Title: **"Improved Miscible Nitrogen Flood Performance Utilizing Advanced Reservoir Characterization and Horizontal Laterals in a Class I Reservoir – East Binger (Marchand) Unit"**

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Principal Author/Investigator: **Teresa Muhic**

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Cooperative Agreement No: **DE-FC26-00BC15121**

Contractor Name & Address: **Binger Operations, LLC, P.O. Box 2850, Cody, Wyoming 82414**

DOE Project Manager: **Gary Walker, National Petroleum Technology Office**

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Table of Contents

Technical Progress Report – 2nd Quarter 2000

Introduction

The cooperative agreement for this project was finalized and signed during April 2000. The official project start date was April 11, 2000. Initial reporting requirements, including the completion of a Project Management Plan, Milestone Plan and Log, and a Hazardous Substance Plan, were completed and submitted to the DOE in early May 2000. Work on the project tasks was initiated in May 2000.

During the course of this budget period, efforts will focus on enhancing reservoir characterization work that had been in progress prior to the start of this grant project, incorporation of this information into an existing 3-D full-field compositional model, and utilization of a "window area" of the model (representing a selected pilot area) to evaluate the impacts of horizontal laterals on recovery in the miscible nitrogen flood. The "window area" model will also be used to design the most effective configuration and placement of the lateral sections. The following is a summary of progress made between April 11, 2000 and June 30, 2000.

Progress Review

In late April 2000, members of the Binger Operations project team and management held a project start-up meeting in Oklahoma City, Oklahoma. Key issues discussed were the organization of the project team, reporting relationships, accounting procedures and budgeting, initial project goals and task details, and time-lines for work completion. An initial timeline and detailed budget information were supplied to members of the team. Also discussed were selection criteria for a pilot area demonstration project (Task 1.1.1) and the geologic and reservoir data requirements to enhance the model reliability (Task 1.1.2).

The following is a detailed review of the work conducted and accomplishments occurring in each of the following tasks during this reporting period.

Task 1.1.1 – Screen Reservoir for Potential Pilot Areas

The purpose of this task to select an area within the reservoir in which to evaluate a pilot-sized field demonstration of the horizontal lateral technology using a "window area" of the 3-D compositional simulation model to represent the pilot area. Work began on this task in May 2000. The original anticipated completion date for this task was June 30, 2000. However, it has become apparent that Task 1.1.1 and *Task 1.1.2 – Reservoir Data Collection* are interdependent, and the completion date for Task 1.1.1 was too

aggressive. During the course of Task 1.1.2, data will be collected that will affect the final selection of a pilot area for this project. At the same time, additional data requirements will be identified during course of reviewing the field for a pilot area. Ultimately, this is not expected to impact the overall timing of the project. *Task 1.1.5 – Build Pilot Area Model* is not scheduled for completion until mid-February, 2001, and the selection of the pilot area (Task 1.1.1) does not need to be finalized until mid- to late-November in order to complete Task 1.1.5 on time.

Initial pilot area screening criteria has been developed, and work to review the well completions and performance has begun. Input was requested and received from Richard Dillon, International Reservoir Technologies, Inc. (IRT), regarding selection criteria for a pilot area from the perspective of model reliability and practical modeling considerations. Key issues or selection considerations that he identified include:

- The need for an area of adequate size to contain enough wells so that an individual well would not dominate the model performance, yet small enough that model run-times were not excessive. Since the window-area model (i.e. pilot area) will be developed with a finer grid than the full-field model (FFM), it will still be important to consider grid size and number. His initial estimate of a practical area was approximately 1280 acres and 16 wells.
- Natural barriers discovered during the completed FFM should be considered and potentially utilized as boundaries.
- Areas with the better relative history matches should have preference to areas with poor history matches.
- Wells which have significantly anomalous behavior (e.g. high/low GOR, high/low pressure) relative to the "typical" East Binger Unit (EBU) wells should be avoided.

Other pilot area selection criteria identified by Binger Operations team members include those listed below.

