Oil & Natural Gas Technology

DOE Award No.: DE-FE0024297

Quarterly Research Performance Progress Report

(Period ending: 6/30/2015)

Marcellus Shale Energy and Environment Laboratory (MSEEL)

Project Period: October 1, 2014 – September 30, 2019

Submitted by:
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Office of Fossil Energy

Quarterly Progress Report

April 1 – June 30, 2015

Executive Summary

The objective of the Marcellus Shale Energy and Environment Laboratory (MSEEL) is to provide a long-term field site to develop and validate new knowledge and technology to improve recovery efficiency and minimize environmental implications of unconventional resource development.

The third quarter of activity on this project has been generally limited to the development of sampling plans, project planning and establishing data sharing infrastructure. Several meetings with the technical teams to establish data requirements have been held. Meetings to date include a review of available pre-existing data from the first well (outside of this project) at the MIP site, a safety and site access overview, air and noise monitoring plan and data requirements, and water sampling plan and data requirements. In the current reporting quarter, the well services contractor was identified. Also in this quarter, the team has worked to modify the drilling and completion plan, and sample collection plan, to reflect changes in the drilling schedule imposed by inclement weather. Heavy rains in this quarter have significantly impacted progress on the drilling of the science well and in production well activities. The project team is currently working with DOE to develop approaches and any required scope modification to respond to these issues.

Quarterly Progress Report

April 1 – June 30, 2015

Project Performance

This report summarizes the activities of Cooperative Agreement DE-FE0024297 (Marcellus Shale Energy and Environment Laboratory – MSEEL) with the West Virginia University Research Corporation (WVURC) during the third quarter of the FY2015 (April 1 through June 30, 2015).

This report outlines the approach taken, including specific actions by subtopic. If there was no identified activity during the reporting period, the appropriate section is included but without additional information.

Topic 1 – Project Management and Planning

Subtopic 1.1. – Project Management

Approach

The project management team will work to generate timely and accurate reporting, and to maintain project operations, including contracting, reporting, meeting organization, and general oversight.

Results and Discussion

In this quarter, the team has worked to modify the drilling and completion plan, and sample collection plan, to reflect changes in the drilling schedule imposed by inclement weather. Heavy rains in this quarter have significantly impacted progress on the drilling of the science well and in production well activities. The project team is currently working with DOE to develop approaches and any required scope modification to respond to these issues.

Subtopic 1.2. – Database Development

Approach

We will use CKAN, open source data portal software (www.ckan.org). This platform is used by NETL-EDX and Data.gov among other organizations and agencies. We will use this platform to store, manage, publish and find datasets.

Results and Discussion

CKAN is up and running and has been used to share data from the existing wells and presentations among research personnel. The MSEEL web site has been enhanced with MSEEL News articles, a time line and with images. We have generated static and dynamic 3D images of the surface and subsurface at the MSEEL site (Figure 1.2)

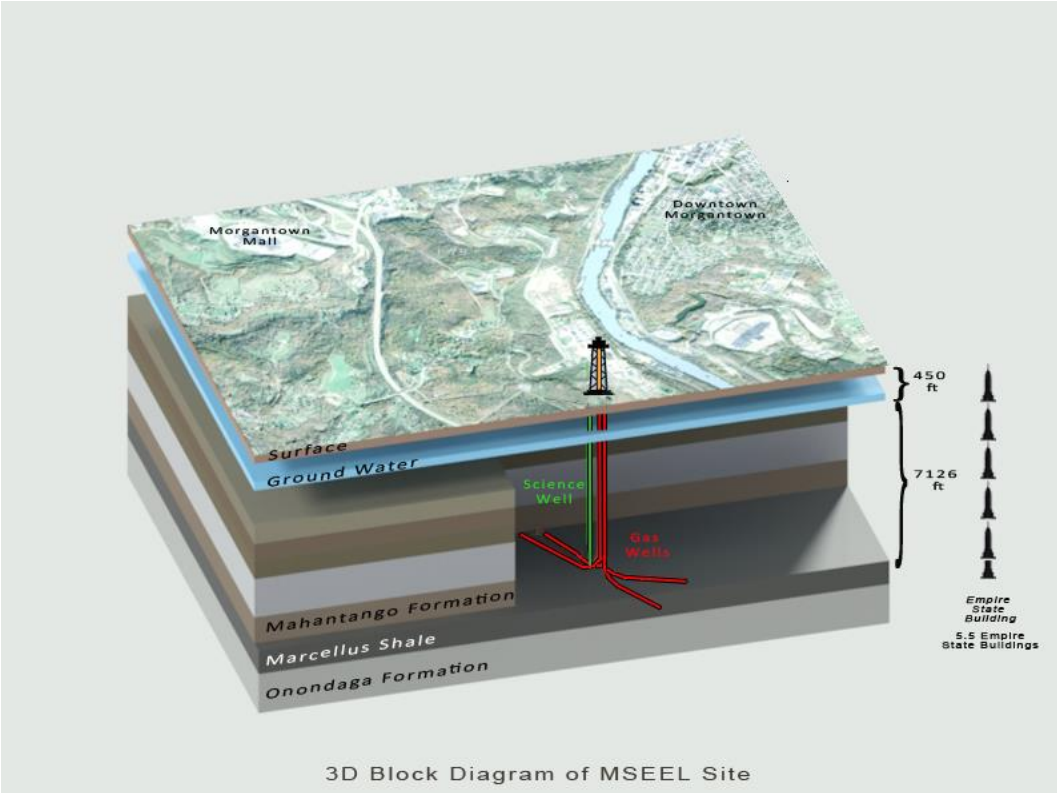

Figure 1.2. Static 3D image of the MSEEL sit showing the existing production wells and the two new production wells along with the science/observation well.

Plan for Next Quarter

Upload 3D static and dynamic images to online site and federate MSEEL portal with EDX.

Topic 2 – Geologic Engineering

Approach

The geologic engineering team will work to generate to improve the effectiveness of fracture stage design. Evaluating innovative stage spacing and cluster density practices to optimize recovery efficiency. The team will use a data driven approach to integrate geophysical, fluid flow and mechanical properties logs, microseismic and core data to better to characterize subsurface rock properties, faults and fracture systems to model and identify the best practices for field implementation, and assess potential methods that could enhance shale gas recovery through experimental and numerical studies integrated with the results of the production wells at the MSEEL site.

