Quarterly Research Performance Progress Report

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Prime Recipient Type	Not for profit organization
Project Title	**THE EAGLE FORD SHALE LABORATORY: A FIELD STUDY OF THE STIMULATED RESERVOIR VOLUME, DETAILED FRACTURE CHARACTERISTICS, AND EOR POTENTIAL**
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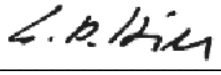
Signature of Principal Investigator:	 Dan Hill

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1. INTRODUCTION

This quarterly research progress report is intended to provide a summary of the work accomplished under this project during the first quarter of the first budget period (July 1st, 2018 - September 30th, 2018). Summarized herein is a description of the project accomplishments to date, which include evaluation of existing candidate site data; final selection of the field test site; preliminary work on the design of the observation wells; and ongoing modeling and simulation efforts for the design of the active source and passive monitoring arrays. Also summarized herein is a summary of the project's milestone status, along with the budgetary information corresponding to this reporting period.

2. ACCOMPLISHMENTS

2.1. Project Goals

The ultimate objective of this project is to help improve the effectiveness of shale oil production by providing new scientific knowledge and new monitoring technology for both initial stimulation/production as well as enhanced recovery via refracturing and EOR. This project will develop methodologies and operational experience for optimized production of oil from fractured shale, an end result that would allow for more production from fewer new wells using less material and energy. While aspects of the proposed project are site-specific to the Eagle Ford formation, there will be many realistic and practical learnings that apply to other unconventional plays, or even apply to other subsurface applications such as unconventional gas recovery and geologic carbon sequestration and storage. The main scientific/technical objectives of the proposed project are:

- Develop and test new breakthrough monitoring solutions for hydraulic fracture stimulation, production, and EOR. In particular, for the first time in unconventional reservoirs, use active seismic monitoring with fiber optics in observation wells to conduct: (1) real-time monitoring of fracture propagation and stimulated volume, and (2) 4D seismic monitoring of reservoir changes during initial production and EOR from the refractured well.
- Improve understanding of the flow, transport, mechanical and chemical processes during and after stimulation (both initial and refracturing) and gain insights into the relationship between geological and stress conditions, stimulation design, and stimulated rock volume
- Assess spatially and temporally resolved production characteristics and explore relationship with stimulated fracture characteristics.
- Evaluate suitability of refracturing to achieve dramatic improvements in stimulation volume and per well resource recovery.
- Evaluate suitability of gas-based EOR Huff and Puff methods to increase per well resource recovery.
- Optimize drilling practices in the Eagle Ford shale based on surface monitoring and near-bit diagnostic measurements during drilling.
- Conduct forward and inverse modeling to test reservoir and fracture models and calibrate simulations using all monitored data. Ultimately, provide relevant guidance for optimized production of oil from fractured shale.
- Disseminate research and project results among a broader technical and scientific audience, and ensure relevance of new findings and approaches across regions/basins/plays.

The project will start with the refracturing of a legacy well that was initially stimulated using now outdated fracturing technology (Task 2). The recipient will drill, complete, and instrument one vertical and one horizontal observation strategically located on both sides of the legacy well to allow for real-time cross-well monitoring of evolving fracture characteristics and stimulated volume. These observation wells will also be used for the other two main project stages, involving a new state-of-the art stimulation effort (Task 3) and a Huff and Puff EOR test (Task 4). Task 3 will be conducted in two new wells of opportunity drilled; these wells will be situated parallel to the horizontal observation well on the other side of the refracturing well. Task 4 will be conducted in the refractured legacy well, testing the efficiency of a Huff and Puff process with natural gas injection for EOR. As described below, each main task comprises various field activities complemented by laboratory testing and coupled modeling for design, prediction, calibration, and code validation. In addition to the three main tasks aligned with refracturing, new stimulation, and EOR, the work plan also comprises Task 1 (Project Management and Planning) and Task 5 (Integrated Analysis, Lessons Learned, Products, and Reporting). The project milestones, description of tasks and subtasks, and current milestone status are shown in **Table 1**.

2.2. Accomplishments

This section summarizes the accomplishments for the current reporting quarter (July 1st – September 30th, 2018).

2.2.1. Central Project Database Creation

A central database for all project data has been created to support collaborative work amongst the project participants. This central project database has been populated with all project data including, but not limited to, existing test site data, petrophysical logs, well deviation surveys, production history, reservoir & fluid properties, reservoir and earth models, numerical simulation files, seismic modeling results, amongst other supporting data.