- Existence of useable wellbores within proposed area – i.e. mechanically sound or limited remedial work required to make them suitable for addition of a lateral section.
- Area needs to be generally representative of the reservoir rock within the main channel of the Marchand 'C'. (The main channel of the Marchand 'C' runs northwest-southeast and is generally represented by the South-west, South-central, and South-east regions in Figure 1 on Page 7.)
- A reasonably accurate understanding of fluid movement patterns, directional permeability trends, and pressure profiles across the pilot area.
- Pilot area should be located within the main channel of the sand where the greatest oil in place and best sand quality exists, as well as largest area in which to expand the pilot should it prove successful.

During June 2000, efforts were initiated at reviewing individual well histories and completions within the main channel of the reservoir to identify the useable wellbores, and to evaluate well histories for justification of performance variations. This work is

being carried out by Teresa Muhic (Project Manager) and Terry Ziehl (Engineering Technician). A data template has been developed in Microsoft Excel to record key information on each wellbore, and is being populated as each well is reviewed. This work will continue and is expected to be completed during the next reporting period. In addition, the team will review the performance of the reservoir in the potential pilot areas using the current full-field model output, identify any additional producibility problems which may affect a pilot project, and evaluate the model accuracy and reliability to determine geologic and reservoir performance data that should be obtained in order to improve the reservoir characterization and model reliability.

Task 1.1.2 – Reservoir Data Collection

The purpose of this task is to obtain geologic and reservoir data to help substantiate areal and vertical fluid movement patterns, improve the full-field model performance prior to creation and use of the "window area" model, and to establish baseline parameters for monitoring the project. This information will also aid in the final selection of the pilot area for this project, as well as improve the reservoir description in the model. The modeling to be conducted during *Task 1.1.6 – Evaluate Horizontal Performance or Other Development* will benefit from any additional information that can be obtained regarding fluid movements within the reservoir and rock properties.

Gas Sampling

During this reporting period, wellhead gas samples were collected by Gas Jack Measurement of Oklahoma City, Oklahoma from 32 wells located predominantly within the main channel of the reservoir. They have been analyzed for hydrocarbon components, nitrogen content, as well as carbon dioxide, hydrogen sulfide and oxygen. The nitrogen content of the collected samples ranged from 2.1 mole percent to 82.1 mole percent. The sampling was done throughout the month of June, and most of the results were received just a few days prior to the end of the quarter and have not yet been integrated into a database for evaluation. Additional samples from the remaining unsampled producing wells will be collected during the 3rd Quarter of 2000. An analysis of the results of all gas samples will be provided in the next quarterly report. This information is expected to provide an important baseline comparison for monitoring movement of the injected nitrogen gas and in identifying improvements in limiting or eliminating injected gas cycling.

Injection Profiles

Two injection profiles were run on wells within the main channel that have historically had anomalously high nitrogen injection rates. The two wells that were profiled were East Binger Unit 68G-01 and 78G-01. These wells are both located in the Southeast region of the field (see Figure 1). The profiles were run in order to determine

whether there were mechanical issues such as parted casing or casing leaks in these wellbores which might affect the local area's selection for a pilot area project.

On #68G-01, Baker Atlas ran an injection profile log consisting of a temperature, radioactive tracer and velocity profile. The profiles indicated that all injected gas was staying within the Marchand sand, however, 72% of the injected gas was entering the Marchand 'A-B' perforations and only 28% was entering the Marchand 'C', which is the primary zone of interest and the main producing body within the field. Within the Marchand 'C', all of the gas appears to be entering only the top 14 feet of sand, with no gas entering the bottom 20 feet. This is in agreement with the overall full-field modeling results suggesting gas channeling at the top of the reservoir. There are no apparent mechanical integrity problems with this wellbore.

Due to a mechanical restriction in the tubing on #78G-01, we were unable to get the logging tools through the end of the tubing to run a full injection profile across the formation. Instead, a radioactive survey was run inside the tubing above the formation to check for injection out of zone. A radioactive slug was injected down the tubing and after waiting 32 minutes for the tracer to move through the tubing and toward the formation, Baker ran a "channel-up" check. The results of this indicated that injected fluids are staying within the Marchand sand. There are no apparent mechanical integrity problems with this wellbore.

