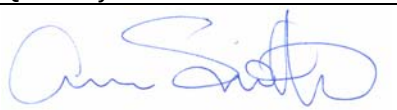
RESEARCH PERFORMANCE PROGRESS REPORT

1. COVER PAGE DATA ELEMENTS: Mandatory

Federal Agency and Organization Element to Which Report is Submitted	**U.S. Department of Energy (DOE)** **National Energy Technology Laboratory (NETL)**
Federal Grant or Other Identifying Number Assigned by Agency	DE-FE0029085
Project Title	Long-Term Methane Emissions Rate Quantification and Alert System for Natural Gas Storage Wells and Fields
PI Name, Title and Contact Information	Ann P. Smith, Vice President apsmith@gsi-net.com; 512.346.4474
Submission Date	October 31, 2017
DUNS Number	181780776
Recipient Organization	GSI Environmental Inc. 9600 Great Hills Trail, Suite 350E Austin, Texas 78759
Project Period	October 1, 2016 to May 31, 2019
Reporting Period End Date	September 30, 2017
Report Term or Frequency	Quarterly
Signature of Submitting Official	

2. ACCOMPLISHMENTS: Mandatory

a) What are the major goals of the project?

The primary goal of the project is to employ a novel combination of complementary measurement methods and technologies to detect and accurately quantify average annual methane emissions from underground natural gas storage facilities, including from above-ground equipment leaks plus seepage at the ground surface from underground leaks.

b) What was accomplished under these goals?

All project goals for the fourth quarter (Q4) reporting period of July 2017 – September 2017 were met. A summary of activities performed to achieve project goals and preliminary data analysis during Q4 is included below.

DOE Phase 1 Progress Meeting: A webex was performed with DOE NETL to detail achievements of milestones and discuss deliverables for Phase 1 on July 13th. Project status, progress and results were presented and decision point criteria were discussed. A Continuation Application was completed and submitted to DOE NETL to support the request for Budget Period 2 funding.

Continuation Application Approved and Phase 2 Started: The continuation application was approved on July 20, 2017 and a contracting modification was completed to award Phase 2 funding, effective August 1, 2017.

Sampling Background Interferences: Conversations were held with DOE NETL representatives on September 16th to discuss compressor blowdowns, how emissions may be influencing background concentrations for our study and the need to quantifying background methane emissions to support analysis of data from Phase I and II sampling events.

Preliminary Data Analysis:

Tracer Gas Correlation: Facility-wide methane emission rates are being calculated using a tracer correlation (TC) analysis following (i) time-series plume integration; (ii) unconstrained slope; and (iii) mixing ratio methods, using formulas adapted from previous studies (USEPA, 2014; Galle et al., 2001; Monster et al., 2014; Schuetz et al., 2011; and Foster-Wittig, 2015). Data are being analyzed in a Microsoft Excel spreadsheet that allows various inputs such as wind bearing and speed, tracer gas emission rate, and measured concentrations (in PPM) of the target gas (Methane) and tracer gas (Sulfur Hexafluoride). Target and tracer gas concentrations were measured using an Open Path Fourier Transform Infrared Spectrometer with a 5 minute sampling rate and path length ranging from 70 - 275 meters (230 – 900 ft).

Emission Factor Development: Component-specific emission factors are being calculated based on high-flow emission measurements and facility-wide component counts. Emission rate measurements from individual component types (e.g., valves) will be averaged and normalized by the total number of emitting components sampled to develop leaker factors. Population factors will be developed by comparing average component-level emission rates with the total population counts. If variability is large among components of the same type, components may be subdiveded by key parameters. For example, components associated with compressors may be normalized by compressor engine horsepower, or subdivided into age ranges. Similarly, pneumatic devices associated with compressors may be differentiated from pneumatic devices associated with separators.

c) What opportunities for training and professional development has the project provided?

Interns from Queens University and the University of Texas at Austin were trained in data collection techniques in the field and data analysis of high flow and OP-FTIR data.

d) How have the results been disseminated to communities of interest?

KOGA Annual Meeting: Preliminary results obtained from the Phase 1 Sampling Event were discussed at the Kentucky Oil and Gas Association Annual Meeting on July 19th and 20th, with attendance from >50 local oil and gas operators.