2.2.2. Modeling and Numerical Simulation Efforts

Further modeling efforts have been conducted by the Lawrence Berkeley National Lab (LBNL) team on the potential Surface Orbital Vibrators (SOV's) configuration. Preliminary results suggest the optimal configuration to be a 2 dimensional linear array overlying the Horizontal Observation Well (HOW), as shown in **Figure 1**.

2.2.3. Surface Orbital Vibrators (SOV's) Configuration

As described above, the preferred configuration for active seismic monitoring with the use of Surface Orbital Vibrators has been determined to be a 2 dimensional linear array overlying the Horizontal Observation Well (HOW). This configuration is illustrated in **Figure 1**.

2.2.4. Modular SOV Foundation

A modular steel reinforced concrete foundation for installing SOV's has been designed. The modular foundation design facilitates construction, installation, and subsequent site remediation with the minimal cost associated with each operation. The proposed design for the modular SOV foundation is illustrated in **Figure 2** and **Figure 3**.

2.2.5. DAS/DTS/DSS Fiber Optic Cable and Interrogators

Competitive bids from the leading DAS/DTS fiber optic cable and associated interrogator box manufacturers/suppliers have been requested to instrument both the Horizontal Observation Well (HOW) and the Vertical Observation Well (VOW). The team is working closely with these suppliers to ensure the design and cost of instrumenting both observation wells with fiber optic cable for DAS/DTS monitoring meets the project objectives and project budget. DSS fiber optic cable and associated interrogator for monitoring is being designed by LBNL. This work is being conducted in support of Subtask 2.2 and 2.3 and is ongoing.

2.2.6. Proppant Tracing

Competitive bids from the leading proppant tracing service companies/suppliers have been requested to trace the proppant being pumped in the refracturing of the Bronco A3H well under Subtask 2.5, Activity 2.5.3. Engineering design of the final tracing program is ongoing.

2.3. Opportunities for Training and Professional Development.

Nothing to Report

2.4. Dissemination of Results to Communities of Interest

Nothing to Report

2.5. Plan for Next Quarter

Building on the current progress achieved by the research team, work planned for the next quarter will include, but is not limited to, the following:

- Finalize design and implementation plan for Surface Orbital Vibrators for active seismic monitoring.
- Finalize design and implementation plan for the Continuous Active Seismic Source Monitoring (CASSM) source and geophone receiver array.
- Continue work related to the HOW and the VOW in support of Subtask 2.2, 2.3, and 2.5:
  - ✓ Surface location selection.
  - ✓ Planning for permitting.
  - ✓ Vertical pilot and well path design (for HOW).
  - ✓ Casing design to accommodate coring and subsequent instrumentation.
- Continue ongoing design and planning for surface monitoring in support of Subtask 2.5:
  - ✓ SOV surface location determination, planning, and permitting.
- Select DAS/DTS fiber optic cable and interrogator supplier.
- Finalize proppant tracing program and contract with tracing supplier/service company.

2.6. Summary of Tasks for Next Quarter (October-December, 2018)

The following provides a summary of the tasks and subtasks to be performed in Q2:

- Task 1 – Project Management and Planning

  Activity is ongoing.

- Task 2 – Phase 1: Evaluation of Refracturing
  - ✓ Subtask 2.1 – Evaluation of Existing Data and Design of Observation Wells
    - *Activity 2.1.2 Design of the Active Source and Passive Monitoring Arrays*

      Activity is ongoing.
    - *Activity 2.1.3 Engineering of Integrated Monitoring Completion*

      Activity is ongoing.

- Special Reporting Requirements
  - ✓ Update and finalize Environmental Questionnaire (EQ).

    Activity is complete (See Section 7.1)

- Obtain Written Authorization from the DOE Contracting Officer and NEPA to proceed with Subtask 2.2, 2.3, and 2.4

  Activity is complete (See Section 7.2)

