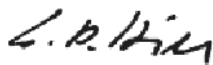


## Quarterly Research Performance Progress Report

Federal Agency and Organization Element to Which Report is Submitted	U.S. Department of Energy Office of Fossil Energy
FOA Name	Advanced Technology Solutions for Unconventional Oil & Gas Development
FOA Number	DE-FOA-0001722
Nature of the Report	Research Performance Progress Report (RPPR)
Award Number	DE-FE0031579
Award Type	Cooperative Agreement
Name, Title, Email Address, and Phone Number for the Prime Recipient	<p><b>Technical Contact (Principal Investigator):</b> Dan Hill, Professor, <a href="mailto:dahill@tamu.edu">dahill@tamu.edu</a>, 979-845-2244</p> <p><b>Business Contact:</b> Ashlee Woolard, Senior Project Administrator II, <a href="mailto:awoolard@tamu.edu">awoolard@tamu.edu</a>, 979-845-0707</p>
Name of Submitting Official, Title, Email Address, and Phone Number	Dante Guerra, EFSL Program Manager, <a href="mailto:danteguerra@tamu.edu">danteguerra@tamu.edu</a> , 979-862-1841
Prime Recipient Name and Address	Texas A&M Engineering Experiment Station 7607 Eastmark Drive, College Station, TX 77840
Prime Recipient Type	Not for profit organization
Project Title	<b><u>THE EAGLE FORD SHALE LABORATORY: A FIELD STUDY OF THE STIMULATED RESERVOIR VOLUME, DETAILED FRACTURE CHARACTERISTICS, AND EOR POTENTIAL</u></b>
Principal Investigator(s)	<p><b>PI:</b> Dan Hill, <i>Texas A&amp;M University</i></p> <p><b>Co-PIs:</b> Jens Birkholzer, <i>Lawrence Berkeley National Laboratory</i> Mark Zoback, <i>Stanford University</i> Karstik Selvan, <i>INPEX Eagle Ford, LLC</i></p>
Prime Recipient's DUNS number	8472055720000
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Period Covered by the Report	July 1, 2019 – September 30, 2019
Reporting Frequency	Quarterly
Signature of Principal Investigator:	 <hr style="width: 30%; margin: auto;"/> <p style="text-align: center;">Dan Hill</p>

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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 sixth quarter of the first budget period (*July 1st, 2019 – September 30th, 2019*). Summarized herein is a description of the project accomplishments to date, along with the planned work to be conducted in the next quarter.

## 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 re-fracturing 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 re-fractured well.
- Improve understanding of the flow, transport, mechanical and chemical processes during and after stimulation (both initial and re-fracturing) 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 re-fracturing 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 re-fracturing 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 re-fracturing well. Task 4 will be conducted in the re-fractured 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 re-fracturing, 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, 2019 – September 30th, 2019*).

### **2.2.1. EFSL Project Performers Summit Meeting**

A summit meeting was held between key representatives from all project performer organizations, namely Texas A&M University (TAMU), Lawrence Berkeley National Laboratory (LBNL), Stanford University (Stanford), and the new site operator INPEX Eagle Ford, LLC (INPEX), to update all participants on the project status and develop a detailed project plan for Phase 1 field activities.

### **2.2.2. Completion and Stimulation Fractal Design Conducted for Optimization**

The completion and stimulation fractal design has been updated for the new project site location and well configurations.

### **2.2.3. Fracture Conductivity Design of Experiments**

A plan of experiments has been developed to measure fracture conductivity of various proppants and concentrations on both core samples and outcrop samples.

### **2.2.4. Fracture Fluid Tracing**

A tracer program for tagging the fracturing fluid has been developed.

### **2.2.5. Fiber Optic Data Analysis Method Developments**

A thermal-mechanical model for low frequency DAS measurements has been developed. This model will be used to analyze and interpret DAS data recorded by the project.

### **2.2.6. Numerical Simulation Efforts**

The team has conducted further development of the fast marching method (FMM) based on coupled flow and geomechanics simulations, with an extension to a full 3D model.