Data Review Meeting with DOE NETL: A meeting was held with the DOE NETL Project Manager on July 27, 2017 to review data collected during the Phase 1

Sampling Event. Data management strategies, quality assurance procedures, and preliminary results of the data collection were discussed.

Technical Advisory Steering Committee (TASC) Meetings: TASC meetings were held on the mornings of September 26th and 27th for industry members to dicuss preliminary results from the Phase I Sampling Event at gas storage facilities in the Clay Basin, Utah and in the Gulf Coast area. Additional TASC meetings, that were open to all members, were held on the afternoons of September 26th and 27th. Attendees for each meeting are listed below.

I**ndustry TASC Meeting:** Attendees included representatives from Houston Advanced Research Center (HARC), British Petroleum (BP), Enbridge Gas, Halliburton Energy Services, Kinder-Morgan, and QEP Resources.

Open TASC Meeting: Attendees included representatives from USU (Utah State University), DOE NETL, Houston Advanced Research Center (HARC), Maryland Department of the Environment, University of Cincinnati, EDF (Environmental Defense Fund), EPA (United States Environmental Protection Agency) Region 6, Purdue University, Utah Division of Air Quality.

e) What do you plan to do during the next reporting period to accomplish the goals?

The Phase II Sampling Event will be performed at Clay Basin, Utah and in the Gulf Coast area in October 2017 to perform repeat emissions measurements from gas storage wells and ancillary equipment.

Continuous subsurface leak monitoring equipment will be installed at two wells in Clay Basin in November of 2017 and confirmatory flux chamber sampling events will be performed in the December/January timeframe.

Results from the Phase I and II Sampling Events will be analyzed to develop preliminary methane emission factors.

3. PRODUCTS: Mandatory

a) Publications, conference papers, and presentations

i. Journal publications.

Not Applicable during this reporting period.

ii. Books or other non-periodical, one-time publications.

Not Applicable during this reporting period.

iii. Other publications, conference papers and presentations.

KOGA Annual Meeting: Preliminary results from the Phase 1 Sampling Event were discussed at the Kentucky Oil and Gas Association Annual Meeting on July 19th and 20th.

b) Website(s) or other Internet site(s)

Not Applicable during this reporting period.

c) Technologies or techniques

Not Applicable during this reporting period.

d) Inventions, patent applications, and/or licenses

Not Applicable during this reporting period.

e) Other products

Not Applicable during this reporting period.

4. PARTICIPANTS & OTHER COLLABORATING ORGNIZATIONS: Optional

a) What individuals have worked on the project?

Name:	Richard L. Bowers
Project Role:	Co-Principal Investigator
Nearest Person Month Worked:	1
Contribution to the Project:	Developed project deliverables and coordinated field activities with project partners.
Funding Support	None
Collaborated with individual in foreign country:	No
Travelled to foreign country:	No

b) What other organizations have been involved as partners?

Organization Name:	Utah State University
Location of Organization:	Vernal, Utah
Partner's contribution to the project:	Subcontractor leading effort to collect gas emission samples during field trials.
Financial Support:	None
In-kind Support:	None
Facilities	Labs at Bingham Research Center, Utah State University, Vernal, UT
Collaborative Research	None
Personnel Exchanges:	None
More detail on partner and contribution:	None

Organization Name:	Houston Advanced Research Center (HARC)
Location of Organization:	The Woodlands, Texas
Partner's contribution to the project:	Assisted with efforts to coordinate TASC participation.
Financial Support:	None
In-kind Support:	None
Facilities	HARC Labs in the Woodlands, TX
Collaborative Research	None
Personnel Exchanges:	None
More detail on partner and contribution:	None

Organization Name:	Colorado State University
Location of Organization:	Fort Collins, Colorado
Partner's contribution to the project:	Subcontractor assisting in effort to design underground sensor network for high resolution leak monitoring.
Financial Support:	None
In-kind Support:	None
Facilities	CSU Labs in Fort Collins, Colorado
Collaborative Research	None
Personnel Exchanges:	None
More detail on partner and contribution:	None

c) Have other collaborators or contacts been involved?

Not Applicable during this reporting period.

5. IMPACT: Optional

a) What is the impact on the development of the principal discipline(s) of the project?

Not applicable during this reporting period.

b) What is the impact on other disciplines?

