LONG-TERM METHANE EMISSIONS RATE QUANTIFICATION AND ALERT SYSTEM FOR NATURAL GAS STORAGE WELLS AND FIELDS

U.S. DEPARTMENT OF ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY

DOE NETL: Methane Emissions Quantification
Project Award: DE-FE0029085

GSI ENVIRONMENTAL

Richard L. Bowers, P.E., BCEE (rlbowers@gsi-net.com)
Ann P. Smith, P.E., BCEE (apsmith@gsi-net.com)

GSI Environmental Inc., Austin, Texas
512-346-4474

DE-FE0029084: Quantification of Compressor Emissions in the G&B Segment

RESULTS – PROJECT COMPLETED JULY 2018

KEY OBSERVATIONS

- Component counts vary based on classification/count methodology
- Component sub-classifications in Subpart W are appropriate
- Total emission rates and type of equipment emitting varied between field campaigns
- Sampling duration does not affect variability *(except pneumatics)*
- Measured emissions >leaker and <population emission calculated under EPA Subpart W

2016 DOE-NETL Project Award

POP: 22 Months
$849K federal; $213K cost share

4 Stations, Gulf Coast Basin, TX
16 Compressors

52,000 components screened; ~300 emit (<1%)

4 Repeat field campaigns

DE-FE0029085: Gas Storage Well Project

CURRENT PROJECT OVERVIEW

KEY OBJECTIVES

1 Methane measurement and emission factor development
- Disaggregated above ground components
- Ground-level seepage

2 High resolution monitoring of below-ground seepage
- In-ground thermal sensors
- Longitudinal methane emissions quantification

2016 DOE-NETL Project Award

POP: 32 Months

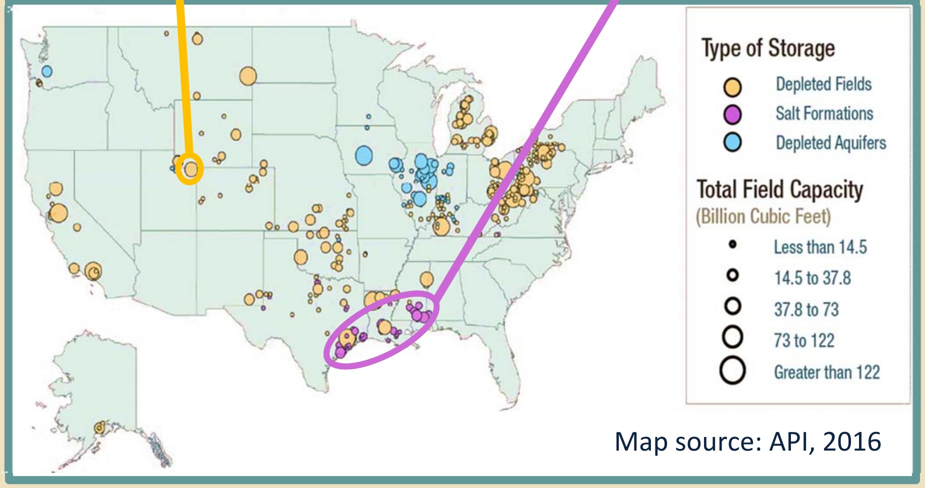
$1.3MM federal; $330K cost share

Clay Basin, Utah

43 Depleted Reservoir Wells

U.S. Gulf Coast

9 Salt Cavern Wells

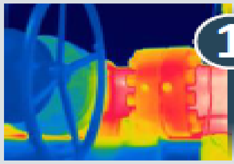


Map source: API, 2016

DE-FE0029085

MEASUREMENT METHODOLOGY

Above-Ground Equipment Leaks



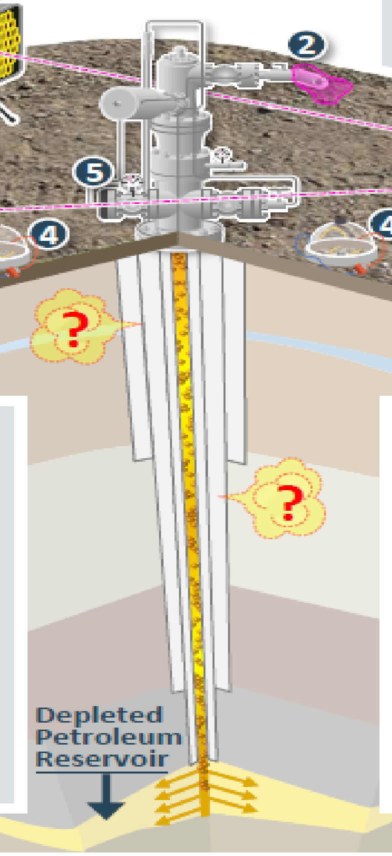
1 Detect leaks using optical imaging and gas sensing devices, as needed

2 Isolate and directly measure leaks with high flow sampling

Seepage thru Ground Surface

3 Continuously monitor potential methane emissions from underground leaks with shallow in-ground sensors

4 Directly measure seepage with isolation flux chamber testing



Deep Underground Casing Leaks

5 Continuously monitor pressure differentials between adjacent casing strings

Total Emissions

6 Measure and compare upwind vs. downwind methane and tracer concentrations over multiple time intervals

EMISSION FACTOR DEVELOPMENT

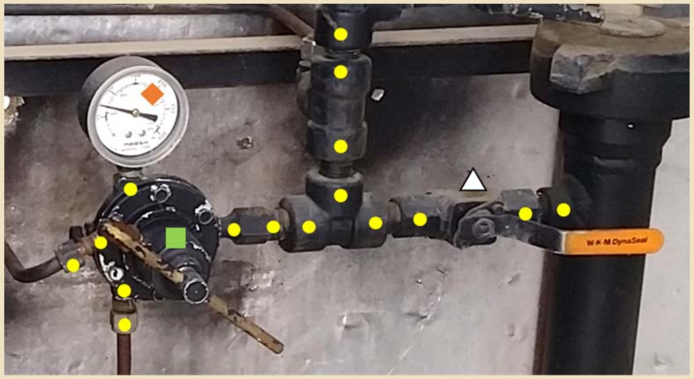
GSI ENVIRONMENTAL

EMISSIONS SCREENING & MEASUREMENTS
Storage Wellheads

		Number of Storage Wellheads	
Field Event		Leak Detection/ Screening	Emissions Measurements
Depleted Reservoir	Mar. 2017	43	24
	Oct. 2017	43	20
Salt Caverns	Mar. 2017	9	9
	Oct/Nov 2017	9	9
	Total	104	62