Results and Discussion

The team has continued the efforts to establish the data requirements and the protocols for sample collection and analysis. The analysis of the production and stimulation data from the existing horizontal wells at the MIP site has continued to develop a base model for the site. In addition, production data from a number of horizontal Marcellus shale wells in the region has been collected and are being analyzed to establish subsurface baseline information.

Products

Plan for Next Quarter

The team will continue the analysis of the data from the existing wells at the site ad nearby wells to develop a base model.

Topic 3 – Deep Subsurface Rock, Fluids, and Gas

Approach

The "Deep Subsurface Rock, Fluids & Gas" team will be responsible for high resolution temporal and/or spatial characterization of the core, produced fluids, and produced gases. The team will use whole and sidewall core and geophysical logs from the science well to conduct various petrophysical analyses to analyze physical rock properties. Data generated by all team members will be integrated to answer following key research questions: 1) geological controls on microbial distribution, diversity and function and how it can effect gas productivity, potential for fracture and pore clogging, well infrastructure and souring 2) major controls on distribution/source/type of organic matter that has implications for oil vs gas production, frackability, restimulation and porosity/permeability effects 3) what are spatiotemporal variations in elemental, isotopic, mineralogical and petrological properties that control presence, geological migration, and modern flow of fluids, water, gases and microorganisms and also effect long-term production behavior of reservoir 4) what are possible water-rock-microbial interactions as a result of injection of fracturing fluids, and 5) does hydraulic fracturing create new pathways for fluid/gas migration

Plan is to develop specific methodology for testing during the next quarter, so that all scientific objectives can be achieved.

Results and Discussion

Subsurface Biogeochemistry task lead Sharma drafted a final core/fluid/gas sampling and sample distribution plan in collaboration with PI's at WVU, OSU and NETL. Sharma also outlined the major research questions to be addressed by the Subsurface Biogeochemistry group and their implications. Different sub-tasks and analyses to be conducted by individual PI's were also define. Several talks and presentations were given at local and regional conferences/universities. A proposal has been submitted and two proposals are currently underworks to support MSEEL research.

Goal 1: Develop a sampling protocol to incorporate into the field plan:

Meetings were held between Sharma's group and OSU group on May 12, 2015 at WVU, Morgantown and then July 12, 2015 at OSU in Columbus to discuss preliminary results, develop sampling/field plans, and plan laboratory experiments. Sharma also has had several conference calls and e-mail discussions with researchers at NETL to finalize core and fluid characterization at MSEEL site. A detailed field sampling and sample distribution plan between WVU, OSU and NETL will be drafted by end of July.

Goal 2: Identify and order any specialized equipment and materials:

Procured a dedicated freezer (-20ºC) in the Environmental Engineering lab (HI 426) for storage of shale core and fluids from the MSEEL project. We also have a dedicated (-80ºC) core freezer for long-term storage of core and fluid samples exclusive for this project in the OSU Microbiology lab. To ensure sample preservation this freezer has CO_2 backup (maintain temperature independent of system power) and wireless sensors to (wirelessly communicate change in temperature). Sharma has procured gas and biomarker standards for isotope analysis and is in process of procuring field supplies for isotope sampling and storage of fluids and gases.

Goal 3: Test out methods for extracting lipid biomarkers from core and fluids:

Sharma supplied shale core samples (~1.5 kg) for methods extraction of lipids. Graduate students from Mouser lab and Sharma Lab traveled to Univ. Tennessee, Knoxville (UTK) to work through a detailed experiment testing the efficiency of lipid extractions from shale core. Data analysis is currently underway and will inform extraction methods for sidewall core to be received this fall.

Goal 4: Develop methods and protocols for sampling fluids and gases for isotopic, molecular and microbiological analysis:

R. Akondi , V. Agrawal two PhD. students with help of A. Warrier in Sharma Lab have developed method for extracting polar and non-polar biomarkers and kerogen from shales of different maturity. R. Daly, a senior researcher in the Wrighton lab, has developed a new method of DNA extraction from shale that accounts for chemistry and mineral properties of this matrix. This method obtained higher yields than previously reported for this system. We expect to obtain DNA from 10 cells/ 5 g of material, but we are currently evaluating the sensitivity and specificity of this new method. We have also developed both visual (0.5 µm fluorescent microsphere) and molecular (presence of DNA) markers to assay for contamination of shale surfaces by exogenous materials (e.g. drilling muds). In this protocol assessment, 2 g shale pieces were exposed to microspheres and cells, incubated above *in situ* pressures (~8500 psi, 40ºC). Continuing protocol development includes evaluation of methodology on sandstone and limestone formations adjacent to the Marcellus and evaluating the impact of steel wool on elemental analyses with D. Cole lab.

Goal 5: Develop liaison between different PI's interested in sub-surface samples:

Task lead Sharma has had several conversations and meeting with PI's at OSU (Mouser, Wrighton, Wilkins, Cole & Darrah) , NETL (Hakala, Crandall, Lopano & Soeder) and WVU (Weislogel & Donovan) to understand their sampling needs, research questions and finalize a sample distribution plan.

Goal 6: High resolution characterization of vertical core in collaboration with NETL:

Carr and Sharma had discussions with Crandall lab at DOE-NETL in Morgantown to finalize plans for transport, scanning and imaging of core. R. Akondi and V. Agrawal received initial training on the CT scanner in Crandall's lab. Training on multi scanner core logger is scheduled for next month.