Not applicable during this reporting period.

c) What is the impact on the development of human resources?

Not applicable during this reporting period.

d) What is the impact on physical, institutional, and information resources that form infrastructure?

Not applicable during this reporting period.

e) What is the impact on technology transfer?

Technology transfer is being consistently performed throughout the project via TASC meetings, focused group meetings with team members and operators, conferences and workshops. These technology transfer activities improve labor skills of participating engineering and scientific companies and increase managerial education and project efficiency by getting real-time feedback on sampling protocols and data analysis.

f) What is the impact on society beyond science and technology?

Better understanding of air emissions sources reduces environmental impacts and minimizes loss to the industry.

g) What dollar amount of the award's budget is being spent in foreign country(ies)?

None.

6. CHANGES/PROBLEMS: Mandatory

a) Changes in approach and reasons for change

GSI successfully achieved all milestones prior to the September 30 end date of budget period 1. Therefore, a contract modification was submitted and approved to change the start date of budget period 2 (FY18) from October 1, 2017 to August 1, 2017. A revised project timeline was submitted and approved.

b) Actual or anticipated problems or delays and actions or plans to resolve them

Not applicable during this reporting period.

c) Changes that have a significant impact on expenditures

Conversations with DOE NETL representatives on emissions from compressor blowdowns that may be influencing background concentrations have resulted in a need for additional funding to quantify background methane emissions to support analysis of data from Phase I and II sampling events.

d) Significant changes in use or care of human subjects, vertebrate animals, and/or Biohazards

Not Applicable to this Award.

e) Change of primary performance site location from that originally proposed

Not applicable during this reporting period.

7. SPECIAL REPORTING REQUIREMENTS: Mandatory

Not applicable during this reporting period.

8. BUDGETARY INFORMATION: Mandatory

A Cost Status Report is included as Attachment 1. In addition, graphs depicting the status of the budgeted versus cumulative costs of the overall project, technical transfer and cost share are included as Attachment 2.

REFERENCES

USEPA. (2014). Other Test Method 33a, 1–91. Retrieved from https://www3.epa.gov/ttn/emc/prelim/otm33a.pdf

Foster-Wittig, T. (2015). Mobile Sensors: Assessment of Fugitive Methane Emissions from Near and Far-Field Sources by Abstract Mobile Sensors: Assessment of Fugitive Methane Emissions from Near and Far-Field Sources by, 220.

Foster-Wittig, T. A., Thoma, E. D., Green, R. B., Hater, G. R., Swan, N. D., & Chanton, J. P. (2015). Development of a mobile tracer correlation method for assessment of air emissions from landfills and other area sources. *Atmospheric Environment*, *102*, 323–330. https://doi.org/10.1016/j.atmosenv.2014.12.008

Galle, B. O., Samuelsson, J., Svensson, B. H., & Borjesson, G. (2001). Measurements of methane emissions from landfills using a time correlation tracer method based on FTIR absorption spectroscopy. *Environmental Science and Technology*, *35*(1), 21–25. https://doi.org/10.1021/es0011008

Monster, J. G., Samuelsson, J., Kjeldsen, P., Rella, C. W., & Scheutz, C. (2014). Quantifying methane emission from fugitive sources by combining tracer release and downwind measurements - A sensitivity analysis based on multiple field surveys. *Waste Management*, *34*(8), 1416–1428. https://doi.org/10.1016/j.wasman.2014.03.025

Scheutz, C., Samuelsson, J., Fredenslund, A. M., & Kjeldsen, P. (2011). Quantification of multiple methane emission sources at landfills using a double tracer technique. *Waste Management*, *31*(5), 1009–1017. https://doi.org/10.1016/j.wasman.2011.01.015

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Research Performance Progress Report

Attachment 1: Cost Plan/Status

DE-FE0029085: Long-Term Methane Emissions Rate Quantification and Alert System for Natural Gas Storage Wells and Fields