EMISSIONS SCREENING & MEASUREMENTS
Wellhead Components

Component Type	Depleted Reservoir *(24+20 Wellheads)*		Salt Caverns *(9x2 Wellheads)*	
	Screened Population	Measurement Count	Screened Population	Measurement Count
Valve, Small (>2" lines)	1,833	69	672	14
Valve, Large (>2" lines)	433	46	142	31
Connector, Flange	1,376	38	854	13
Connector, Other	8,128	23	2,618	25
Pressure Relief Valve	0	0	20	2
Open-Ended Line	369	12	2	1
Regulator	242	3	36	3
TOTAL	**12,732**	**191**	**4,418**	**89**

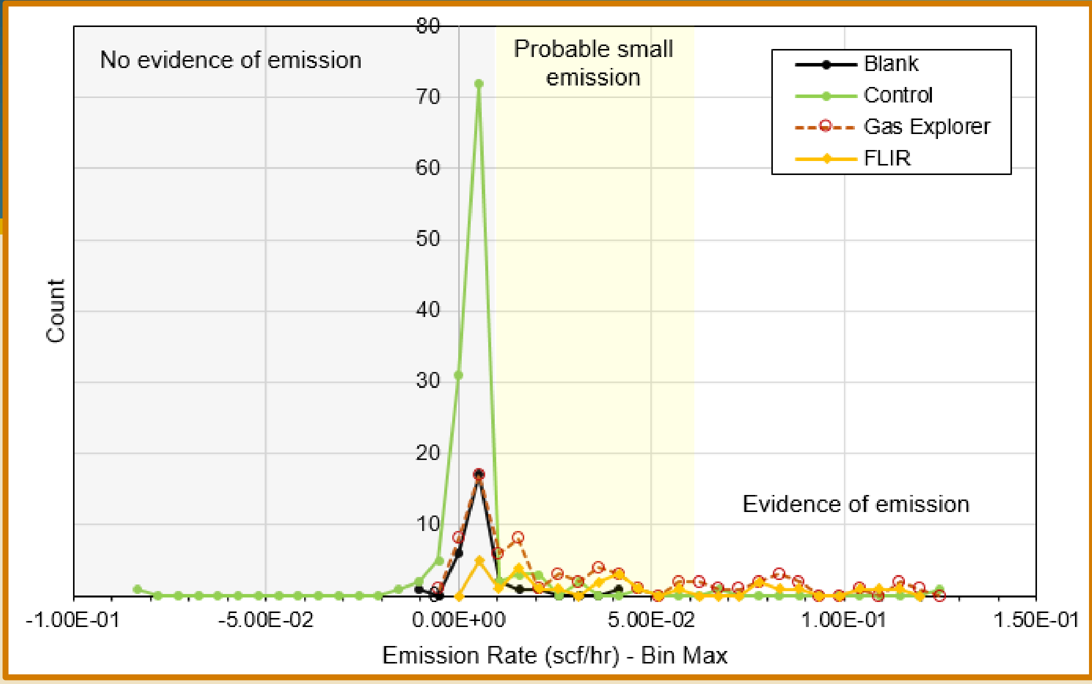


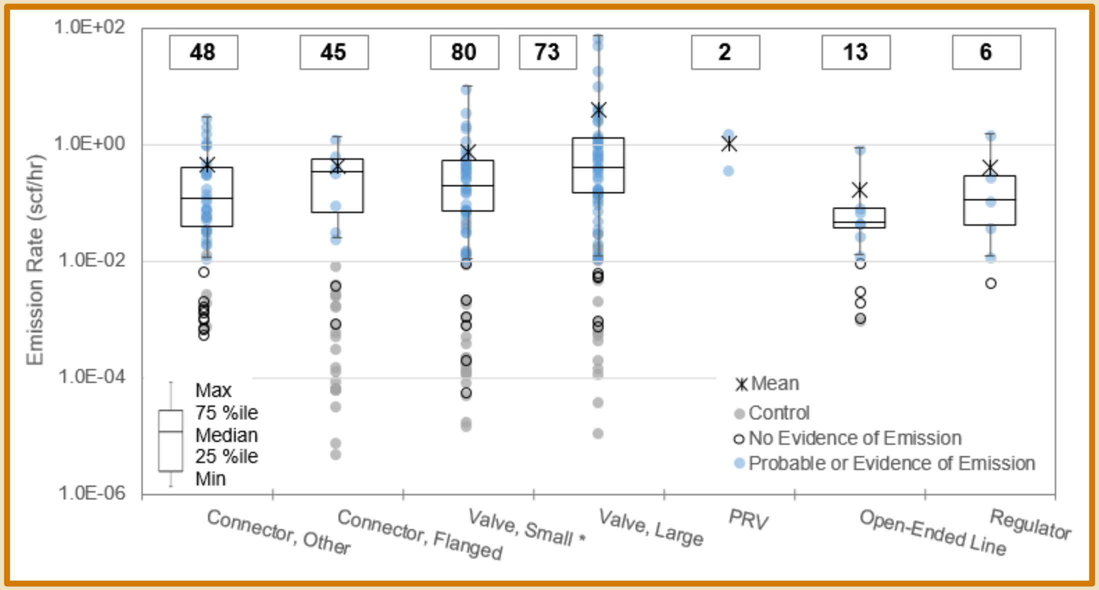
Other connector △ Small valve Gauge Regulator

Flanged connector △ Large valve

EMISSION FACTOR CONSIDERATIONS

- **False positive leak ID rates;** ***(FLIR and sniffer screening)***
- **Leak rate detection limits** ***(scf/hr)***
- **Sampled vs. total component population counts**





EMISSION FACTORS FOR DISAGGREGATED WELLHEAD COMPONENTS

Component Type	PF[1]			LF[2]		
	EPA[4]	GSI	n	EPA[4]	GSI	n
Connector	0.01	0.0047	6,488	-	0.88	15
Valve	0.1	0.20	1,540	4.1	3.6	59
PRV	0.17	-	10	3.7	-	1
OEL	0.03	0.011	186	2.3	0.27	4
Regulator	-	0.018	139	-	0.11	4