<u>Training/Professional Development</u>

- Rawlings Akondi, PhD student with Sharma and Ryan Trexler, MS student with Mouser were trained with Susan Pfiffner at UTK to extract and analyze lipid biomarker signatures from shale using GC-MS.
- Rawlings Akondi and Vikas Agrawal PhD. students with Sharma attended 1 day CT scan workshop organized by Crandall Lab at DOE-NETL
- Morgan Volker, PhD student with Mouser attended the workshop on "Utica Shale Play Book Study" hosted by the WVU National Research Center for Coal and Energy in Cannonsburg, PA on July 14.
- Ajay Warrier, Travis Wilson from Sharma Lab and Rebecca Daly from Wrighton Lab, completed Safe-Land training required to access MSEEL site.
- Mike Wilkins and his PhD student Anne Booker, attended DOE EMSL at Pacific Northwest National Laboratory facility to learn to process in situ microbial rate measurements at high pressures expected in the Marcellus formation.
- Kelly Wrighton was invited to represent the MSEEL project-team at the Deep Carbon Observatory Strategic Planning meeting in Portugal, May 2015. This meeting developed road-map for deep-life research in the next 4 years.

<u>Data Dissemination</u>

- Sharma, Wrighton & Wilkins gave several presentations highlighting the importance of MSEEL research in future discoveries.
- Mouser, P, The Impact of Fracking on the Microbiology of Deep Hydrocarbon Shale, American Society for Microbiology (ASM) Annual Conference, New Orleans, LA, May 30-June 2, 2015.
- Wrighton et al, Drivers of microbial methanogenesis in deep shales after hydraulic fracturing. American Society of Microbiology. New Orleans, LA. May 30-June 2, 2015.
- Daly et al, Viral Predation and Host Immunity Structure Microbial Communities in a Terrestrial Deep Subsurface, Hydraulically Fractured Shale System. American Society of Microbiology. New Orleans, LA.

Plan for Next Quarter

Develop a sample labelling and QA/QC plan for core, fluid and gas samples to be collected from MSEEL site in August-September. Identify and procure funding to support PhD. students and technicians involved in sampling, analysis and interpretation of data to be collected from MSEEL site

Topic 4 – Geophysical and Geomechanical

Approach

Team will conduct microseismic analyses during the frac jobs of the production wells and tie that data back to the geophysical logs obtained from the science well, providing a clearer picture of proppant placement through the establishment of a detailed rock velocity model. Some inferences toward fracture quantity and patterns will also be vetted.

Plan is to identify specific methodology to obtain the data that will provide most understanding of subsurface rock model

Results and Discussion

Task 4a - Geophysics:

This past quarter data from the MIP site were posted on the MSEEL data repository. These data were examined to obtain perspectives on the type of data we ae likely to encounter as data become available from the science well and future laterals.

The examination included some minor adjustments to γ ray log pics (Figure 1).

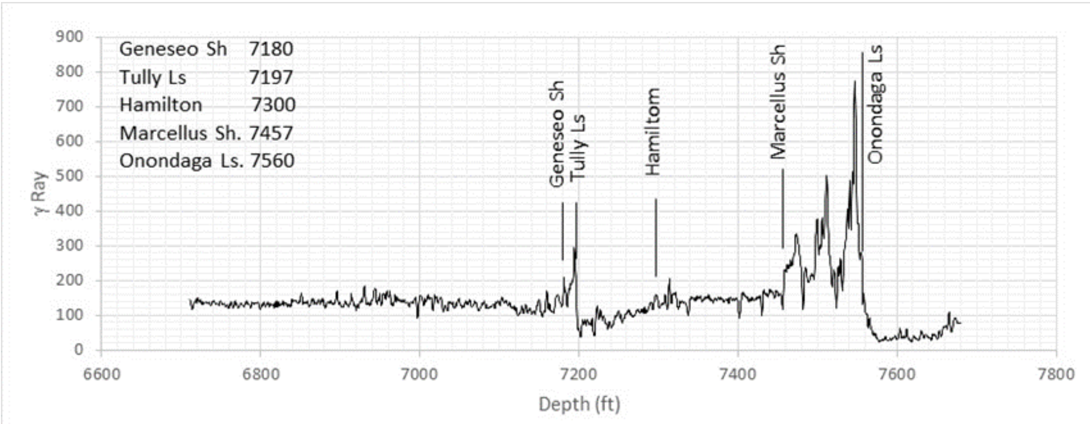

Figure 4a.1: γ ray log from the MIP 4H well.

Differentiation of the Upper, Middle and Lower Marcellus (high γ) zones (1-3) were also noted (Figure 2).

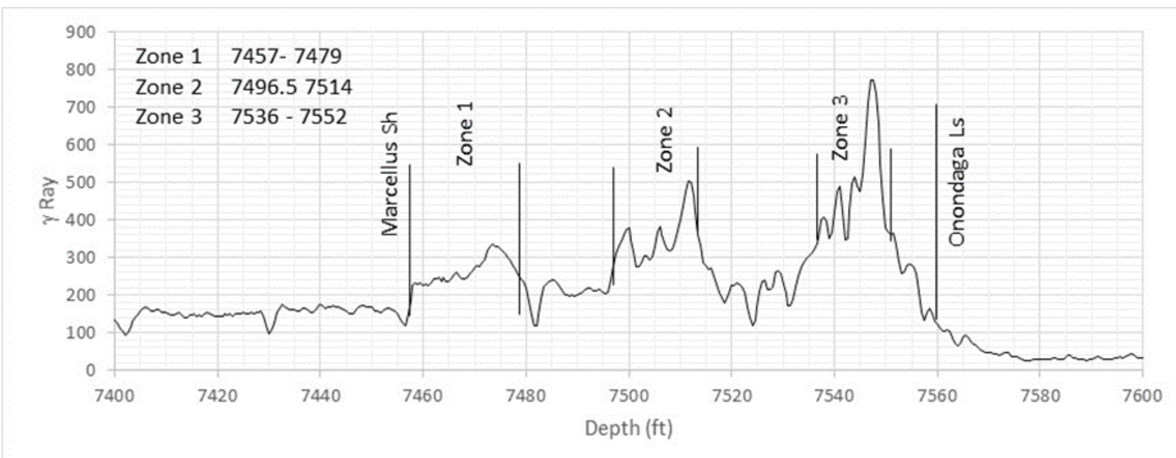

Figure 4a.2: γ ray log focused on the Marcellus Shale section observed the MIP 4H well.

