Quantification of Methane Emissions from M&R Stations

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Together, Building
a Better California

Pacific Gas and Electric (PG&E)

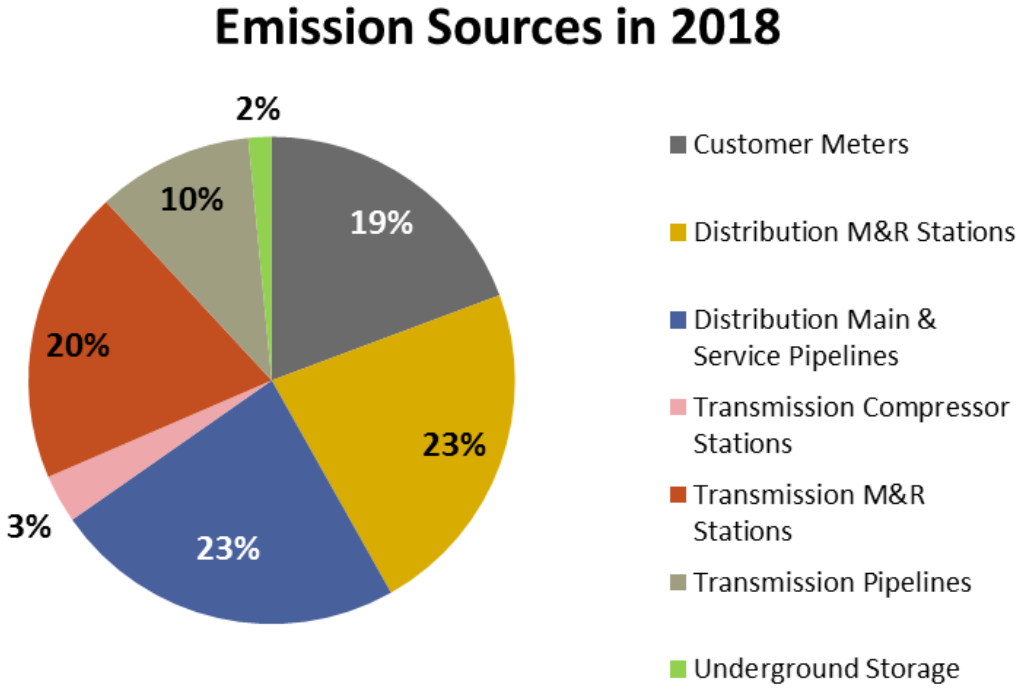
Key Statistics

- **6,600 miles** of gas **transmission** pipeline
- **43,100 miles** of gas **distribution** main
- **4.5 million** natural gas customers
- Throughput of **839 BCF** in 2018
- **8 compressor** stations
- **3 underground** storage facilities
- **2389 distribution** M&R stations
- **2809 transmission** M&R stations

SB 1371 Annual Emission Report, 2018

SB 1371

- Required CA utilities to report methane emissions focused on 7 categories.
- Reporting began in 2015 (baseline year)
- M&R stations represent 43% of our reported system emissions.
- Population-based emission factors Using GRI 1996 study results.
- Population-based emission factors do not reward leak abatement efforts



M&R Station Emission Factors

Transmission: emissions are driven by two categories of M&R stations: A2 and A3

Station Classification	Number of Stations	Annual Emissions (Mscf)	Emission Factor (Scfh)
Farm Taps	2459	30,000	1.4
T-to-T Interconnects	42	65,302	177.5
T-to-T Intraconnects	**308**	**478,878**	**177.5**
	Total (Mscf)	**574,180**	

EPA Inventory :
T-to-T stations: 2,674 (2016)
EF: 28,000 kg/year = 166 scfh
Total emissions: 3.9 bcf/y