Table 1. Summary of Milestone Status

Milestone	Task	Sub-task	Title/Description	Planned Completion Date	Actual Completion Date	Verification Method	Comments
A	1	1	Project Management & Planning	3/31/2021	Ongoing	Report	None
	2 - Phase 1: Re-Fracturing Evaluation	2.1	Evaluation of Existing Data and Design of Observation Wells	9/30/2018	Ongoing	Report	None
B		2.2	Drill, Complete, & Instrument Horizontal Observation Well	9/30/2018	Not Started	Report	None
		2.3	Drill, Complete, & Instrument Vertical Observation Well	9/30/2018	Not Started	Report	None
		2.4	Recomplete Well to be Re-Fractured	9/30/2018	Not Started	Report	None
C		2.5	Monitoring of Re-Fracturing	12/31/2018	Not Started	Report	None
		2.6	Analysis of Re-Fracturing Monitoring	12/31/2019	Not Started	Report	None
D		2.7	DTS/DAS/DSS & Seismic Monitoring During Production	12/31/2019	Not Started	Report	None
		2.8	Laboratory Evaluation of EOR Potential	6/30/2020	Not Started	Report	None
E		2.9	Coupled Modeling for Design, Prediction, Calibration & Code Validation	9/31/2020	Not Started	Report	None
	3 - Phase 2: Fracturing Evaluation	3.1	Drill, Complete & Instrument Two New Producing Wells	6/30/2019	Not Started	Report	None
F		3.2	Drilling Optimization	6/30/2020	Not Started	Report	None
		3.3	Monitoring of Fracturing of Two New Producing Wells	12/31/2019	Not Started	Report	None
		3.4	Analysis of Fracturing Monitoring of Two New Producing Wells	12/31/2020	Not Started	Report	None
		3.5	Coupled Modeling for Design, Prediction, Calibration & Code Validation	12/31/2020	Not Started	Report	None
	4 - Phase 3: EOR Pilot Test	4.1	Conduct Huff & Puff EOR Pilot Test	6/30/2020	Not Started	Report	None
		4.2	Monitor Injected Gas Placement with Active & Passive Seismic Monitoring	12/31/2020	Not Started	Report	None
		4.3	Monitor Injected Gas Distribution with DTS/DAS in Pilot Well	12/31/2020	Not Started	Report	None
G		4.4	Modeling of the Huff & Puff EOR Pilot Test	12/31/2020	Not Started	Report	None
	5 - Final Report	5.1	Multi-Purpose Optimization & Lessons Learned	3/31/2021	Not Started	Report	None
		5.2	Products & Reporting	3/31/2021	Not Started	Report	None

3. PRODUCTS
Nothing to Report

4. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS
Nothing to Report

5. IMPACT
Nothing to Report

6. CHALLENGES/PROBLEMS
Nothing to Report

7. SPECIAL REPORTING REQUIREMENTS

7.1. Environmental Questionnaire
A revised Environmental Questionnaire (EQ) for the selected EFSL test site was submitted on 10/02/2018. This revised EQ was approved by the DOE Project Manager on 10/03/2018.

7.1. Categorical Exclusion (CX) Designation Form
The Categorical Exclusion (CX) Designation Form for the project test site was approved by the NEPA Compliance Officer on 10/10/2018. This approval allows the project to proceed past Subtask 2.2.

8. BUDGETARY INFORMATION

A summary of the budgetary information for the first reporting quarter of the project is provided in **Table 2**. This table shows the original planned costs, the actual incurred costs, and the variance. The costs are split between federal share and non-federal share.

Table 2. Budgetary Information for Budget Period 1, Q1 & Q2

Baseline Reporting Quarter	Budget Period 1		
	Q1	Q2	Cumulative Total
	04/01/2018 - 06/30/2018	07/01/2018 - 09/30/2018	
Baseline Cost Plan			
Federal Share	$1,564,127.00	$1,564,127.00	$3,128,254.00
Non-Federal Share	$500,000.00	$500,000.00	$1,000,000.00
Total Planned	$2,064,127.00	$2,064,127.00	$4,128,254.00
Actual Incurred Cost			
Federal Share	$119,579.07	$152,177.46	$271,756.53
Non-Federal Share	$0.00	$0.00	$0.00
Total Incurred Cost	$119,579.07	$152,177.46	$271,756.53
Variance			
Federal Share	$1,444,547.93	$1,411,949.54	$2,856,497.47
Non-Federal Share	$500,000.00	$500,000.00	$1,000,000.00
Total Variance	$1,944,547.93	$1,911,949.54	$3,856,497.47