Additional analysis included computation and visualization of λρ, μρ properties in the Marcellus and bounding intervals. Visualization of λρ, μρ in reservoir intervals may reveal intervals for optimal frac placement. This exercise was undertaken to provide preliminary assessment of λρ, μρ distribution. Computed λρ and μρ for the MIP4H well (Figure 3) were plotted for the Tully through Onondaga limestone intervals (Figure 3), the Marcellus and the upper, middle and lower Marcellus (Figure 4).

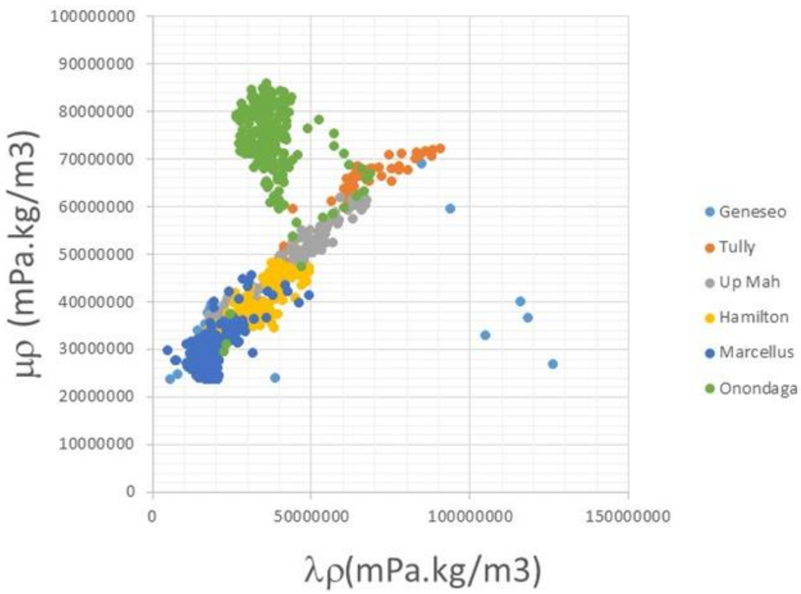

Figure 4a.3: λρ and μρ plot for Tully-Onondaga strata.

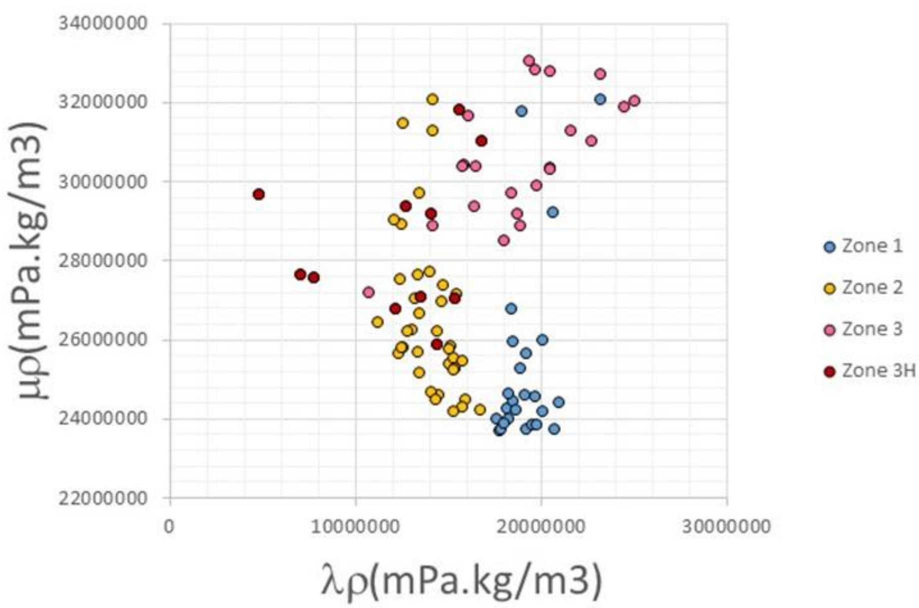

Figure 4a.4: λρ and μρ plot for Marcellus strata with hot (high γ) zones differentiated.

Brittleness was also computed from log-derived elastic parameters using the following relationships:

$$E_{brittleness} = \frac{E - E_{min}}{E_{max} - E_{min}},$$

$$\nu_{brittleness} = \frac{\nu - \nu_{max}}{\nu_{min} - \nu_{max}},$$

$$Brittleness_{average} = \frac{(E_{brittleness} + \nu_{brittleness})}{2}.$$

In the above, E is Young's modulus and ν is Poisson's ratio.

Log interpretations of the shale section extending from above the Geneseo and into the Onondaga are shown (Figure 5) for the NNE MIP 4H well.