Distribution: emissions are driven by two categories of M&R stations: A2 and A3

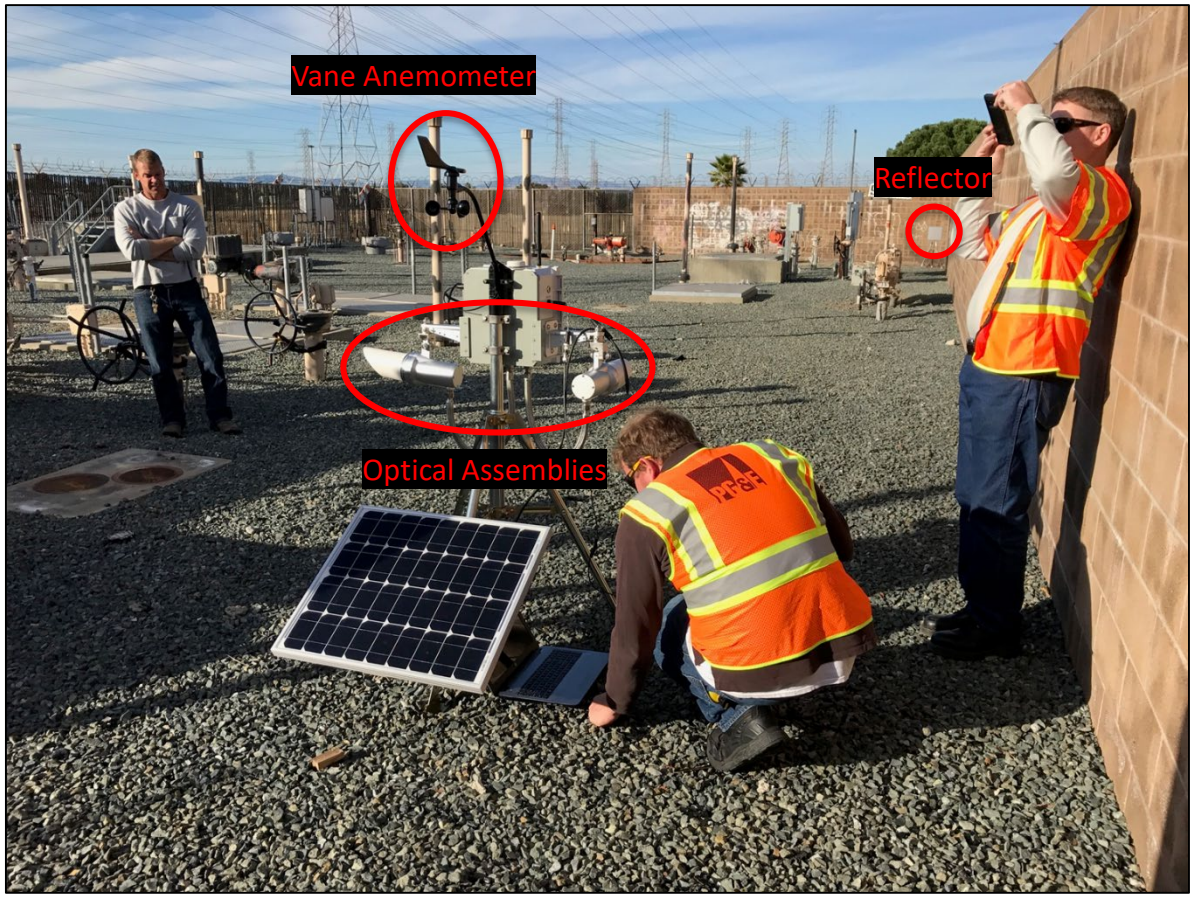
Station Classification	Number of Stations	Annual Emissions (Mscf)	GRI Emission Factor (Scfh)
A1: Above Ground < 100 psi	13	365	4.6
A2: Above Ground [100-300] psi	**92**	**82,478**	**102.3**
A3: Above Ground >300 psi	**391**	**633,372**	**192.3**
B1: Below Ground < 100 psi	323	310	0.11
B2: Below Ground [100-300] psi	683	1,281	0.21
B3: Below Ground >300 psi	887	10,958	1.4
	Total (Mscf)	**754,014**	

Source: R15-01-008 2018 June Report

Transmission Stations

Distribution Stations

Sensit: Overview



Sensit FPL unit set up at a Transmission Station in Pittsburg

Use:

- Sensit Gas Trac FPL (Fixed Point Laser)
- Installed at multiple stations for 6 months
- Collected methane concentration and wind data
- Post-processed data for flowrates

