PROJECT MANAGEMENT PLAN

OPTIMIZING DEVELOPMENT STRATEGIES TO INCREASE RESERVES IN UNCONVENTIONAL GAS RESERVOIRS

Area of Interest 1: Gas Shale
Area of Interest 3: Tight Sands

prepared for

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A.1 Work Breakdown Structure

I. OBJECTIVES

The overall objective of the proposed research is to determine optimal development strategies for unconventional gas reservoirs. A specific objective is to develop technology and tools to help operators determine optimal well spacing and completion strategies in highly uncertain and risky unconventional gas reservoirs as quickly as possible. Specific objectives also include applying the technology and tools to determine optimal well spacings in the Barnett Shale in Parker County, Texas, and in the Deep Basin tight gas sands in the Berland River area, Alberta.

II. SCOPE OF WORK

To achieve the research objectives, we will first develop a fast, approximate, probabilistic reservoir model to match and predict production performance in unconventional gas reservoirs. The reservoir model will be validated against simulation-based methods with synthetic reservoir data sets. We will develop a Bayesian decision model that will incorporate the risk facing operators with the development and testing decisions they can make. The decision model will be fully integrated with the reservoir model to provide operators with a robust decision support system. Applying these integrated tools and working with operating companies, we will model specific development decisions in specific unconventional gas reservoirs to determine optimal development strategies. Specifically, we will work with Pioneer Natural Resources Company to determine optimal well spacing strategies for the Barnett Shale in Parker County, Texas. In addition, we will work with Unconventional Gas Resources Canada Operating, Inc., to determine optimal well spacing strategies for Deep Basin tight gas sands in the Berland River area, Alberta. Both of these studies will involve analysis and integration of production and pressure data, well logs, stimulation and microseismic data, and other data, as well as application of the integrated reservoir and decision models.

III. TASKS TO BE PERFORMED

<u>Task 1.0 -- Project Management Plan</u>

The Awardee shall develop a Project Management Plan consisting of a work breakdown structure and supporting narrative that concisely addresses the overall project as set forth in the agreement. The Awardee shall provide a concise summary of the objectives and approach for each Task and, where appropriate, for each subtask. The Awardee shall provide schedules and planned expenditures for each Task including any necessary charts and tables, and all major milestones and decision points. The Awardee shall identify key milestones that need to be met prior project proceeding to the next phase.

Task 2.0 --Technology Status Assessment

The Awardee shall perform a Technology Status Assessment and submit a summary report describing the state-of-the-art of the proposed technology. The report should include both positive and negative aspects of each existing technology.

Task 3.0 --Technology Transfer

We will work closely with the participating companies and RPSEA to develop a program to transfer the results of this research. This will include the training of key personnel on the theory and use of the reservoir and decision models developed. We will disseminate our research results primarily through a series of SPE papers and presentations. We anticipate at least four papers. In addition to these papers, we will present our results to members of the Center for Unconventional Gas Resources in the Crisman Institute for Petroleum Research at Texas A&M University. Finally, our research results will be integrated into the curricula of both the Department of Petroleum Engineering at TAMU and the Graduate Program in Operations Research at UT.

Task 3 Planned Expenditures: At least $3,140 (2.5% of the award) will be used to fund technology transfer activities.

Task 4.0 --Reservoir Model

Subtask 4.1 --Develop fast reservoir model

In this task, we will develop a fast, approximate, probabilistic reservoir model for predicting performance of unconventional gas reservoirs

Since the reservoir model will be combined with a Bayesian decision model and will be run thousands, and possibly millions, of times in a typical evaluation, it will be designed to be very fast. The model will be intermediate between statistical moving window approaches and simulation-based approaches. A major extension over previous methods will be including quantification of uncertainty. Input reservoir and well parameters will be treated as random variables, and predictions of future performance will be in the form of distributions rather than deterministic values.

Subtask 4.2 –Validate reservoir model

The reservoir model will be tested and validated as it is being developed. Validation will be conducted against synthetic data sets generated using reservoir simulation, but with random noise introduced to mimic actual production data. Since the true reservoir description and reservoir performance will be known, we will be able to quantify the reliability of the approximate reservoir model and incorporate model uncertainty into the modeling process.

Task 4 Planned Expenditures: Approximately $2750 is required for a fast, dedicated desktop computer to run the computationally demanding models.

Task 5.0 --Decision Model

Subtask 5.1 --Develop Flexible Decision Model

In this task we will develop a Bayesian decision model that will allow operators to choose the optimal primary and secondary development plans in unconventional gas

reservoirs. We will work with the operating companies to fully specify the number of development stages to consider

Subtask 5.2 –Validate Decision Model

We will work closely with the co-funding companies to validate the structure and assumptions of the decision model. The model will be rigorously tested on simple development problems before being extended to actual development decisions.

Task 5 Planned Expenditures: Approximately $3250 is required for ILOG's CPLEX optimization software to be used in the decision modeling.