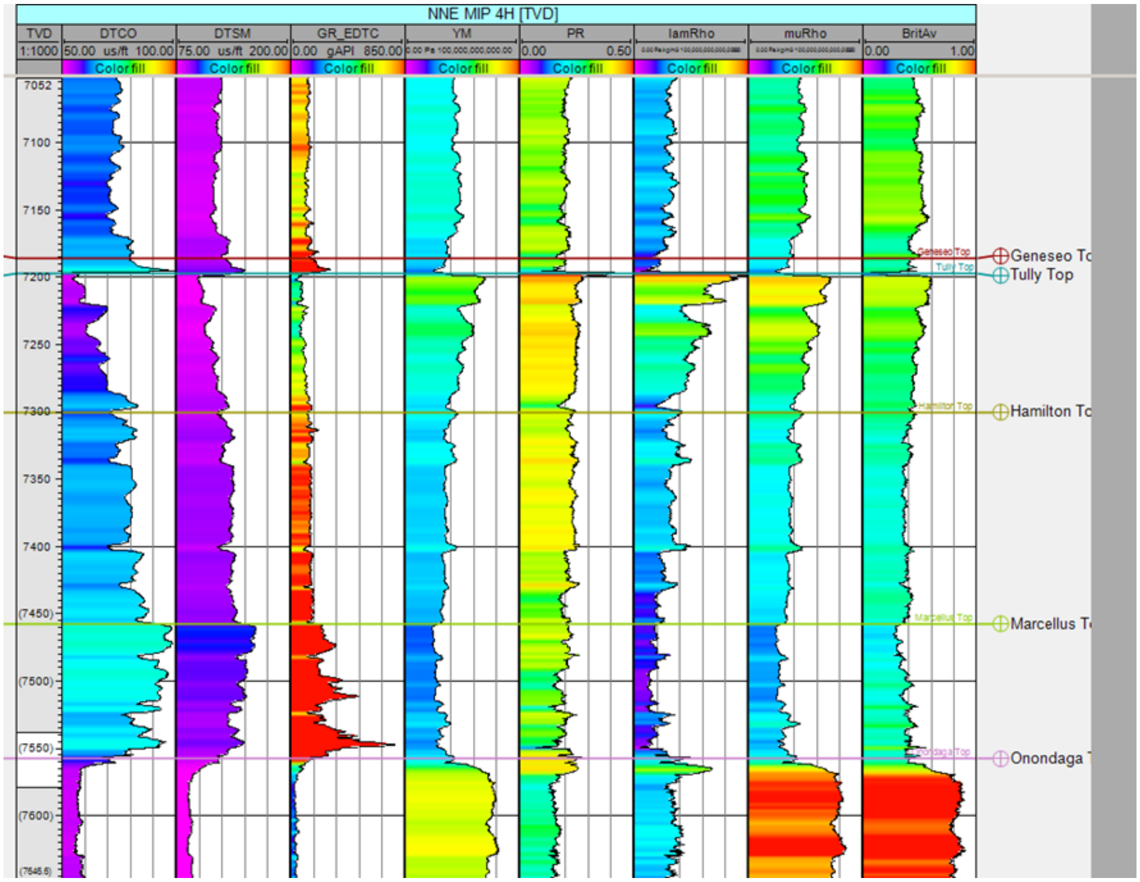

Figure 4a.5: Log displays for the NNE MIP 4H well include compressional (DTCO) and shear (DTSM) sonic, γ ray (GR_EDTC), Young's modulus (YM), Poisson's ratio (PR), λρ, μρ and brittleness average, left-to-right.

The λρ, μρ data for the Tully-to-Onondaga section are replotted and colored by Young's modulus (Figure 6). We see that the Marcellus is characterized in general by lower λρ, μρ and Young's moduli.

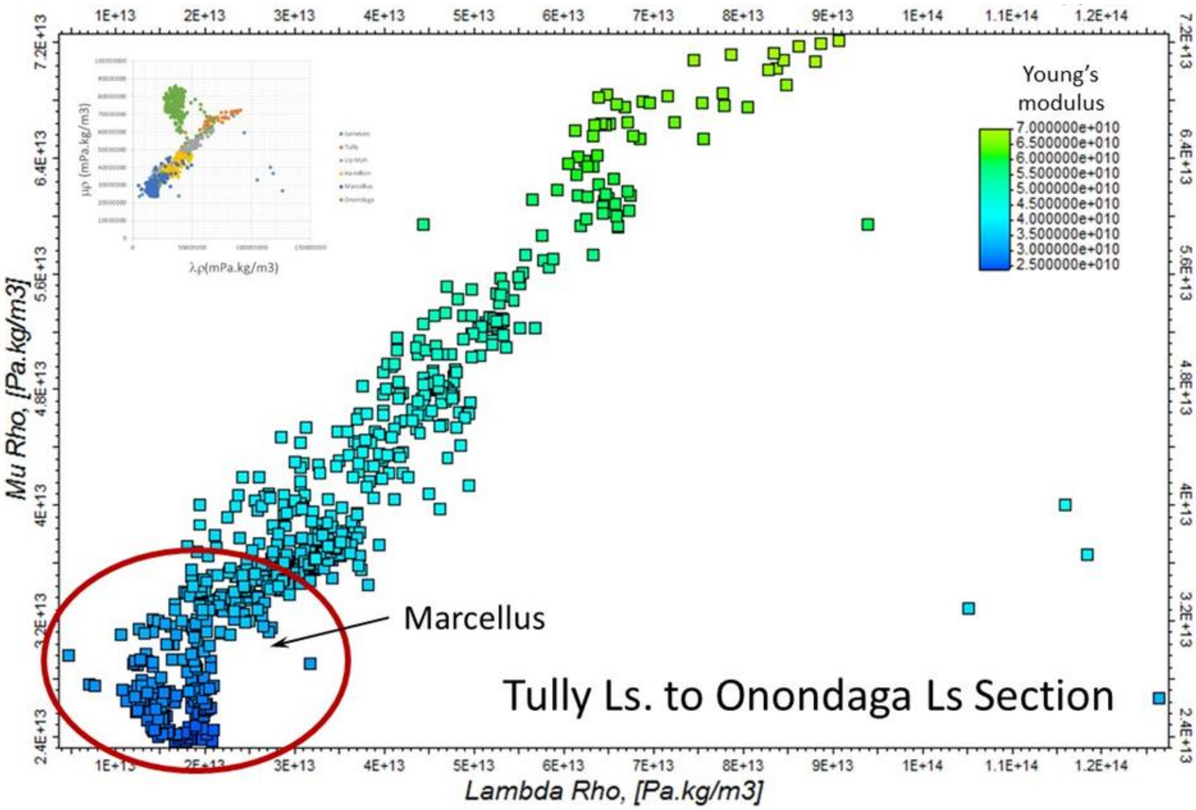

Figure 4a.6: λρ, μρ plot for the Tully to Onondaga section colored by Young's moduli. The Onondaga is excluded in this plot.

The λρ, μρ plot was also subdivided based on Poisson's ratio and Young's modulus for the entire Marcellus section (Figure 7).

The high-γ zones (assumed higher TOC) tend to have Poisson's ratios between 0.15 and 0.2 and Young's moduli between about 2.4×10^{10} and 3.4×10^{10} Pa.

The brittleness average (Figure 8) did not break out high γ zones. Higher γ ray intervals tend to have brittleness averages between 0.35 and 0.45. Brittle intervals tend to have lower Poisson's ratio and fall in the range of Young's moduli noted above.