Subcategory A	PF[1]			LF[2]		
	EPA[4]	GSI	n	EPA[4]	GSI	n
Other	-	0.0058	5373	1.1	1.2	9
Flanged	-	0.0026	1,115	3.4	0.49	6
Small[3]	-	0.032	1,253	-	0.96	26
Large	-	0.92	288	-	5.7	33

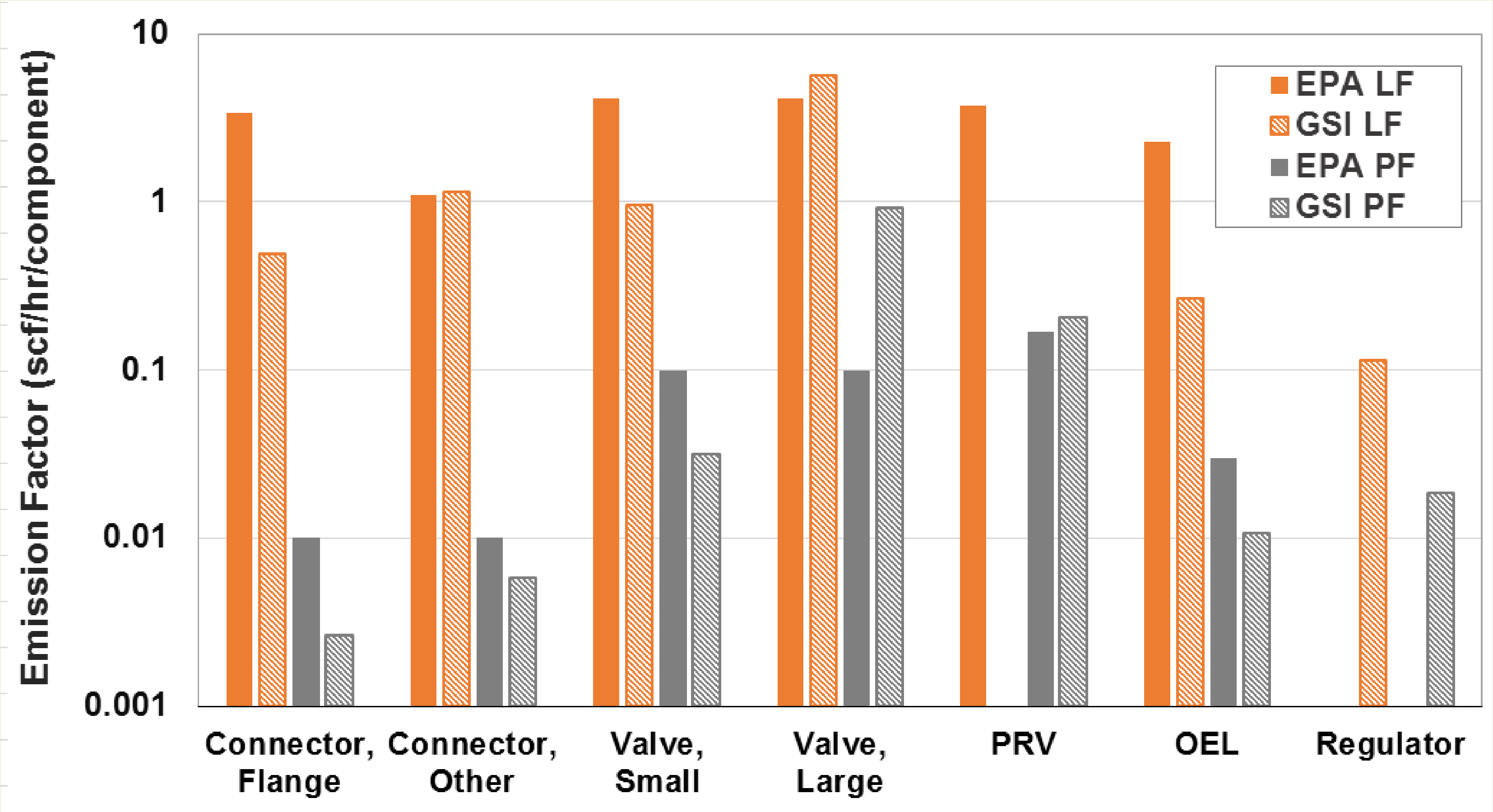
[1] PF = Population Factor

[2] LF = Leaker Factor

[3] Small valve can be easily turned with 1 hand

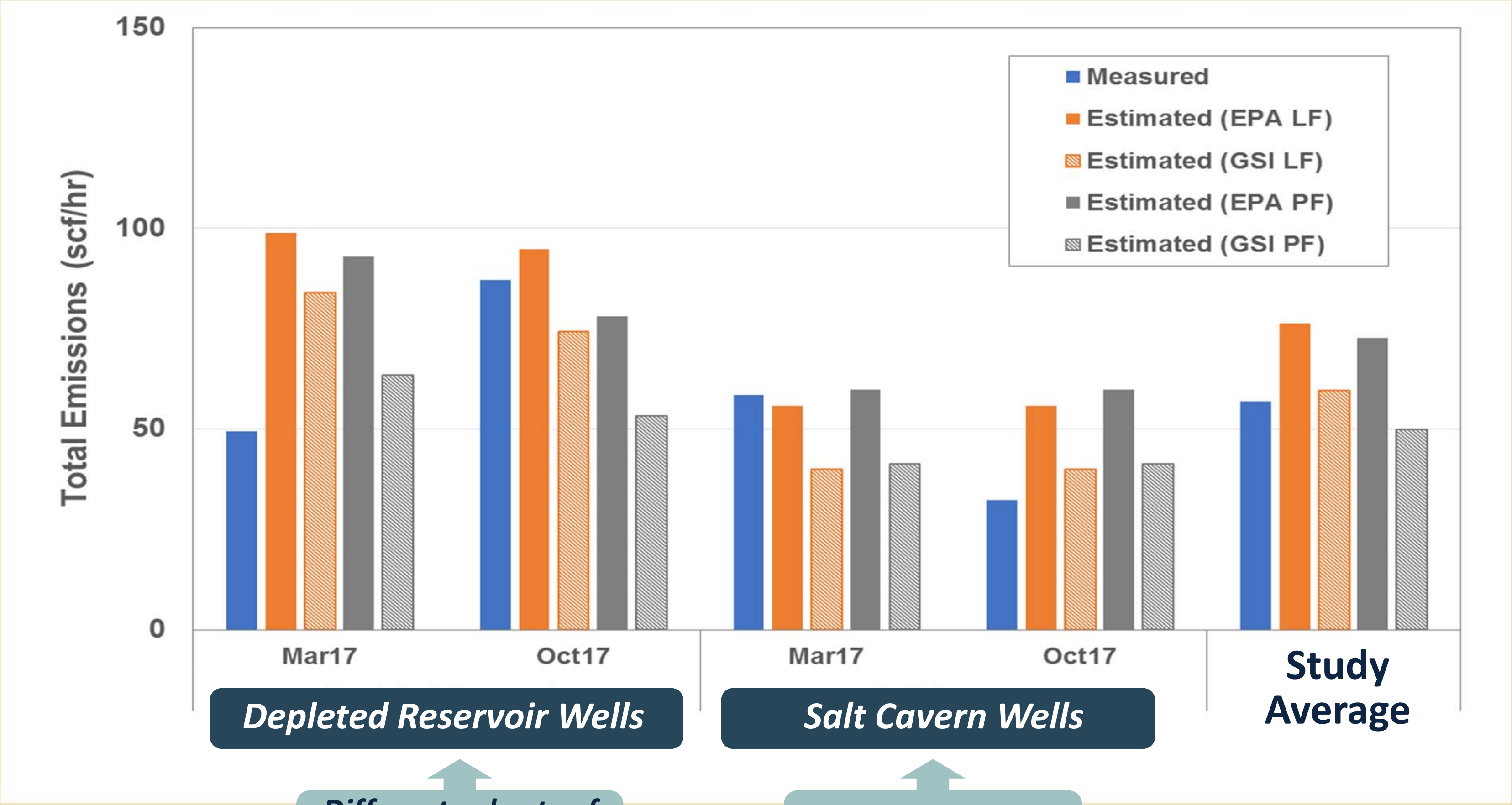
[4] Greenhouse Gas Reporting Program - 40 CFR Part 98, Subpart W, Table W-4A&B

EMISSION FACTORS FOR DISAGGREGATED WELLHEAD COMPONENTS



New emission factors are *similar to or lower than* current EPA values

POPULATION EMISSION FACTORS FOR GAS STORAGE WELLHEADS



Different subsets of 24 and 20 wells

Same 9 wells

Well Population Factors