Baseline Reporting Quarter	Budget Period 1								Budget Period 2								Budget Period 3					
	Q1		Q2		Q3		Q4		Q1		Q2		Q3		Q4		Q1		Q2		Q3 *	
	10/01/2016 - 12/31/2016		01/01/2017 - 03/31/2017		04/01/2017 - 06/30/2017		07/01/2017 - 09/30/2017		10/01/2017 - 12/31/2017		01/01/2018 - 03/31/2018		04/01/2018 - 06/30/2018		07/01/2018 - 09/30/2018		10/01/2018 - 12/31/2018		01/01/2019 - 03/31/2019		04/01/2019 - 06/30/2019	
	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total
Baseline Cost Plan																						
Federal Share	$ 173,000.00	$ 173,000.00	$ 28,000.00	$ 201,000.00	$ 151,000.00	$ 352,000.00	$ 169,000.00	$ 521,000.00	$ 188,645.00	$ 709,645.00	$ 49,986.00	$ 759,631.00	$ 152,089.00	$ 911,720.00	$ 42,367.00	$ 954,087.00	$ 63,582.00	$ 1,017,669.00	$ 111,628.00	$ 1,129,297.00	$ 79,152.00	$ 1,208,449.00
Non-Federal Share	$ -	$ -	$ 10,500.00	$ 10,500.00	$ 88,000.00	$ 98,500.00	$ 32,500.00	$ 131,000.00	$ -	$ 131,000.00	$ -	$ 131,000.00	$ 142,000.00	$ 273,000.00		$ 273,000.00	$ -	$ 273,000.00	$ -	$ 273,000.00	$ 32,000.00	$ 305,000.00
Total Planned	***$ 173,000.00***	***$ 173,000.00***	***$ 38,500.00***	***$ 211,500.00***	***$ 239,000.00***	***$ 450,500.00***	***$ 201,500.00***	***$ 652,000.00***	***$ 188,645.00***	***$ 840,645.00***	***$ 49,986.00***	***$ 890,631.00***	***$ 294,089.00***	***$ 1,184,720.00***	***$ 42,367.00***	***$ 1,227,087.00***	***$ 63,582.00***	***$ 1,290,669.00***	***$ 111,628.00***	***$ 1,402,297.00***	***$ 111,152.00***	***$ 1,513,449.00***
Actual Incurred Cost																						
Federal Share	$ 113,409.00	$ 113,409.00	$ 274,728.10	$ 388,137.10	$ 123,206.81	$ 511,343.91	$ 103,724.54	$ 615,068.45				$ -		$ -		$ -		$ -		$ -		$ -
Non-Federal Share	$ -	$ -	$ 131,400.00	$ 131,400.00	$ -	$ 131,400.00	$ 4,500.00	$ 135,900.00				$ -		$ -		$ -		$ -		$ -		$ -
Total Incurred Cost	***$ 113,409.00***	***$ 113,409.00***	***$ 406,128.10***	***$ 519,537.10***	***$ 123,206.81***	***$ 642,743.91***	***$ 108,224.54***	***$ 750,968.45***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***
Variance																						
Federal Share	$ (59,591.00)	$ (59,591.00)	$ 246,728.10	$ 187,137.10	$ (27,793.19)	$ 159,343.91	$ (65,275.46)	$ 94,068.45				$ -		$ -		$ -		$ -		$ -		$ -
Non-Federal Share	$ -	$ -	$ 120,900.00	$ 120,900.00	$ (88,000.00)	$ 32,900.00	$ (28,000.00)	$ 4,900.00				$ -		$ -		$ -		$ -		$ -		$ -
Total Variance	***$ (59,591.00)***	***$ (59,591.00)***	***$ 367,628.10***	***$ 308,037.10***	***$ (115,793.19)***	***$ 192,243.91***	***$ (93,275.46)***	***$ 98,968.45***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***	***$ -***