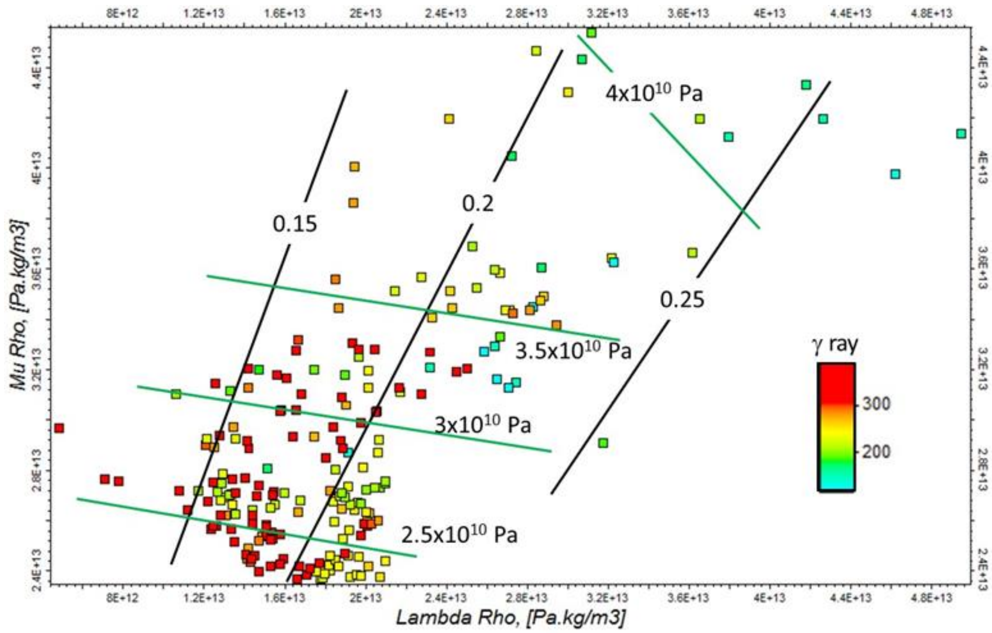

Figure 4a.7: λρ, μρ plot for the Marcellus. Contour lines of equal Poisson's ratio and Young's modulus are shown.

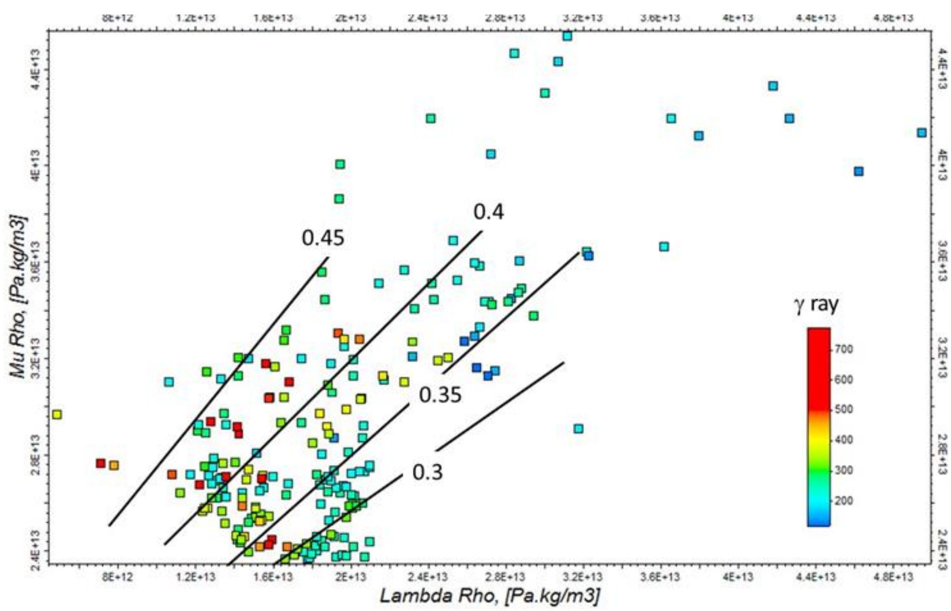

Figure 4a.8: λρ, μρ plot for the Marcellus showing approximate variations of brittleness. λρ, μρ values are colored by γ ray.

Some additional exploratory analysis was also undertaken of the completions data. Instantaneous shut-in pressures and breakdown pressures were tabulated and plotted on a stage-by-stage basis (not shown). The density log was also integrated to obtain S_V (vertical stress) at the reservoir depth. S_{hmin} (minimum horizontal stress) was estimated from the average instantaneous shut-in pressures. These data were used along with maximum and average injection pressures to develop a stress polygon (Figure 9).