3.9 scf/hr/well

5.3 scf/hr/well

4.3 scf/hr/well

EMISSION FACTORS *Next Steps*

GSI ENVIRONMENTAL

TECH TRANSFER

- **Publish EF results in peer-reviewed journal**
- **Present at conference(s)**

NATIONAL ENERGY TECHNOLOGY LABORATORY

STAKEHOLDER ENGAGEMENT

- **GHGRP (Subpart W) –** ***New component-level EFs represent actual gas storage wells (not production wells)***
- **GHGI –** ***New well-level EFs supplement existing storage station-level EFs***

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

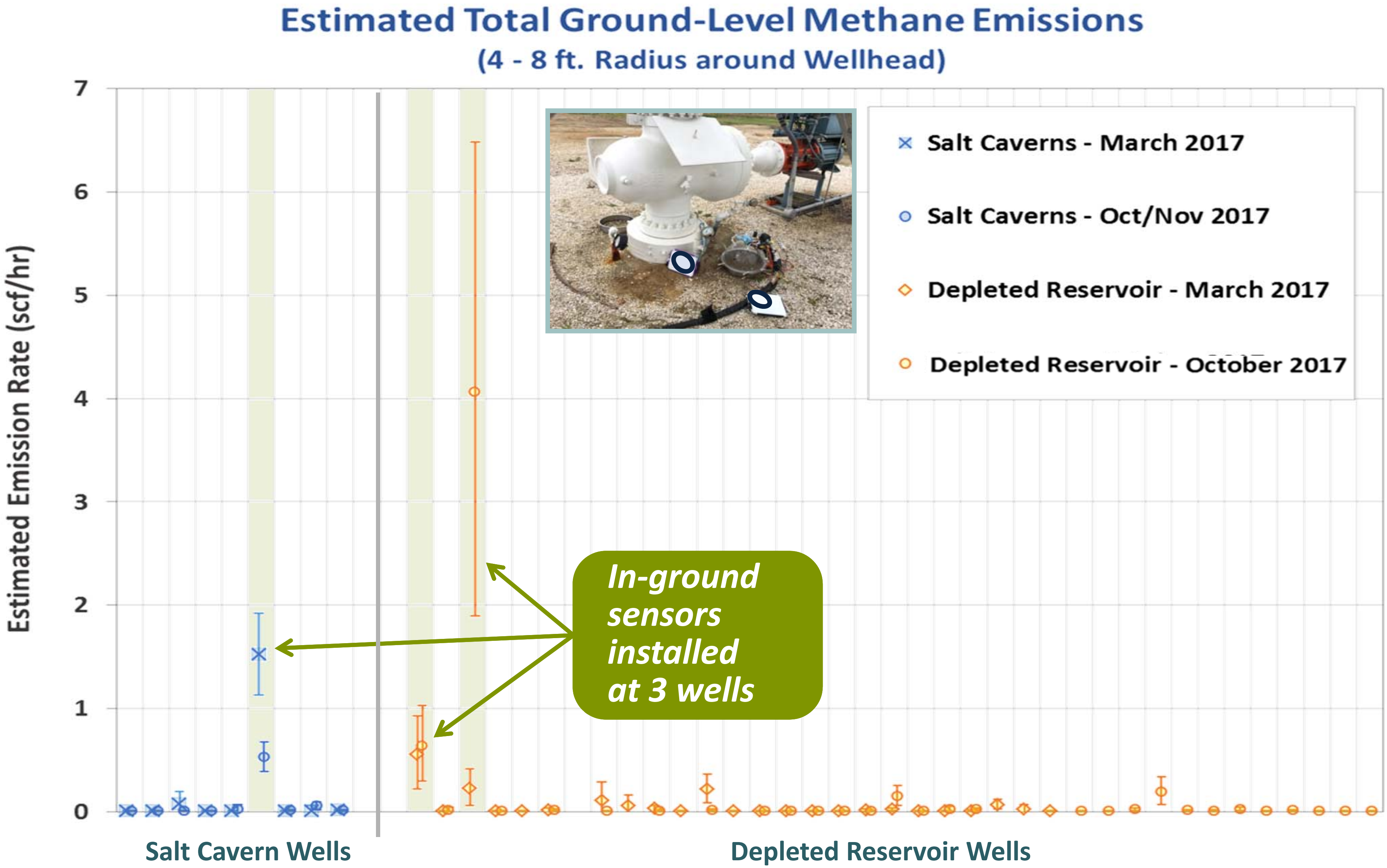
KEY POINT: **Results offer EPA and industry defensible *gas storage well-specific* emission factors previously lacking in the GHGRP and GHGI.**