### **2.2.7. Geomechanical Measurements and Testing**

Analysis of existing log data for the new test site is underway. Analysis of the new log data will aid in the selection of intervals of interest for downhole core sampling and testing.

### **2.2.8. Monitoring System Design**

Design of the active source and passive monitoring arrays as well as the integrated monitoring completion has been completed (Subtask 2.1).

**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 (BP1-Q7: October 1st – December 31st, 2019)**

Given the change of test site operator and related field test site location (See **Section 4**), the project schedule has been updated accordingly (see **Section 2.7**), with the primary change being the rescheduling of Subtask 2.2: Drill, Complete and Instrument Horizontal Observation Well, which is scheduled within this next quarter.

**2.6. Summary of Tasks for Next Quarter (BP1-Q7: October 1st – December 31st, 2019)**

The following provides a summary of the tasks, subtasks, and activities planned in BP1-Q7:

- Task 1 – Project Management and Planning
- Task 2 – Phase 1: Evaluation of Re-fracturing
  - ✓ Subtask 2.2 – Drill, Complete, & Instrument Horizontal Observation Well
    - *Activity 2.2.1 Drill Pilot Hole*
    - *Activity 2.2.2 Drill Horizontal Well Parallel to Refrac Well*
    - *Activity 2.2.3 Log Horizontal Observation Well (Open-hole logs)*
    - *Activity 2.2.4 Installation of Fiber Optic Cable, Pressure Gauges, and Seismic Source*

## 2.7. Summary of Milestone Status

The following table provides a summary of milestones and updated planned completion dates:

Table 1. Summary of Milestone Status

Milestone	Task	Sub-task	Title/Description	Planned Completion Date	Actual Completion Date	Comments
A	1	1.1	Project Management & Planning	3/31/2022	-	Ongoing
	2 - Phase 1: Re-Fracturing Evaluation	2.1	Evaluation of Existing Data and Design of Observation Wells	9/30/2018	8/1/2019	Complete
2.2		Drill, Complete, & Instrument Horizontal Observation Well	1/31/2020	-	-	
2.3		Drill, Complete, & Instrument Vertical Observation Well*	1/31/2020	-	*Vertical section of a horizontal well will be instrumented in place of a standalone vertical observation well.	
2.4		Recomplete Well to be Re-Fractured	2/29/2020	-	-	
C		2.5	Monitoring of Re-Fracturing	7/31/2020	-	-
		2.6	Analysis of Re-Fracturing Monitoring	7/31/2020	-	-
D		2.7	DTS/DAS/DSS & Seismic Monitoring During Production	7/31/2020	-	-
		2.8	Laboratory Evaluation of EOR Potential	7/31/2020	-	-
E		2.9	Coupled Modeling for Design, Prediction, Calibration & Code Validation	7/31/2020	-	-
F	3 - Phase 2: Fracturing Evaluation	3.1	Drill, Complete & Instrument Two New Producing Wells	5/30/2020	-	-
		3.2	Drilling Optimization	12/31/2020	-	-
		3.3	Monitoring of Fracturing of Two New Producing Wells	6/30/2020	-	-
		3.4	Analysis of Fracturing Monitoring of Two New Producing Wells	12/31/2020	-	-
		3.5	Coupled Modeling for Design, Prediction, Calibration & Code Validation	12/31/2020	-	-
G	4 - Phase 3: EOR Pilot Test	4.1	Conduct Huff & Puff EOR Pilot Test	1/30/2021	-	-
		4.2	Monitor Injected Gas Placement with Active & Passive Seismic Monitoring	6/30/2021	-	-
		4.3	Monitor Injected Gas Distribution with DTS/DAS in Pilot Well	6/30/2021	-	-
		4.4	Modeling of the Huff & Puff EOR Pilot Test	12/31/2021	-	-
5 - Final Report	5.1	Multi-Purpose Optimization & Lessons Learned	3/31/2022	-	-	
	5.2	Products & Reporting	3/31/2022	-	-	

**3. PRODUCTS**

Nothing to Report.