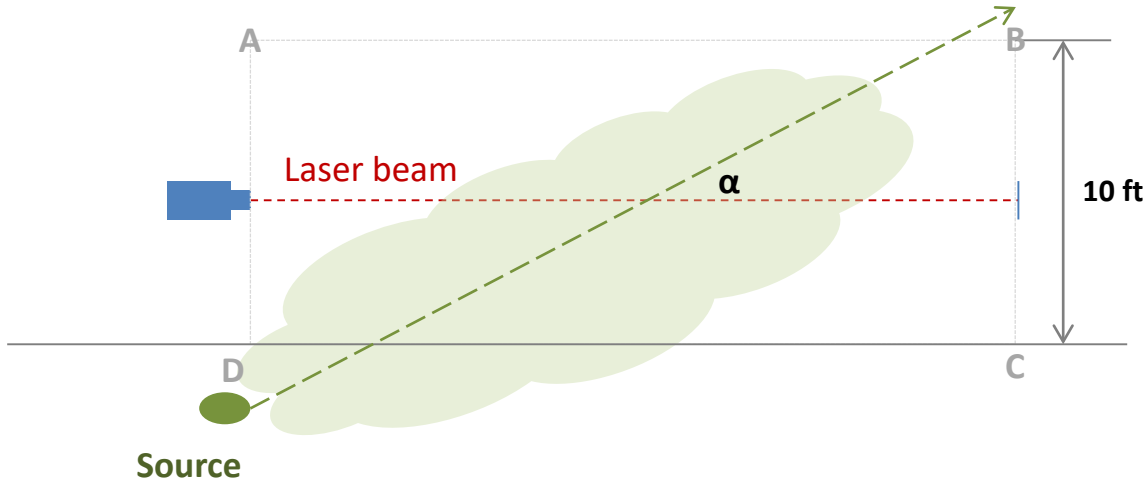
Pros:

- Continuous station monitoring
- Quick setup
- Easily accessible data

Cons:

- Only two laser paths to cover entire station
- Heavily reliant on wind
- Flowrate calculations are rough (order of magnitude)

Sensit: Flow Rate Calculation



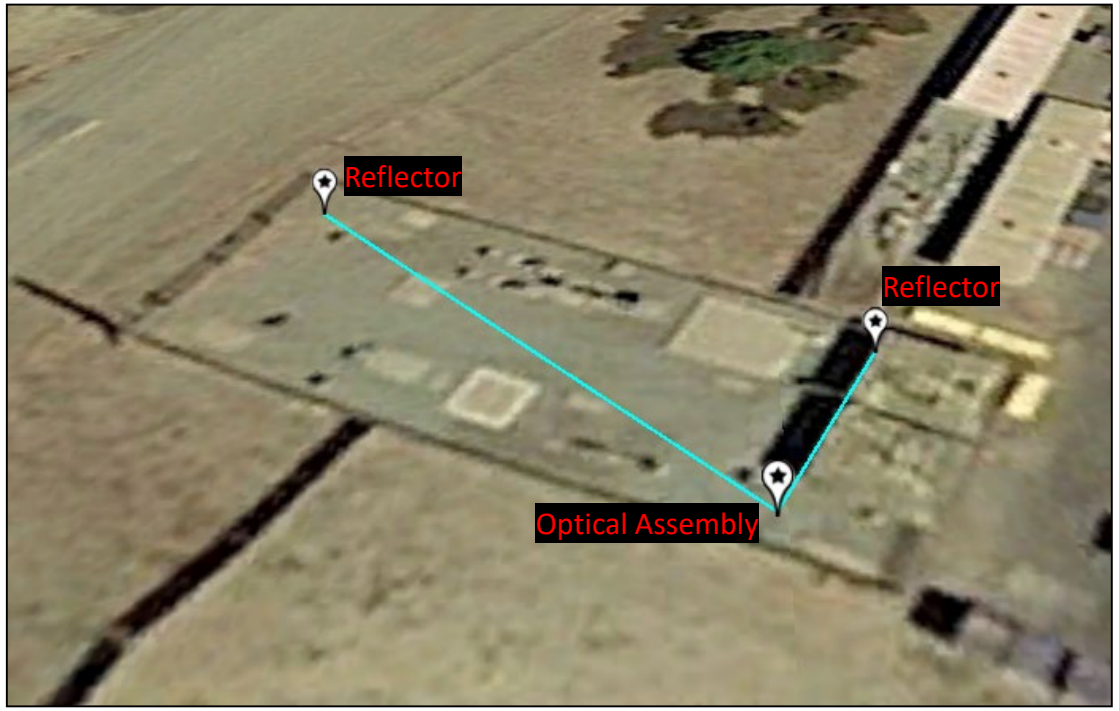
$$Flow = \left(\frac{\overline{meas}}{L} - c_{\infty}\right) \cdot L \cdot h \cdot \sin\alpha \cdot w_{Speed}$$