GHGRP = Greenhouse Gas Reporting Program; GHGI = Greenhouse Gas Inventory

BELOW GROUND EMISSIONS QUANTIFICATION

GSI ENVIRONMENTAL

GROUND-LEVEL METHANE SEEPAGE AROUND WELL HEADS

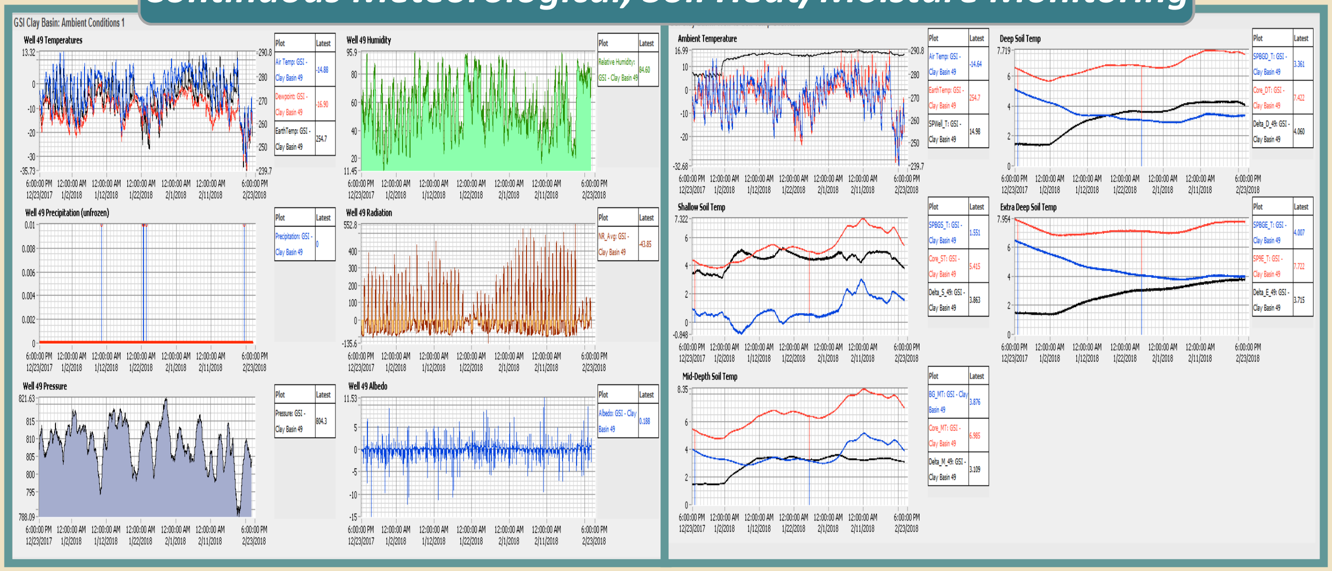


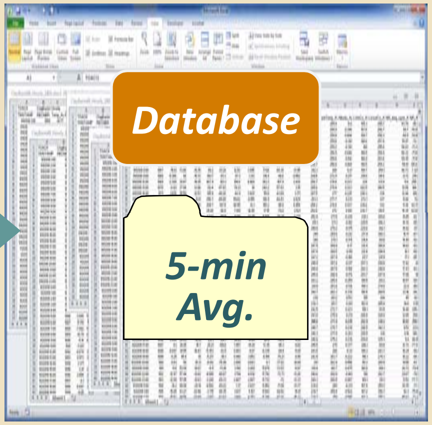
IN-GROUND SENSOR INSTALLATION
(Nov 2017, Mar 2018)

HIGH RESOLUTION SOIL HEAT MONITORING

Data Collection and Analysis

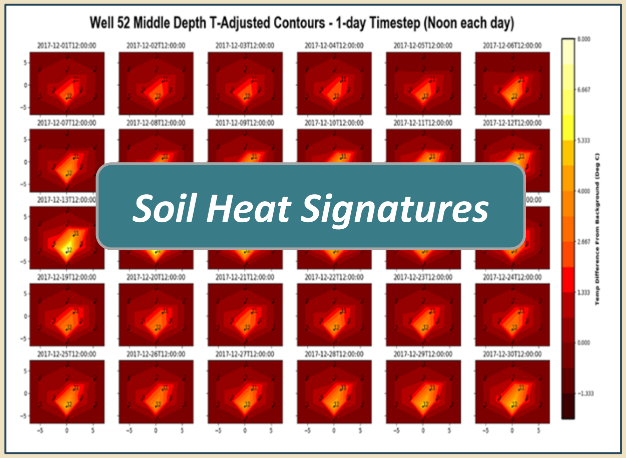
Continuous Meteorological, Soil Heat/Moisture Monitoring



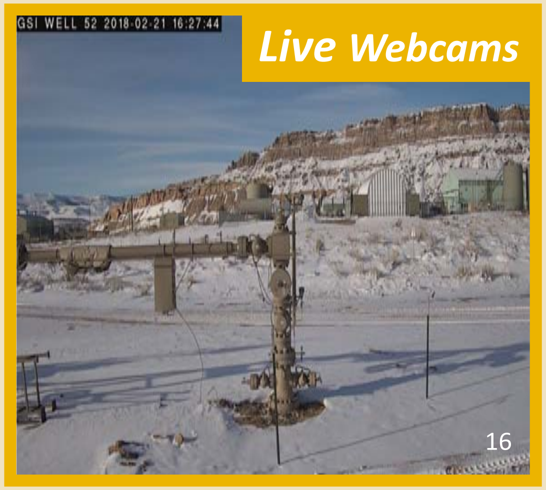


Database

5-min Avg.