Additional surveys are expected to be run during the 3rd Quarter of 2000 to continue to identify areas with acceptable wellbore integrity and to continue to improve the information about injected fluid distribution with the Marchand sand.

Calibration of Horizontal Productivity

Two wells have been selected in which a horizontal lateral section will be drilled in order to obtain productivity data of a horizontal wellbore for calibration of the model. These wells are producer # 46-02 and injector #64G-02 (see Figure 1). The criteria used during selection these wells was as follows:

- Wells must have mechanical integrity.
- Wells must have 5-1/2" producing string, or wells with 4-1/2" producing string must have an intermediate string of sufficient depth such that the 4-1/2" could be pulled and a window cut through the intermediate string.
- Wells must be located within the main channel.
- Wells must have sand thickness and quality representative of the overall reservoir and not be near an edge which might negatively affect results.
- Wells must have production and injection rates that are representative of the overall reservoir.
- Wells must be located sufficiently far from one another so as not to interfere with the results of the other lateral.

- Producing well must be located in an area from which a lateral may access high oil saturation areas. Injection well must be located in an area from which the lateral will access reasonably gas saturated sections of the upper part of the Marchand 'C'.

Planned work for the 3rd Quarter of 2000 includes completing the permitting and planning process for these wells. It is also planned to attempt to initiate drilling operations, however, there is an apparent shortage of rigs available. This shortage may affect the timing of the drilling of these test laterals.

Other

Additional data collection will occur during the next reporting period. The nature and location of this work is partly dependent on the results of work proceeding in Task 1.1.1, wherein wells within the main channel of the reservoir are being reviewed for inclusion within a pilot area.

Task 1.1.3 – Technology Transfer Activities

The initial version of the web pages that will populate the planned website were developed. Efforts were also made to establish a domain for the site and a project specific e-mail address. However, our efforts to work directly with Network Solutions, who issues domain names, have been unsatisfactory, and we plan to have our local internet provider handle the details of setting up a domain. This website will be a major technology transfer vehicle throughout this project, and will include copies of each of the reports submitted to the DOE, as well as other pertinent information.

Planned activities for the next quarter include finalizing the establishment of a domain, populating the website, and updating it with the first quarterly report.

Task 1.1.4 – Update Full-Field Model

In preparation for updating and re-validating the existing full-field model, the measured production (oil, water, and gas) and nitrogen gas injection data, gas analysis (N_2 %), and reservoir pressure tests obtained during the period from March 1, 1999 to April 30, 2000 were collected and sent to International Reservoir Technologies, Inc. (IRT).

IRT converted this data to Landmark VIP simulator input format on individual well, region and total field levels. Landmark VIP is the simulation software that was used for the full-field modeling work completed prior to this project, and is the software that will continue to be used during the course of this project.

Future work expected to be completed during the next quarter will include running the full-field model from its current end-of-history point of February 28, 1999 through to the April 30, 2000. The model performance will be compared with the updated data from the field and the determination will be made if any significant modifications are required, or whether the model remains valid without modification. Any new data obtained during the course of *Task 1.1.2 – Reservoir Data Collection*, will also be reviewed and analyzed for consistency with previous modeling results, prior to finalizing this Task.

Validation of the model is important since the structure and individual grid parameters will be clipped and used to populate a finer grid window area model during Task 1.1.5. This fine grid model will be the tool by which various development plans of the pilot area are evaluated and individual horizontal laterals are designed to optimize performance and impact.

Task 1.1.5 – Build Pilot Area Model

No work has yet been done on this task. It is dependent on the completion of Task 1.1.4.

Task 1.1.6 – Evaluate Horizontal Performance or Other Development Design

No work has yet been done on this task. It is dependent on the completion of Task 1.1.5.

Task 1.1.7 – Design Upgrade & Additions to Facilities

No work has yet been done on this task. It is dependent on the completion of Task 1.1.5 and 1.1.6.

Budget and Scheduling

As of June 30, 2000, the project is on budget and with a minor exception, is also on schedule. The only major concern at this point is with respect to rig availability to drill the horizontal lateral sections.