**4. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS****4.1. Change of Field Test Site Operator**

INPEX Eagle Ford, LLC is now a project partner and has fully committed to participate in the project. A new field test site location for the project has been selected in La Salle County, TX within an area leased by INPEX Eagle Ford, LLC.

**5. IMPACT**

Nothing to Report.

**6. CHALLENGES/PROBLEMS**

Nothing to Report.

**7. SPECIAL REPORTING REQUIREMENTS****7.1. No Cost Time Extension for Budget Period 1 (NCTE - BP1)**

A no cost time extension (NCTE) has been submitted to extend Budget Period 1 to a current end date of March 31<sup>st</sup>, 2020. Under this requested NCTE, the current budget period start and end dates are as follows:

- BP1: 04/01/2018 - 03/31/2020
- BP1: 04/01/2020 - 03/31/2021
- BP1: 04/01/2020 - 03/31/2022

**8. BUDGETARY INFORMATION**

A summary of the budgetary information for Q1-Q6 of BP1 for the project is provided in **Table 3**. 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- Q6

Baseline Reporting Quarter	EFSL Budget Period 1 (04/01/2018 - 12/31/2019)							
	Q1		Q2		Q3		Q4	
	04/01/2018 - 06/30/2018		07/01/2018 - 09/30/2018		10/01/2018 - 12/31/2018		01/01/2019 - 03/31/2019	
	Federal Share	Non-Federal Share	Federal Share	Non-Federal Share	Federal Share	Non-Federal Share	Federal Share	Non-Federal Share
<b>Baseline Cost Plan</b>								
TAMU	\$182,669.50	\$0.00	\$182,669.50	\$0.00	\$182,669.50	\$0.00	\$182,669.50	\$0.00
INPEX Egle Ford, LLC	\$850,000.00	\$500,000.00	\$850,000.00	\$500,000.00	\$850,000.00	\$500,000.00	\$850,000.00	\$500,000.00
LBNL	\$166,750.00	\$0.00	\$166,750.00	\$0.00	\$166,750.00	\$0.00	\$166,750.00	\$0.00
Stanford	\$31,456.25	\$0.00	\$31,456.25	\$0.00	\$31,456.25	\$0.00	\$31,456.25	\$0.00
<b>Total Planned</b>	<b>\$1,230,875.75</b>	<b>\$500,000.00</b>	<b>\$1,230,875.75</b>	<b>\$500,000.00</b>	<b>\$1,230,875.75</b>	<b>\$500,000.00</b>	<b>\$1,230,875.75</b>	<b>\$500,000.00</b>
<b>Actual Incurred Cost*</b>								
TAMU	\$119,579.07	\$0.00	\$152,177.46	\$0.00	\$108,898.29	\$0.00	\$110,749.32	\$0.00
INPEX Egle Ford, LLC	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
LBNL	\$57,679.00	\$0.00	\$104,547.00	\$0.00	\$168,294.00	\$0.00	\$303,022.00	\$0.00
Stanford	\$29,084.28	\$0.00	\$4,847.38	\$0.00	\$16,552.39	\$0.00	\$34,658.84	\$0.00
<b>Total Incurred Cost</b>	<b>\$206,342.35</b>	<b>\$0.00</b>	<b>\$261,571.84</b>	<b>\$0.00</b>	<b>\$293,744.68</b>	<b>\$0.00</b>	<b>\$448,430.16</b>	<b>\$0.00</b>
<b>Variance</b>								
TAMU	\$63,090.43	\$0.00	\$30,492.04	\$0.00	\$73,771.21	\$0.00	\$71,920.18	\$0.00
INPEX Egle Ford, LLC	\$850,000.00	\$500,000.00	\$850,000.00	\$500,000.00	\$850,000.00	\$500,000.00	\$850,000.00	\$500,000.00
LBNL	\$109,071.00	\$0.00	\$62,203.00	\$0.00	(\$1,544.00)	\$0.00	(\$136,272.00)	\$0.00
Stanford	\$2,371.97	\$0.00	\$26,608.87	\$0.00	\$14,903.86	\$0.00	(\$3,202.59)	\$0.00
<b>Total Variance</b>	<b>\$1,024,533.40</b>	<b>\$500,000.00</b>	<b>\$969,303.91</b>	<b>\$500,000.00</b>	<b>\$937,131.07</b>	<b>\$500,000.00</b>	<b>\$782,445.59</b>	<b>\$500,000.00</b>

