimize potential fouling of the RO membranes. Bench studies were conducted to evaluate the ability of chlorine dioxide to oxidize the complex organics to smaller entities that are less prone to fouling membranes.

Current Status (June 2006)
The majority of tasks and subtasks in the project have been completed. Operation of the demonstration plant was completed in March 2005, and the facility has been demobilized. The remaining technology transfer tasks and preparation of the final project report is in the final stages of edits and approvals.

Funding
This project was selected in response to DOE's solicitation DE-PS26-02NT15373.

Publications
Evaluating the Potential for Beneficial Use of Oilfield Produced Water for Agricultural Irrigation in San Ardo, CA, presentation, 20th Annual WateReuse Symposium, Denver, CO, September 2005.

Overview of Regulations for Potential Beneficial Use of Oilfield Produced Water in California, presentation, 12th Annual Integrated Petroleum Technology Conference, Houston, TX, November 2005.

Semi-annual progress reports on this project have been submitted to DOE. At DOE's request, the final comprehensive project report will be submitted after the completion of the technology transfer tasks, no later than July 31, 2006.

Project Start: September 27, 2002
Project End: July 31, 2006

Anticipated DOE Contribution: $1,087,369
Performer Contribution: $277,224 (21% of total)

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Reverse osmosis section of demonstration plant.

San Ardo oilfield from Highway 101 in California.