$\overline{meas}$: $Measurement\ averaged\ on\ 10\ minutes\ [ppm \cdot m]$
h: $Height\ of\ the\ plane\ (ABCD)\ [m]$
L: $Length\ of\ the\ laser\ beam\ [m]$
c_{∞}: $Background\ methane\ concentration\ [ppm]$
α: $Angle\ between\ the\ wind\ direction\ and\ the\ plan\ (ABCD)[degrees]$
W_{Speed}: $Wind\ speed\ [m \cdot s^{-1}]$

- Assumptions:
  1. All methane molecules from the source cross the vertical plane (ABCD) defined by the laser beam extended from the ground to a maximum height of 10 feet.
  2. The integrated concentration of methane across the laser beam is representative of the average concentration across the plane (ABCD)

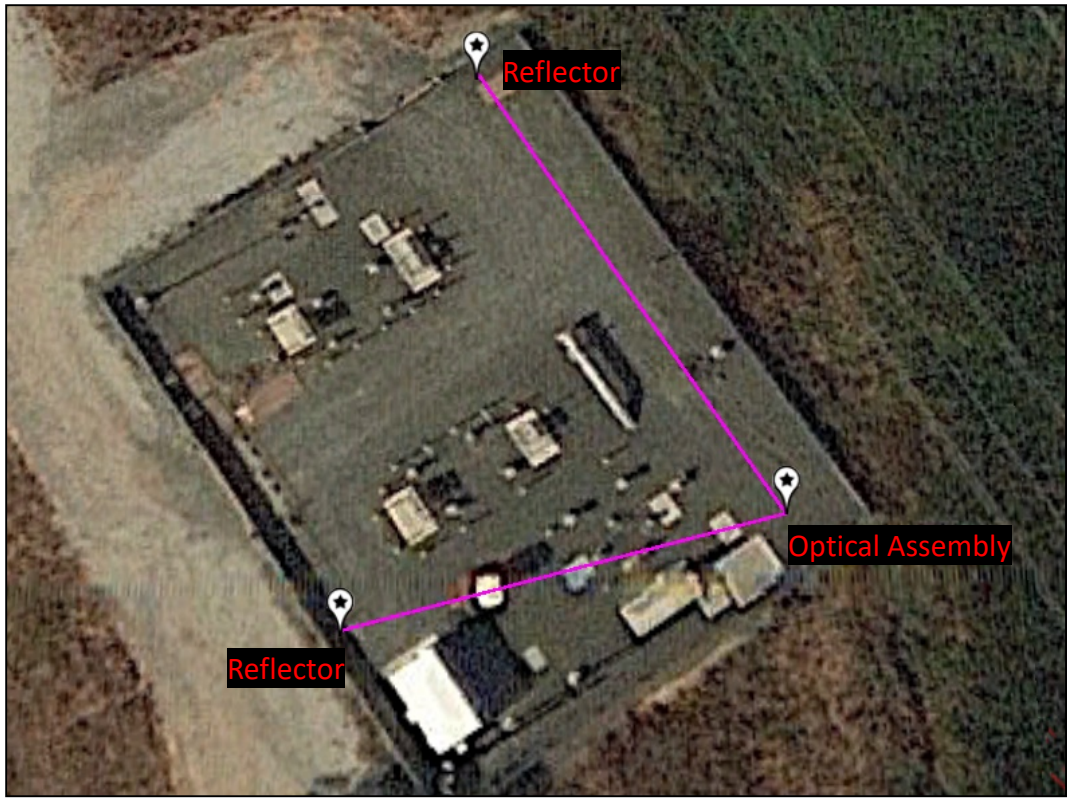
Sensit: Station Information

Harkins Road Station



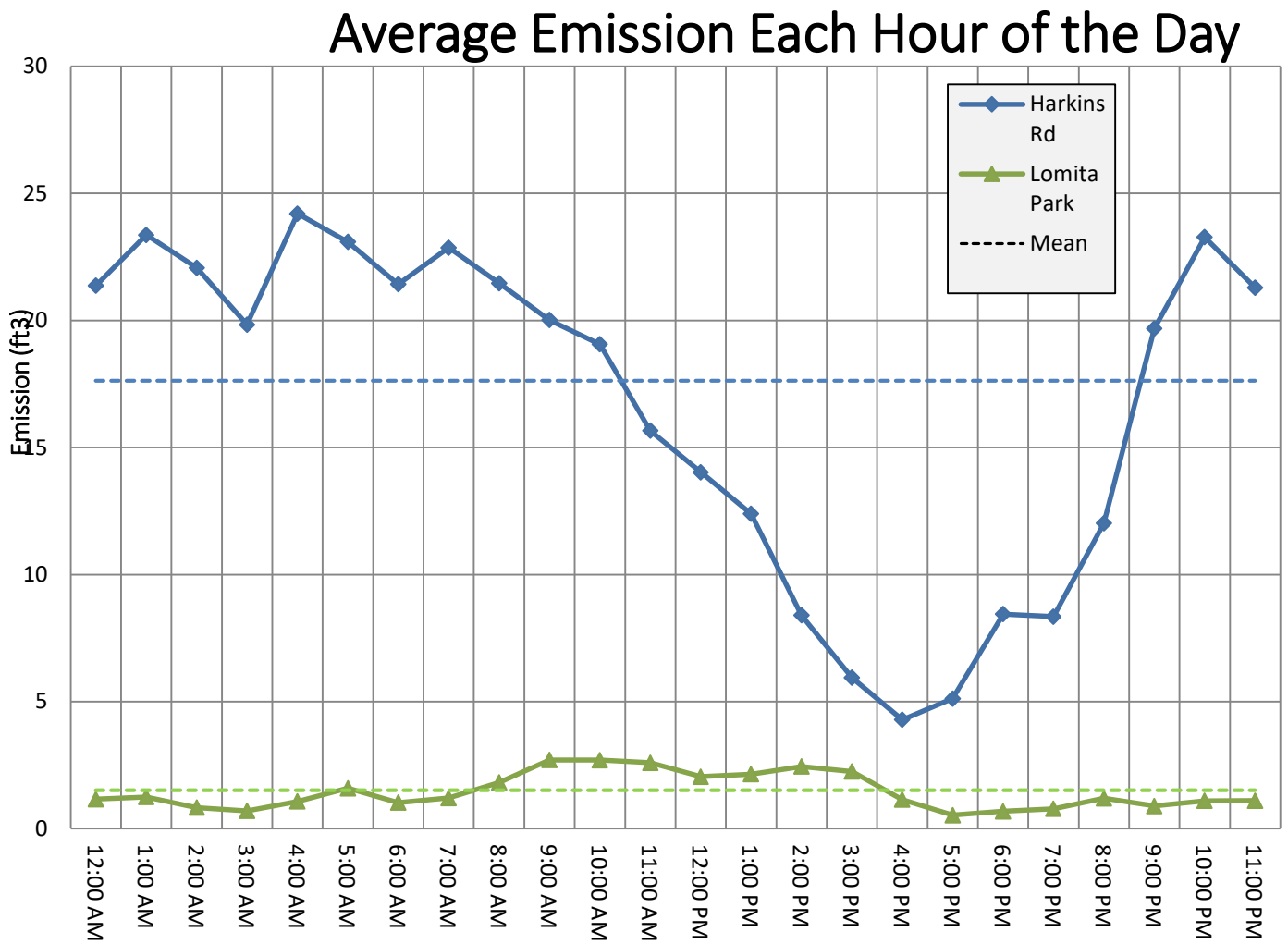
- Last upgraded in 1991
- Continuous bleed controllers

Lomita Park Station



- Rebuilt in 2015
- Intermittent bleed controllers

Sensit: Emission Data



Takeaways:

- Variations due to flow and valve actuation requirements during the day
- Spot measurements are difficult due to the variability throughout the day
- Continuous monitoring allows us to view the dynamics of the emissions

HI FLOW: Overview

Use:

- Visited 10 transmission and 10 distribution stations
- Quantified all detected leaks using a Bacharach HI FLOW sampler

Pros:

- More confidence in emission data
- More detailed information on the specific emission source

Cons:

- Not all emissions were quantifiable (below HI FLOW reading threshold of 0.6 SCFH)
- Emission readings are dependent on the time of day that the station was measured

Results were in-line with results from Sensit FPL data

Location	Sensit Avg. Reading [SCFH]	HI FLOW Measurement [SCFH]
Harkins Rd.	17.5	46.1
Lomita Park	1.5	1.3

HI FLOW: Transmission

Takeaways:

- Significant difference in data based on equipment at the station
  - Continuous bleed pneumatics vs newer intermittent bleed pneumatics
- Random large leaks at stations could drive station emissions

Highest Emitting Transmission Stations Visited:

Location	HI FLOW Measurement [SCFH]	Emissions from Vented Gas
California St	44.5	100%
Harkins Rd	46.1	98%
SP3 & L-191	63.2	92%
SF Gas Load Center	32.1	48%
Tracy	45.5	0%

HI FLOW: Transmission equipment

Continuous bleed equipment (controllers and actuators) contributing to high station emissions.