\*Actual incurred costs represent total expenditures (direct costs & indirect costs).

Baseline Reporting Quarter	EFSL Budget Period 1 (04/01/2018 - 12/31/2019)							
	Q5 - NCTE 1		Q6		Q7		Total	
	04/01/2019 - 06/30/2019		07/01/2019 - 09/30/2019		10/01/2019 - 12/31/2019		04/01/2018 - 12/31/2019	
	Federal Share	Non-Federal Share	Federal Share	Non-Federal Share	Federal Share	Non-Federal Share	Federal Share	Non-Federal Share
<b>Baseline Cost Plan</b>								
TAMU	\$0.00	\$0.00	\$435,200.50	\$0.00	\$435,200.50	\$0.00	\$1,601,079.00	\$0.00
INPEX Egle Ford, LLC	\$0.00	\$0.00	\$362,500.00	\$0.00	\$362,500.00	\$0.00	\$4,125,000.00	\$2,000,000.00
LBNL	\$0.00	\$0.00	\$333,166.50	\$0.00	\$333,166.50	\$0.00	\$1,333,333.00	\$0.00
Stanford	\$0.00	\$0.00	\$59,798.00	\$0.00	\$59,798.00	\$0.00	\$245,421.00	\$0.00
<b>Total Planned</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$1,190,665.00</b>	<b>\$0.00</b>	<b>\$1,190,665.00</b>	<b>\$0.00</b>	<b>\$7,304,833.00</b>	<b>\$2,000,000.00</b>
<b>Actual Incurred Cost*</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>
TAMU	\$207,650.59	\$0.00	\$7,195.98	\$0.00	\$0.00	\$0.00	\$706,250.71	\$0.00
INPEX Egle Ford, LLC	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
LBNL	\$9,811.00	\$0.00	(\$1,329.00)	\$0.00	\$0.00	\$0.00	\$642,024.00	\$0.00
Stanford	\$31,992.78	\$0.00	\$31,899.24	\$0.00	\$0.00	\$0.00	\$149,034.91	\$0.00
<b>Total Incurred Cost</b>	<b>\$249,454.37</b>	<b>\$0.00</b>	<b>\$37,766.22</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$1,497,309.62</b>	<b>\$0.00</b>
<b>Variance</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>
TAMU	(\$207,650.59)	\$0.00	\$428,004.52	\$0.00	\$435,200.50	\$0.00	\$894,828.29	\$0.00
INPEX Egle Ford, LLC	\$0.00	\$0.00	\$362,500.00	\$0.00	\$362,500.00	\$0.00	\$4,125,000.00	\$2,000,000.00
LBNL	(\$9,811.00)	\$0.00	\$334,495.50	\$0.00	\$333,166.50	\$0.00	\$691,309.00	\$0.00
Stanford	(\$31,992.78)	\$0.00	\$27,898.76	\$0.00	\$59,798.00	\$0.00	\$96,386.09	\$0.00
<b>Total Variance</b>	<b>(\$249,454.37)</b>	<b>\$0.00</b>	<b>\$1,152,898.78</b>	<b>\$0.00</b>	<b>\$1,190,665.00</b>	<b>\$0.00</b>	<b>\$5,807,523.38</b>	<b>\$2,000,000.00</b>

\*Actual incurred costs represent total expenditures (direct costs & indirect costs).

9. PROJECT OUTCOMES

Nothing to Report