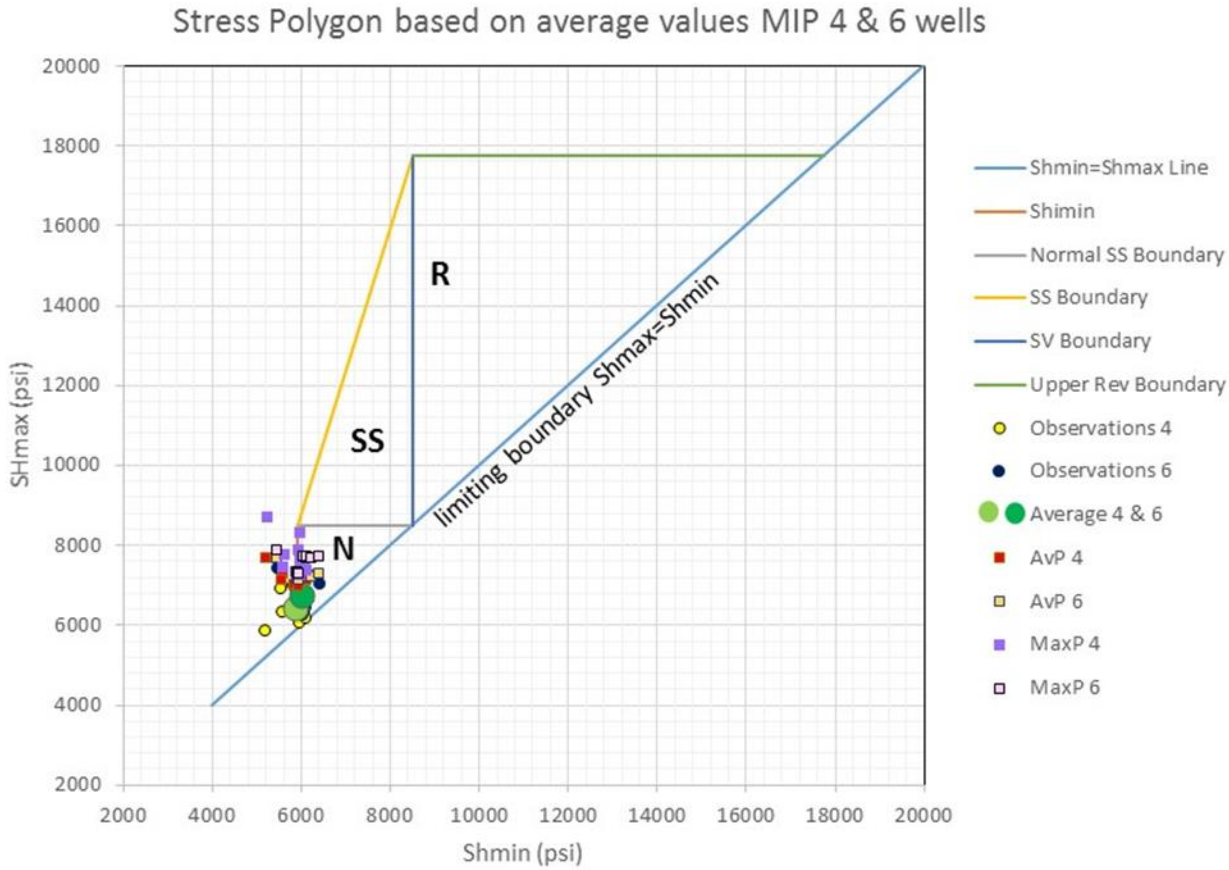

Figure 4a.9: Stress polygon obtained for the NNE MIP 4H and 6H wells.

Based on estimates of S_{hmin} and S_v along with the reported injection pressures the resulting stress polygon suggests that natural fractures and small faults, if present, will likely fail through normal offset in response to hydraulic fracture treatment. In addition to the open mode hydraulic fractures developed stage-by-stage in the forthcoming hydraulic fracture treatment of the MIP 5H well, we may observe rupture and microseismic activity along properly oriented natural fractures and small faults in the vicinity of the lateral.

Task 4b - Geomechanical:

This past quarter data from the MIP site were posted on the MSEEL data repository. Review of these data was initiated in order to identify modeling parameters for the anticipated hydraulic fracturing operation. Following specific items were performed.

(a) Participated in a one-day safety training course.

(b) Participated in a meeting with NNE to discuss anticipated operational parameters of the hydraulic fracturing operations

(c) Participated in a meeting held with Schlumberger at NNE to discuss the proposed down-hole measurements, and its potential use in fracturing modeling work.

(d) Review of geologic information was initiated to establish geometric details of the strata above and below the reservoir layer.

Products

Plan for Next Quarter

Task 4a – Geophysical:

Some analysis of data from the science well will be undertaken as logs become available. Of particular interest will be information regarding orientations of the natural fractures, faults, induced tensile fractures and compressive breakouts observed in the FMI log along with orientations and magnitudes of S_{Hmax} and S_{hmin} based on sidewall core and sonic scanner analysis. Preliminary planning for the analysis of microseismic data from the site will also be initiated. In addition, and, if available, we will incorporate any 2D seismic data available for the site into our database.

Task 4b - Geomechanical:

A preliminary modeling work will be performed on the basis of available data. Information on the hydraulic fracturing field parameters (fluid volumes, pumping rate, and proppant schedule) will be sought from NNE for the planned field operations.

Topic 5 – Surface Environmental

Approach

Surface water baseline sampling was conducted in June at the three points selected along the Monongahela River. Based on the timeline for gas well development being shortened and activities moved up, two separate sampling events were conducted. Figure 5.1 shows the locations of sampling points MR-1, MR-2, and MR-3 in red with the Northeast Energy site indicated in purple.