* The project end date is May 30, 2019

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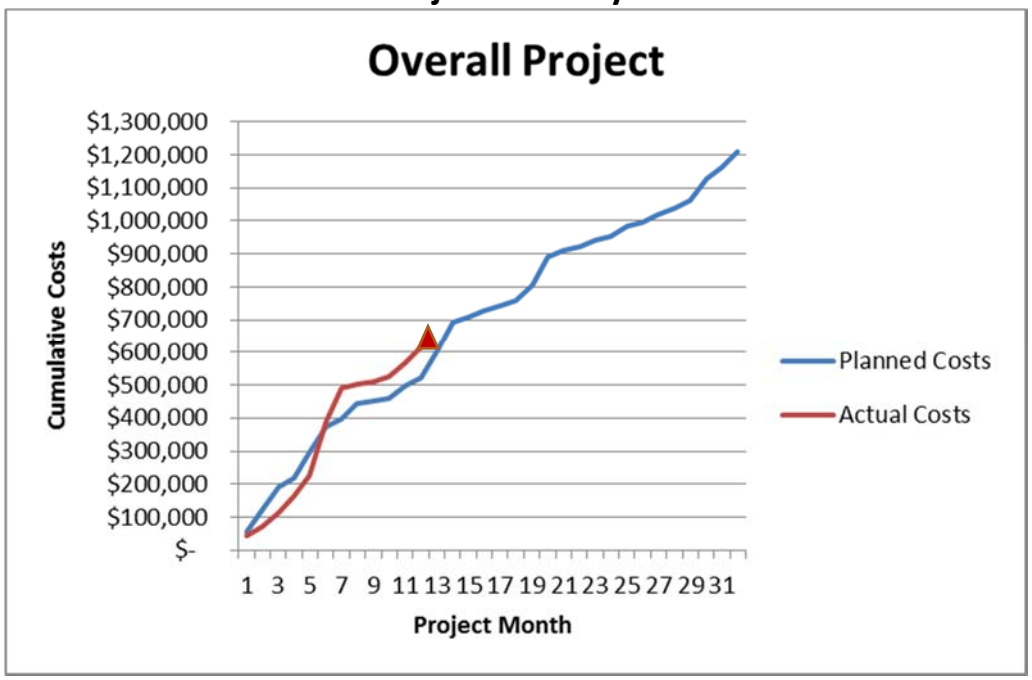
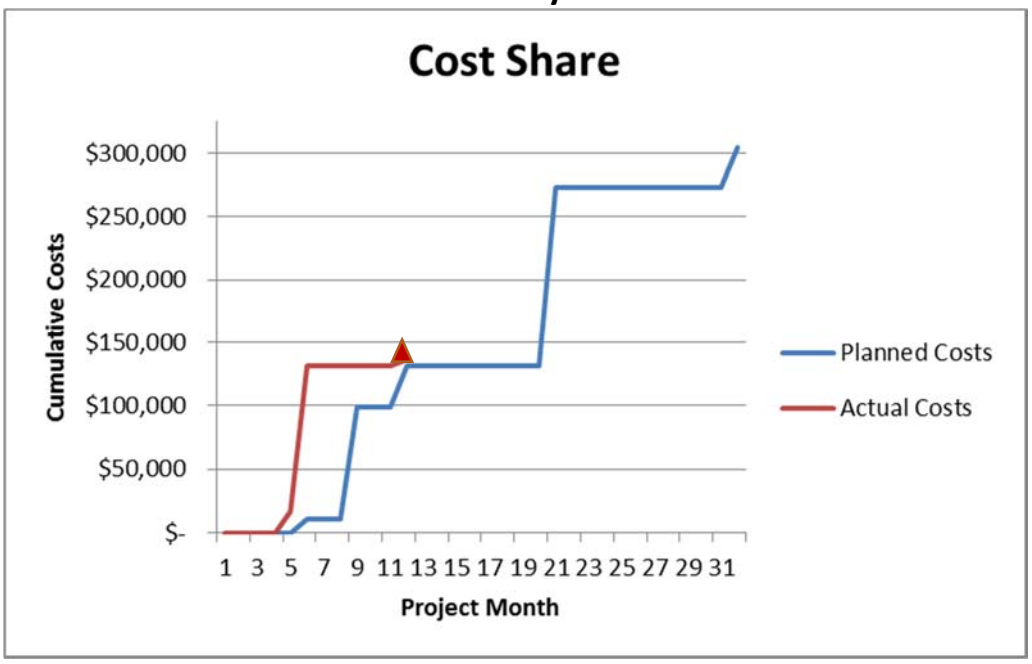
RESEARCH PERFORMANCE PROGRESS REPORT

Attachment 2: Summary Charts of Actual vs. Planned Expenditures
DE-FE0029085: Costs through September 30, 2017

Total Project Costs by Month



Cost Share by Month



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Summary Charts of Actual vs. Planned Expenditures
Costs through September 30, 2017, cont.

Technology Transfer by Month