Task 6.0 –Integrate Reservoir and Decision Models

The decision model will be integrated with the reservoir model. The decision model will start from the final stage, *N*, and will specify the optimal development given all possible combinations for the previous production, spacing, and completion histories. The decision model will pass this history to the reservoir model, along with the spacing and completion strategy currently under consideration. The reservoir model will return a probabilistic production forecast from stage *N* forward. With the optimal strategy for stage *N* defined, the decision model will then back up to stage $N - 1$ and repeat the process, taking into account the fact that the optimal stage *N* program has already been designed. We will test the integrated reservoir and decision models on synthetic data sets, both to verify the reliability of the models as well as to ensure that the models can be run in practical time frames.

Task 7.0 –Reservoir Characterization in Test Reservoirs

We will apply the integrated reservoir and decision model in two different unconventional reservoirs. We will characterize the reservoirs for the purpose of compiling the input data required to run the models. Both of these studies will require review, analysis and integration of production, pressure, well log, well test, stimulation, microseismic and other data, as well as review of pertinent literature on the producing fields and formations.

Subtask 7.1 - Barnett Shale, Parker County, Texas

In this subtask, we will work with Pioneer to characterize the Barnett Shale in Parker County, Texas.

Subtask 7.2 - Gething Formation, Berland River Area, Alberta

In this subtask, we will work with UGR to characterize the Gething formation in the Berland River area of Alberta.

Task 7 Planned Expenditures: Approximately $44,000 in proprietary testing/data acquisition activities will be conducted and contributed by Pioneer and UGR during the two-year term of the project.

Task 8.0 –Determine Optimal Well Spacing in Test Reservoirs

Once the reservoir and decision models have been integrated and fully tested, they will be populated with data, obtained in Task 7.0, representing actual field development decisions faced by Pioneer and UGR. We will work closely with each operator to determine best spacing and completion strategies in their respective fields. Key recommendations will be the optimal

primary well spacing and number and locations of pilot downspacings. At this time, the participating companies will make recommendations and suggest changes that will be incorporated into the models and decision process.

Subtask 8.1 - Barnett Shale, Parker County, Texas

In this subtask, we will work with Pioneer to determine the optimal well spacing and completion method in the Barnett Shale in Parker County, Texas.

Subtask 8.2 - Gething Formation, Berland River Area, Alberta

In this subtask, we will work with UGR to determine the optimal well spacing and completion method in the Gething formation in the Berland River area of Alberta.

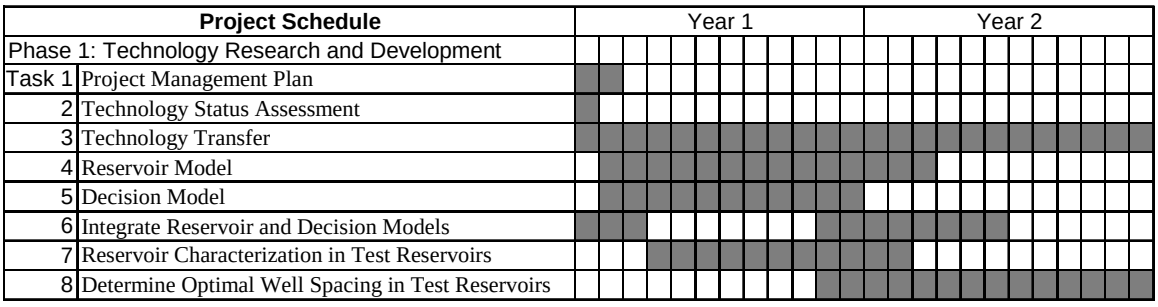
A.2 Labor Hours and Categories

The following table shows labor categories and hours for the proposed project. Principal Investigators include Dr. Duane McVay and Dr. Eric Bickel. Graduate Students include two Ph.D. students, one in Petroleum Engineering at TAMU and one in Operations Research at UT Austin, over the two-year term of the project.

Task	1	2	3	4	5	6	7	8	Total
	Estimated Labor Hours								
Principal Investigators	55	55	42	333	305	125	250	222	1387
Graduate Students	83	166	62	1040	957	354	790	707	4160
UGR - Engineer	2	4	3	105	26	39	52	31	261
Pioneer - Engineer	2	2	2	12	6	6	53	36	119

A.3 Project Schedule and Milestones

An overview of the project schedule is as follows.



Significant milestones and decision points include the following.

- Development and testing of the reservoir model and the decision model must be completed prior to integration of these models.
- Integration and testing of the reservoir and decision models and reservoir characterization in the test reservoirs must be completed prior to the determination of optimal well spacings in these reservoirs.

As shown in the project schedule, many of the tasks overlap as we expect the technology to be somewhat iterative. For example, we plan to test the reservoir and decision models throughout their development. In addition, we expect to start the analysis of the test reservoirs before completing the models, and actually expect to run the models on the test reservoirs several times as the models evolve.

A possible problem that could affect the project schedule is that the reservoir model may initially require more computation time than practical in a decision framework that may possibly require millions of model assessments. If this happens, a possible solution may be coarsening the resolution of either the reservoir or decision model, or both. Alternatively, we may need to modify the reservoir model to run faster, possibly introducing additional approximations in the formulation. The iterative development plan is designed to help mitigate this possible problem.

Another key risk is obtaining the right amount of data and participation from the co-funding companies in a timely manner. Their participation and data are critical to the success of our effort. We will manage this risk by meeting with our co-funding companies on a regular basis.