9. PROJECT OUTCOMES

Nothing to Report

10. APPENDIX

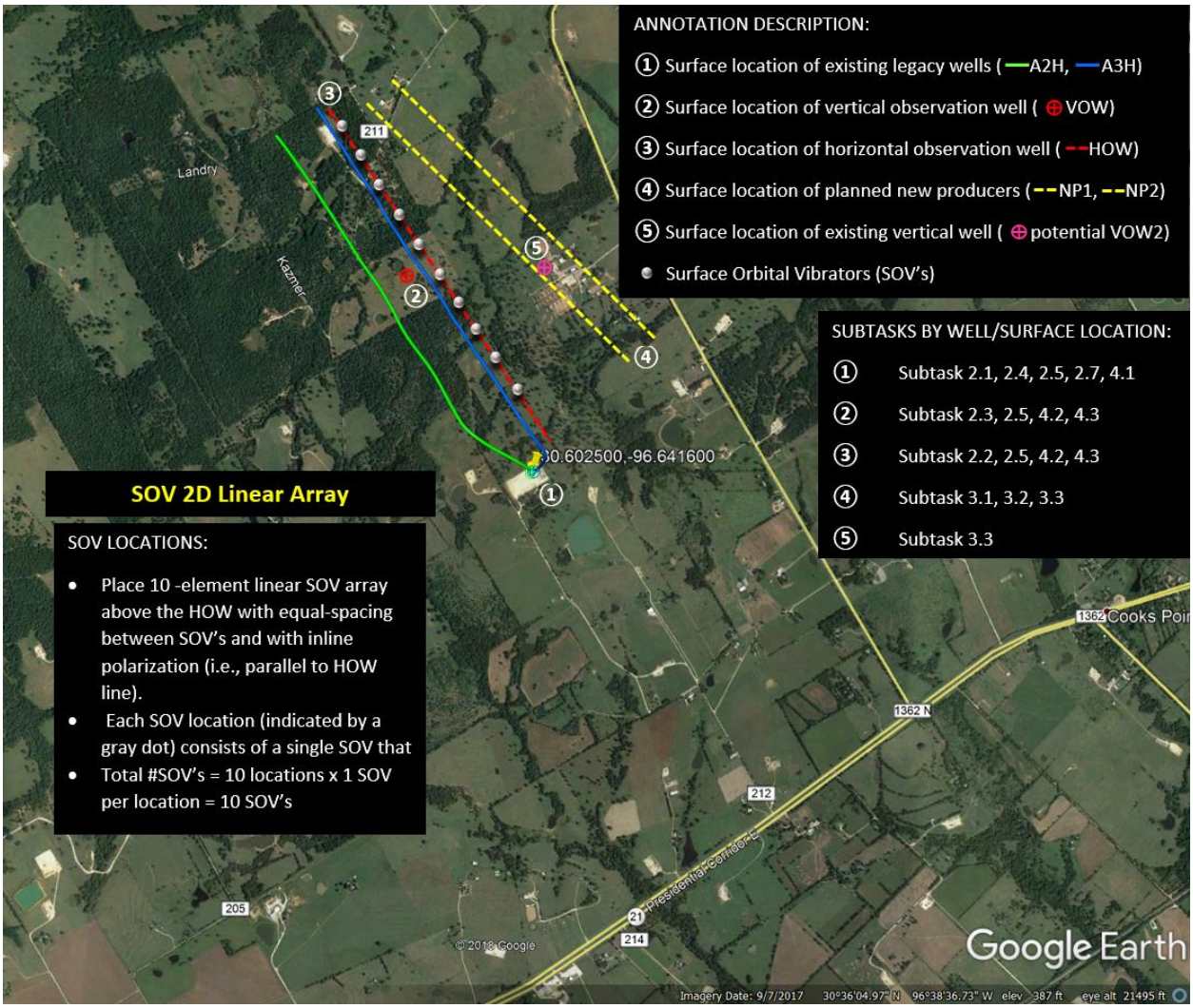

Figure 1.Proposed Surface Orbital Vibrator 2D Linear Array.