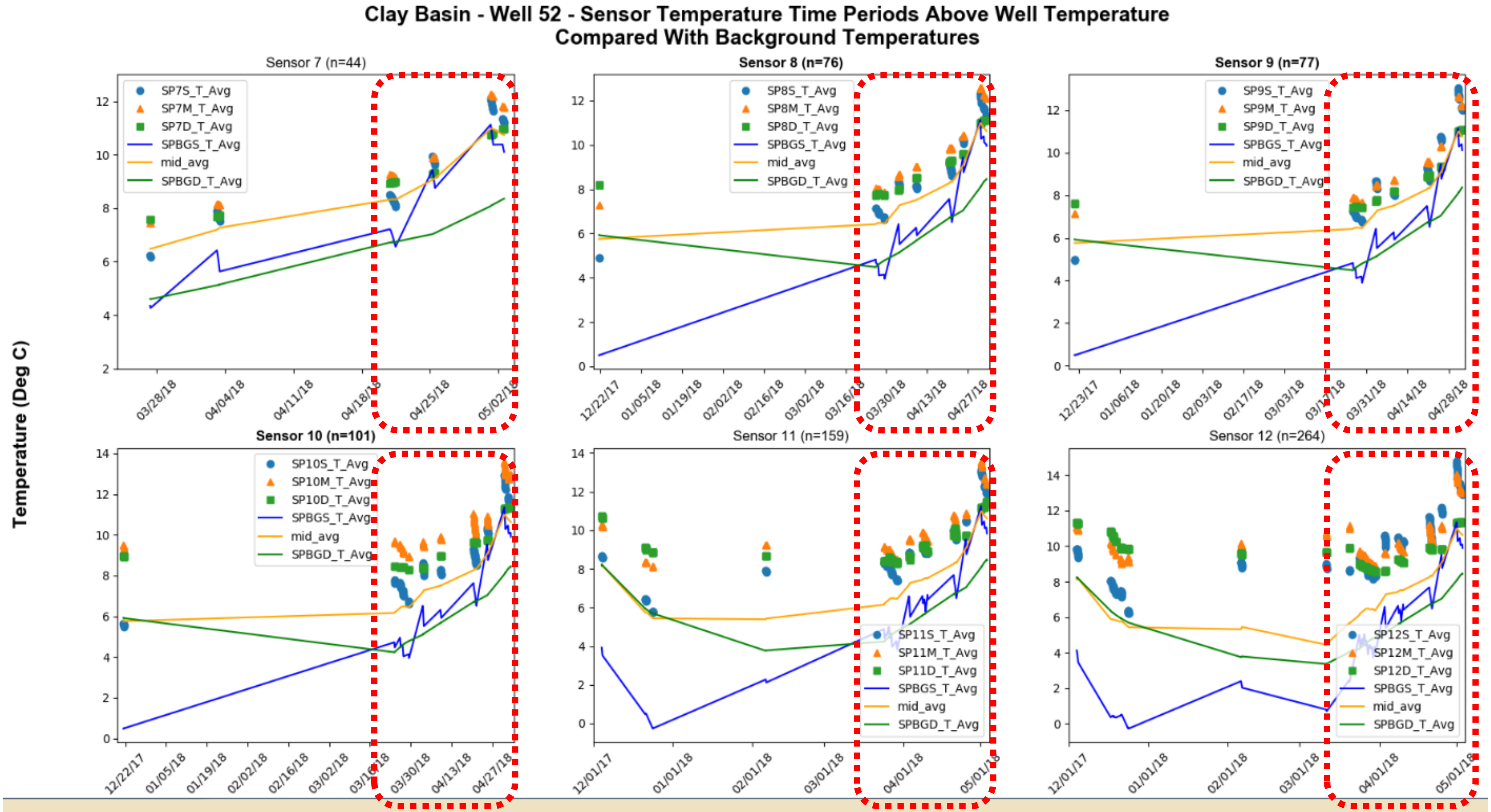


Soil Heat Signatures

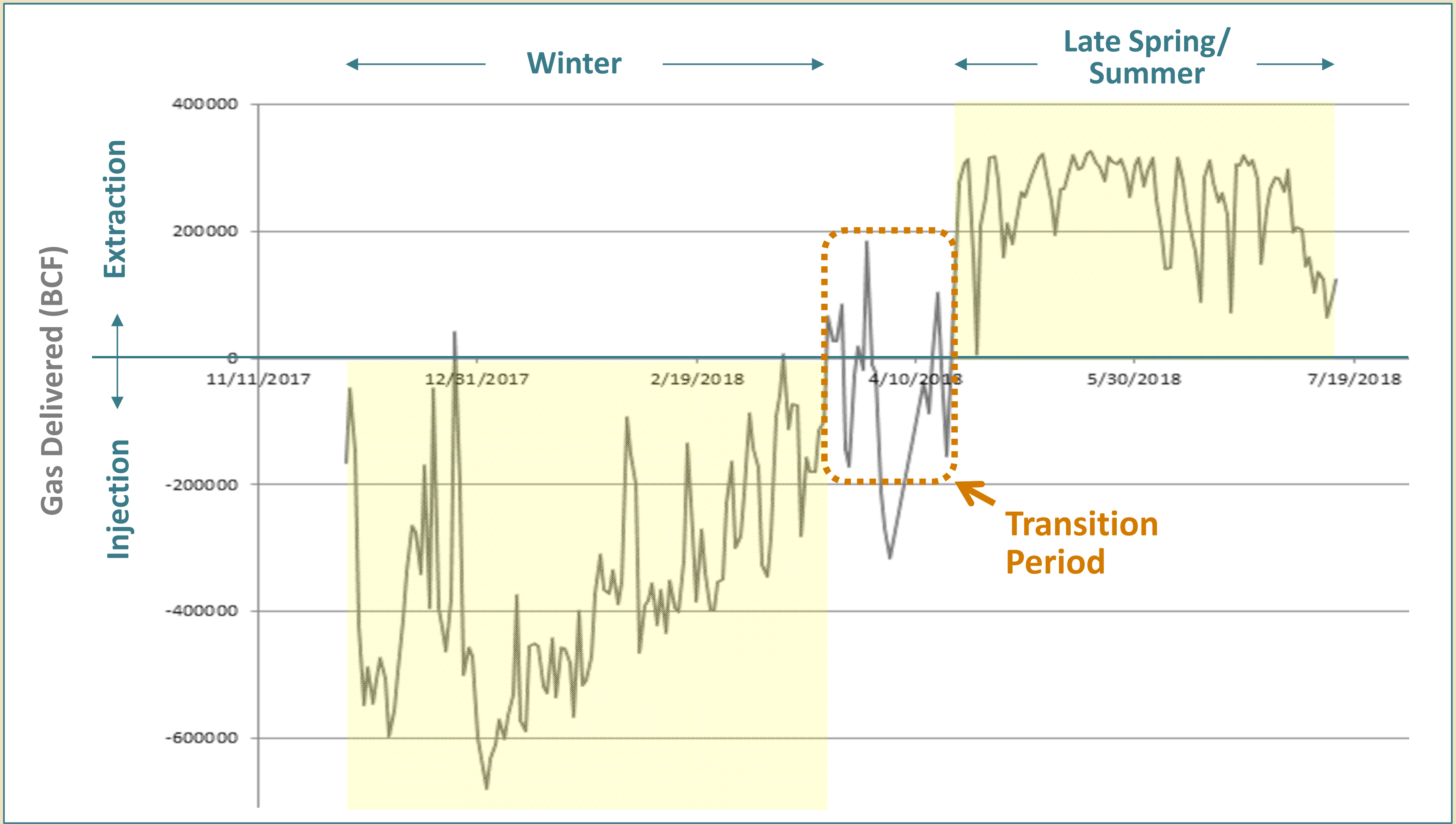


Live Webcams

SOIL HEAT MONITORING
Preliminary Observations

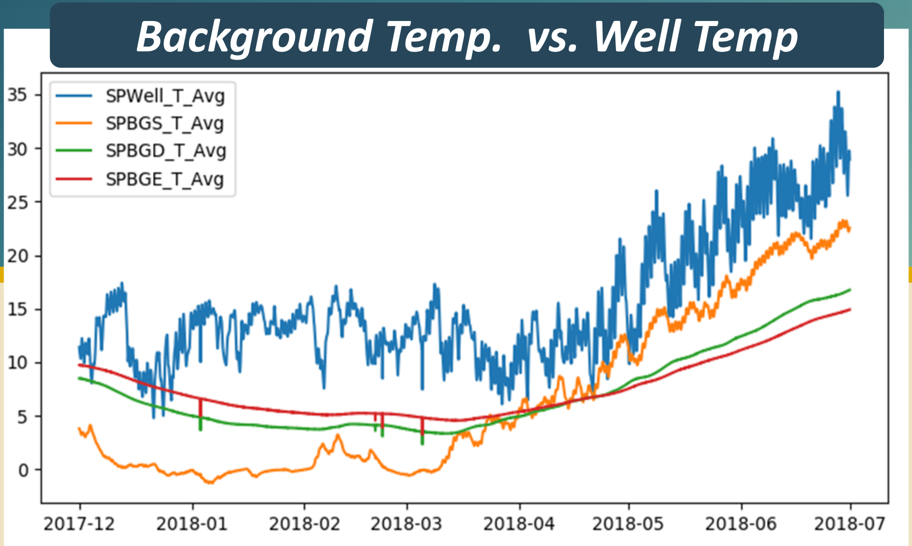


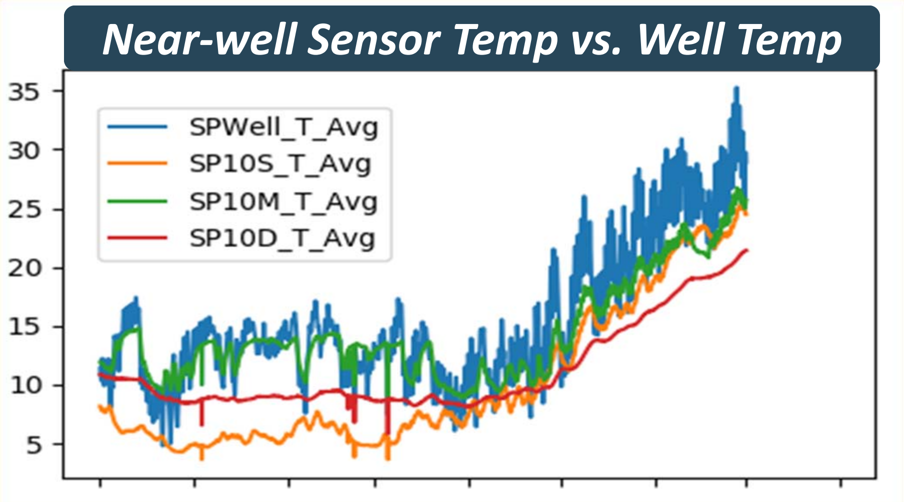
FACILITY OPERATIONS
Gas Injection vs. Extraction

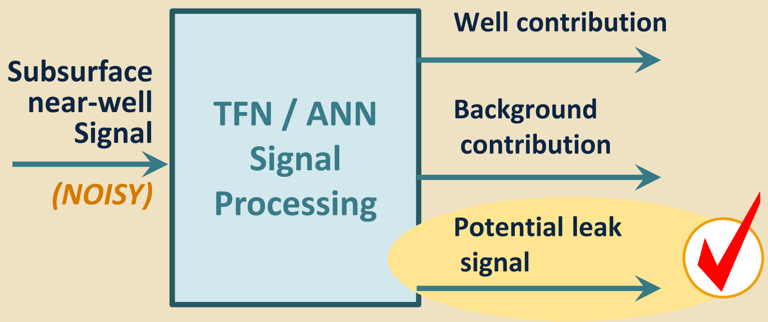


WELL HEAT INTERFERENCE
Key Observations

- **Valuable data collected in the past >8 months by the installed instrumentation.**
- **Subsurface near-well temperature signals largely overshadow methane-generated temperature signals**
  - *Except during "quiet" injection/extraction transition periods; ~2 months/yr*
- **More desired temperature change observations (due to methane seepage) can potentially be detected by advanced data analysis**
  - *Transfer-function-noise (TFN)*
  - *Artificial neural network (ANN)*
- **Controlled methane releases can provide valuable data to verify signal processing approach**
  - *Constant vs. pulsed releases at select sensor locations using existing installed equipment*