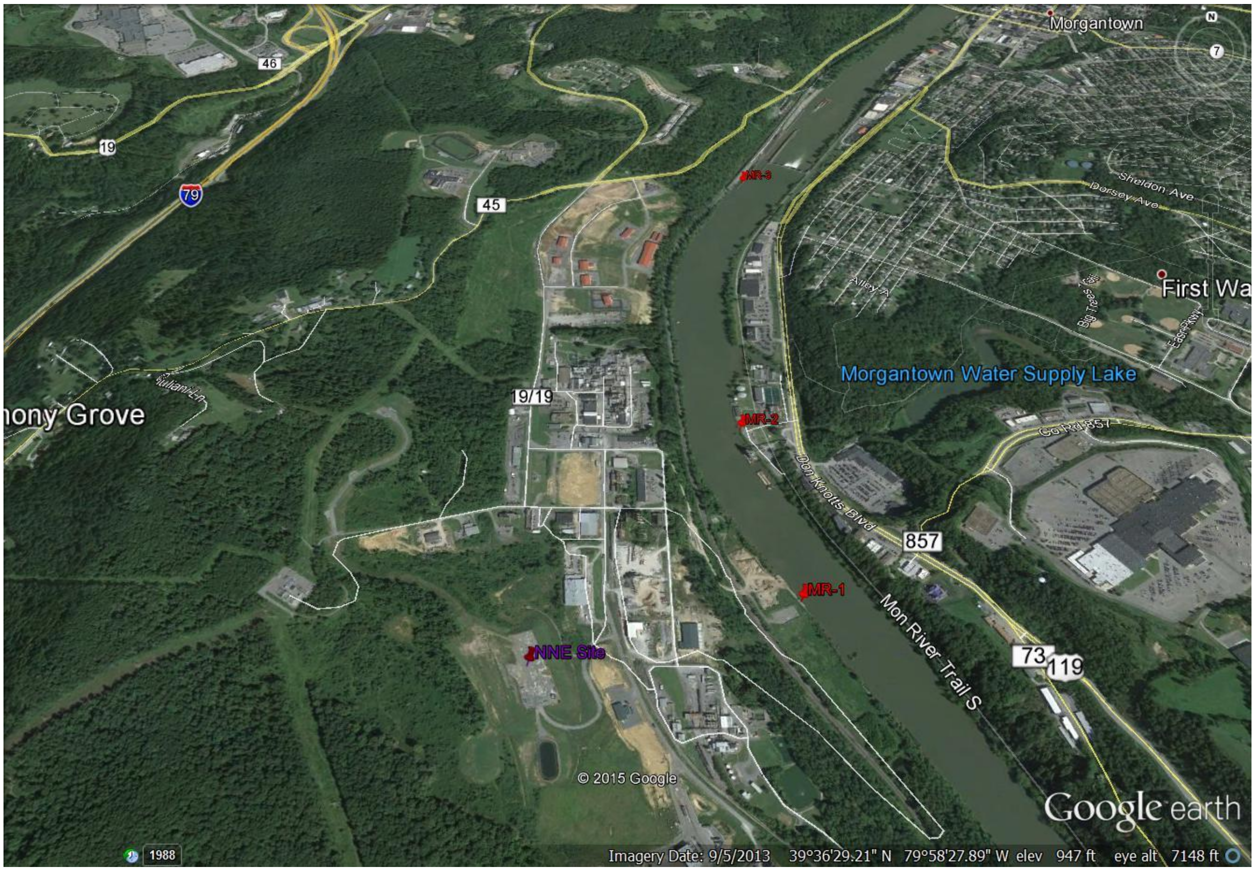

Figure 5.1: MSEEL surface water sampling locations

The sampling schedule for surface water and gas well development water/waste streams is detailed in Table 5.1.

Table 5.1: MSEEL sampling schedule

	Freshwater		Aqueous/Solids: drilling/completion/production									
	Mon River	ground water	HF fluid makeup	HF fluids	flowback/ produced	drilling fluids	drilling muds*	drilling cuttings	total aqueous	total solids	Sampling Dates	Notes
Sampling Stations	3	0	2	2	2	2	2	2				
Subtask 1.4.1 Test surface sampling plan												
ID and review existing GW/SW data	Completed-flow path identification, otherwise no other value											
Finalize project surface sampling plan	Completed-see below											
Subtask 1.4.3 Develop water qualiity baseline												
Groundwater baseline prior to drilling	Access denied-groundwater will not be sampled											
Surface water baseline prior to drilling	3								3		6/12/2015	
	4								4		6/25/2015	Field duplicate taken
Subtask 2.1.1 Environmental monitoring-Drilling												
Vertical drilling	3								3		7/8/2015	surface water only
								1		1		
								1		1		
Horizontal drilling	3					1	1	1	5	2		liquids & solids fraction of muds
						1	1	1	2	2		liquids & solids fraction of muds
Subtask 2.2.1 Environmental monitoring-Completion												
Hydraulic fracturing	3		2	2					7			
flowback Initial	3				2				5			
Flowback 1 week	3				2				5			
Flowback 2 weeks	3				2				5			
Flowback 4 weeks	3				2				5			
Flowback 8 weeks	3				2				5			
Subtask 2.3.1 Environmental monitoring-Production												
Production 3 stations x 3/yr x 4 yrs	36				24				60			

Surface water samples are being analyzed for the following parameters, see Table 5.2.

Table 5.2: Analytical parameters

Aqueous chemistry parameters					
Inorganics				Organics	Radionuclides
	Anions	Cations			
pH	Alkalinity	Ag	Mg	Benzene	α
TDS	Br	Al	Mn	Toluene	β
TSS	Cl	As	Na	Ethylbenzene	^{40}K
Conductance	SO_4	Ba	Ni	Xylene	^{226}Ra
		Ca	Pb	MBAS	^{228}Ra
		Cr	Se		
		Fe	Sr		
		K	Zn		

Results and Discussion

None this quarter.

Products

None this quarter.

Plan for Next Quarter

Activities moving forward will follow the schedule provided in Table 5.1 above.

Topic 6 – Economic and Societal

Approach

The lead on the political and societal project will work to identify and evaluate the factors shaping the policymaking response of local political actors. Included in this assessment will be an accounting, past and present, of the actions of public and private individuals and groups acting in favor of or opposed to shale gas drilling at the MSEEL site.

First year activity includes developing, distributing, collecting and compiling the responses from a worker survey and a vendor survey. The worker survey will address job characteristics and offsite expenditures. The vendor survey will help to identify per-well cost structures.

Results and Discussion

Activity on this task has been relatively limited in this quarter, as well activities have not fully initiated. In this quarter, the team designed and obtained project T-Shirts for survey participant incentives, and printed survey forms and delivered to NNE for distribution to on-site workers. To date, approximately 20 surveys have been completed.

Products

Plan for Next Quarter

Continue working surveys and data collection in the local area.

Cost Status

Project Title:	Marcellus Shale Energy and Environment Laboratory at West Virg University
DOE Award Number:	DE-FE0024297

Year 1

Start: 10/01/2014 End: 09/30/2015

Baseline Reporting Quarter	Q1 (12/31/14)	Q2 (3/30/15)	Q3 (6/30/15)
Baseline Cost Plan	(From 424A, Sec. D)		
(from SF-424A)			
Federal Share	$549,000	$549,000	$3,549,000
Non-Federal Share	$0.00	$0.00	$0.00
Total Planned (Federal and Non-Federal)	$549,000	$549,000	$3,549,000
Cumulative Baseline Costs			
Actual Incurred Costs			
Federal Share	$0.00	$14,760.39	
Non-Federal Share	$0.00	$0.00	
Total Incurred Costs - Quarterly (Federal and Non-Federal)	$0.00	$14,760.39	
Cumulative Incurred Costs	$0.00	$14,760.39	
Uncosted			
Federal Share	$549,000	$534,239.61	
Non-Federal Share	$0.00	$0.00	
Total Uncosted - Quarterly (Federal and Non-Federal)	$549,000	$534,239.61	

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