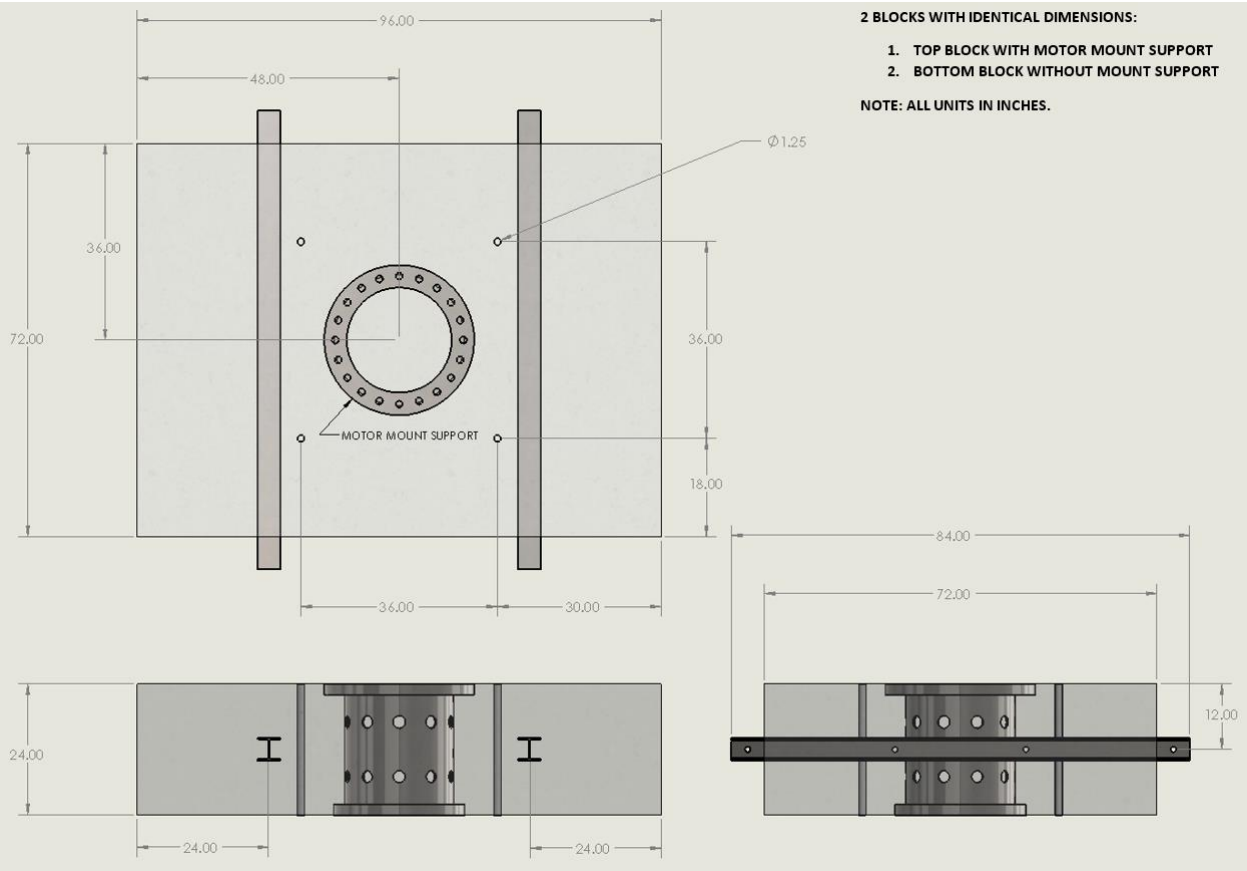

Figure 2.Engineering drawings for modular Surface Orbital Vibrator (SOV) concrete foundation.

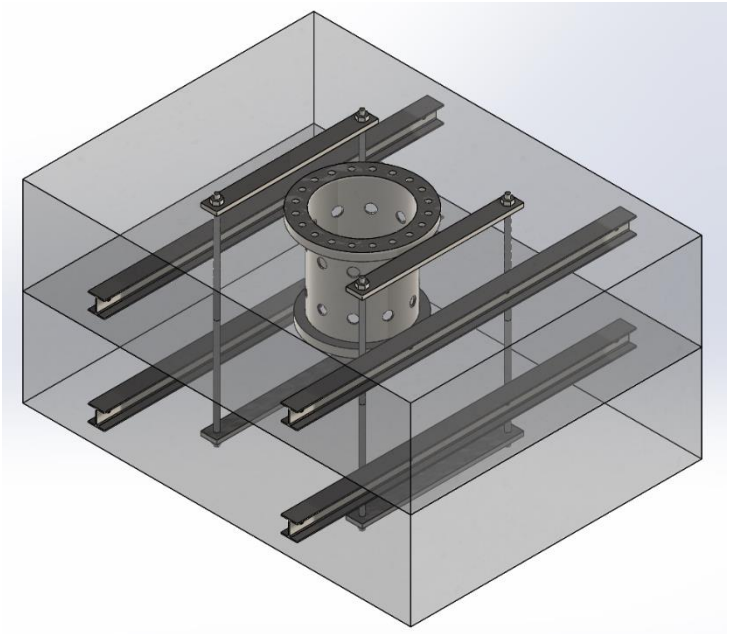

Figure 3. Isometric view of assembled modular SOV foundation.