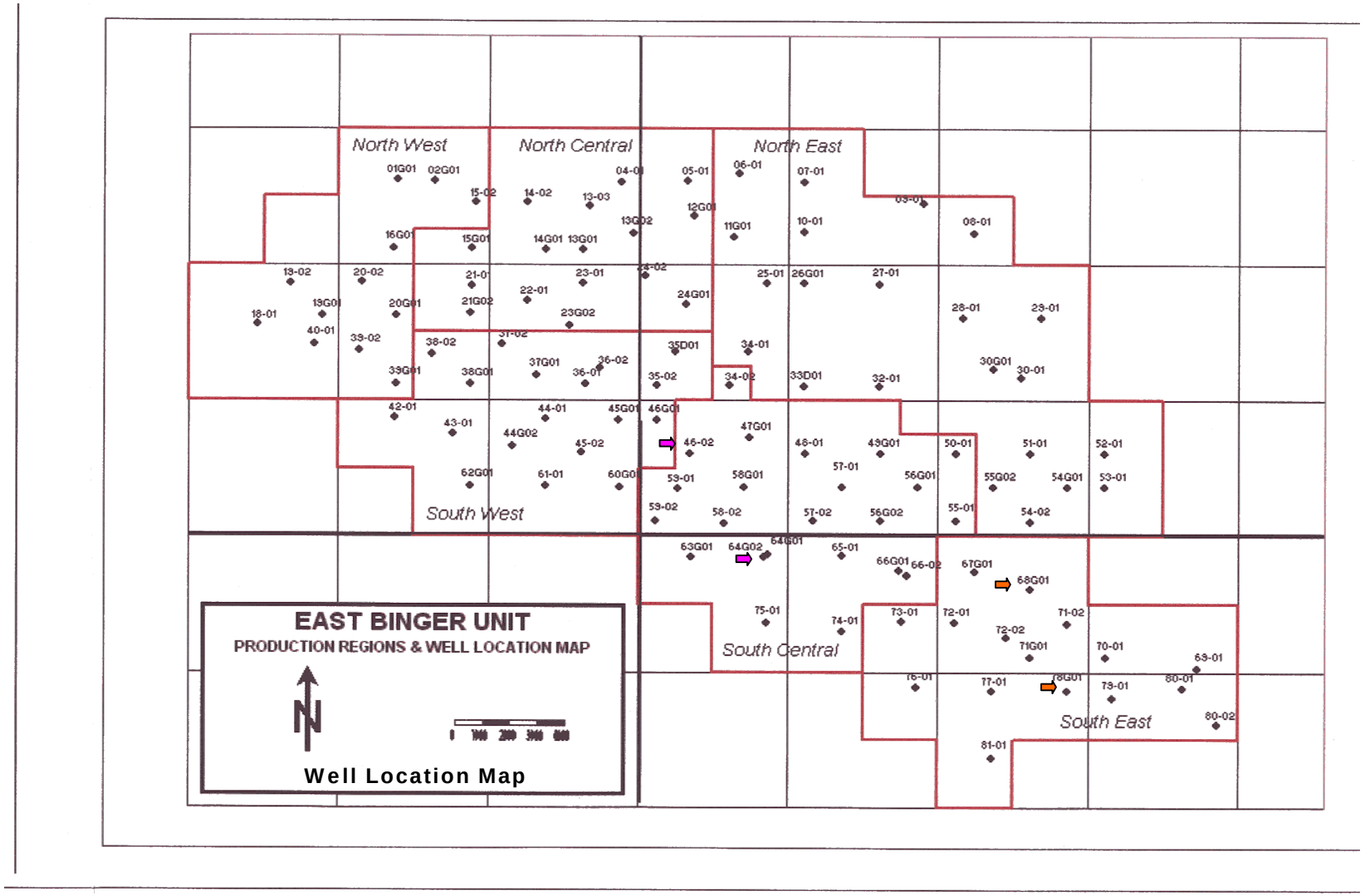

Figure 1. –Map showing location of planned test horizontal lateral wells (purple arrows) and completed injection profiles (orange arrows)