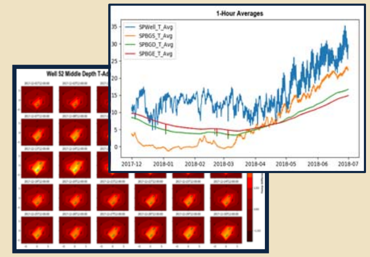




BELOW-GROUND SEEPAGE *Next Steps*

DATA ANALYSIS

- Signal processing → Heat of biodegradation from subsurface methane seepage



LONGITUDINAL FLUX TESTING

- Focused testing on well(s) with strongest usable heat signal
- Controlled below-ground methane release

TECH TRANSFER

- TASC Meetings
- Conferences / Publications

TECHNOLOGY TRANSFER ACTIVITIES

Interactive Project Collaboration

- **Technical Advisory Steering Committees (TASCs)**
  >50 participants from industry/regulatory/academia/ government/NGO on 3 TASC calls in May 2018
- **DOE participants on 2 calls in March 2018**
- **All provided critical feedback to assess EF development and in-ground sensor program**

Gas Composition - Industry

Q: ***Could GSI separate data by site visit, e.g., what is the % leaking for FC1 compared to FC2?***

A: ***Yes, done. Comparable results indicate no need for seasonally variable EFs.***

Storage Wells Comment – EPA

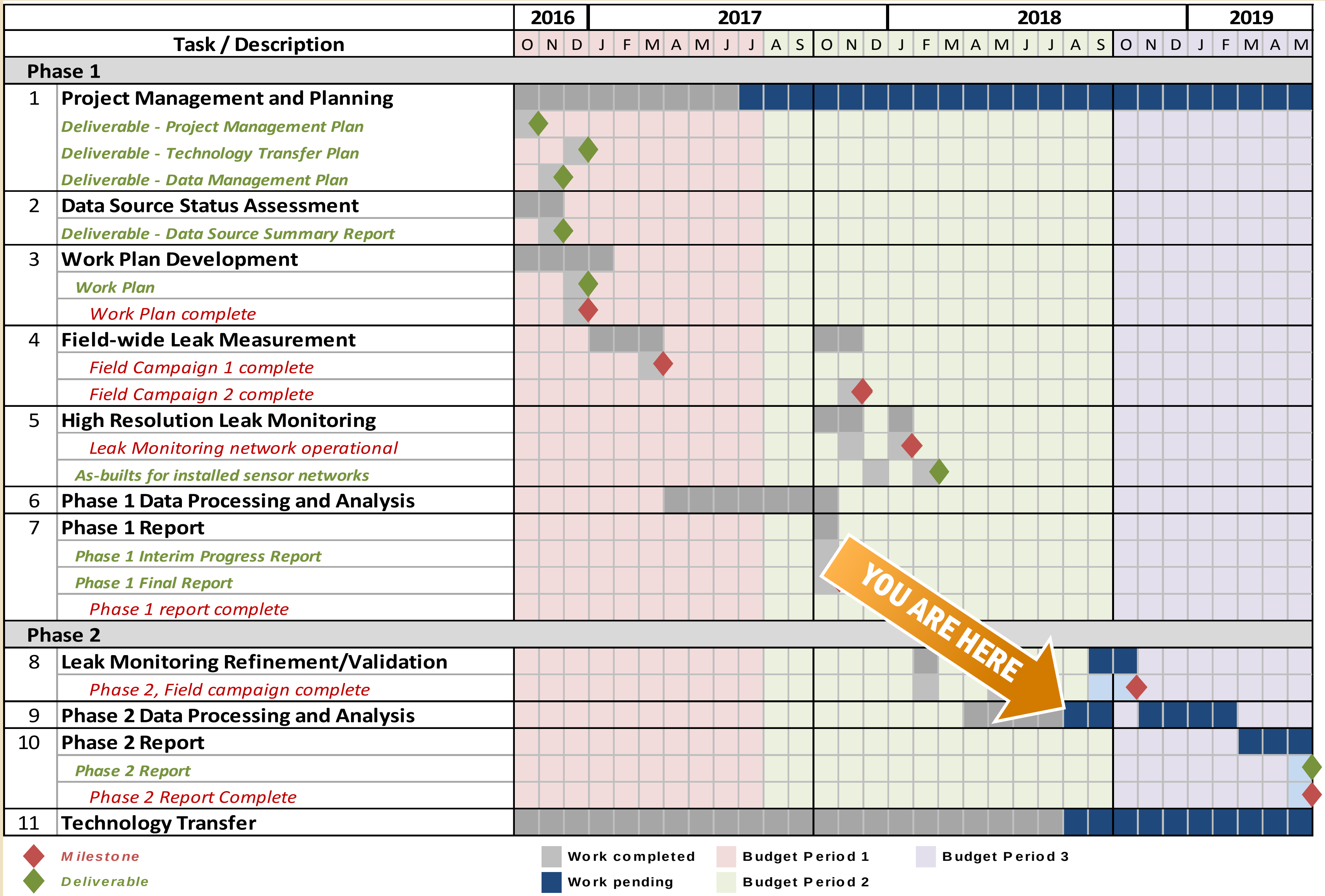
"Storage wells are a small source of methane emissions, but EPA does, and will continue to, track"

Gas Fingerprinting - Industry

Q*: Can you speak to separating out biogenic vs. thermogenic sources for subsurface CH4?*

A: ***Performed analysis of methane, ethane, propane, etc. ratios to fingerprint gas type.***

PROJECT PROGRESS / TIMELINE



THANK YOU!

Richard L. Bowers, PE, BCEE
512-346-4474
rlbowers@gsi-net.com

Ann P. Smith, PE, BCEE
512-346-4474
apsmith@gsi-net.com

GSI ENVIRONMENTAL