Continuous bleed regulating valve at California St.

Continuous bleed controller at Harkins Rd.

Continuous bleed controller at SP3 L-191 X-tie.

*PG&E replaced 72 high bleed devices in 2018 and has now eliminated all high bleed devices at compressor stations and underground storage facilities.

HI FLOW: Distribution

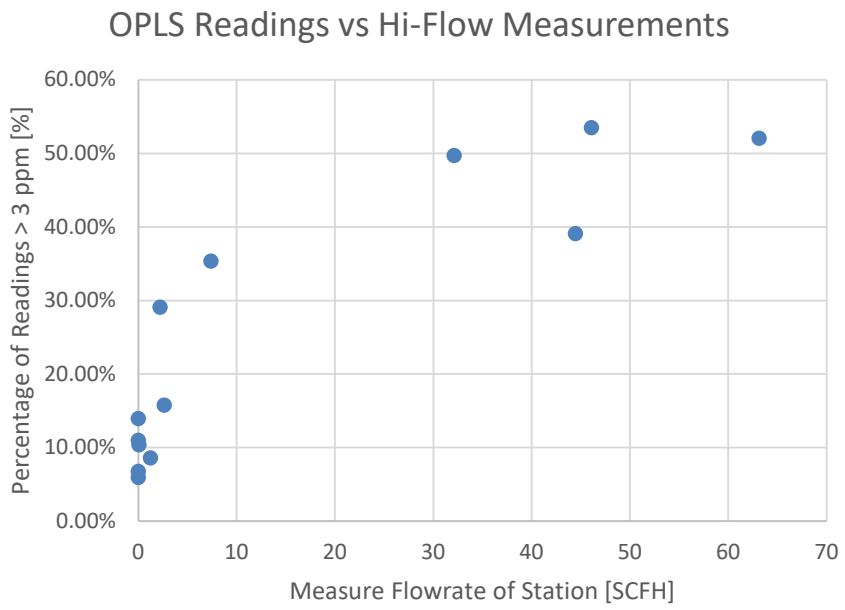
Takeaways:

- Low emissions (7 SCFH max, 1.5 SCFH average)
- Leak driven emissions

Location	HI FLOW Measurement [SCFH]	Emissions from Vented Gas
19th St	0	0%
Figueroa St	7.41	0%
Gigling Rd	2.23	0%
Hercules Station	0	0%
Pajaro St	0	0%
PA Metering Station 4	1.12	0%
Pittsburg Station	0.06	0%
Church Rd	0	0%
Rio Vista Station	1.57	33%
Sanitary Fill Rd	2.66	0%

RKI Open Path Laser Spectrometer

Station	OPLS > AVG	OPLS > 3 ppm	Recorded Emissions
19th	9.60%	10.98%	0
Figueroa	21.53%	35.32%	7.41
Gigling	17.73%	29.08%	2.23
Hercules	7.18%	5.94%	0
Pajaro	11.21%	13.93%	0
PAMS4	-	-	1.12
Pittsburg	8.23%	10.35%	0.06
Church	-	-	0
RioVista	-	-	1.57
Rumrill	7.13%	6.75%	0
Sanitary	11.10%	15.77%	2.66
California	21.90%	39.05%	44.46
Fontanoso	-	-	0
Harkins	29.37%	53.46%	46.1
Lomita	7.69%	8.59%	1.26
PLS7	-	-	32.94
SFGLC	23.16%	49.70%	32.14
Sheridan	-	-	8.96
SP3	15.06%	52.02%	63.15
Tracy	-	-	45.52



Use:

- Prototype handheld OPLS device
- Scanned equipment while at station for HI FLOW visits

Pros:

- High sensitivity (10ppb)
- Quick scanning capabilities

Cons:

- Still in development
- Dependent on wind

Takeaways:

- Data shows opportunity to evaluate station health
- Could quickly check during regular maintenance

SeekOps Emission Quantification by Drone

Use:
- Same JPL sensor as in the RKI OPLS tool
- Drone flight allows for flowrate calculations
- Visited 5 Transmission and 4 Distribution stations

Pros:
- Provides top-down emissions quantification
- Performed well in Stanford/EDF Mobile Monitoring Challenge

Cons:
- Need operators at location
- Long test required for quantification

Takeaways:
- Valuable for larger stations
- Good for identifying stations that are heavy emitters

Results of flight test

Flight test at Sheridan Rd.

1st generation of sniffer on an sUAS

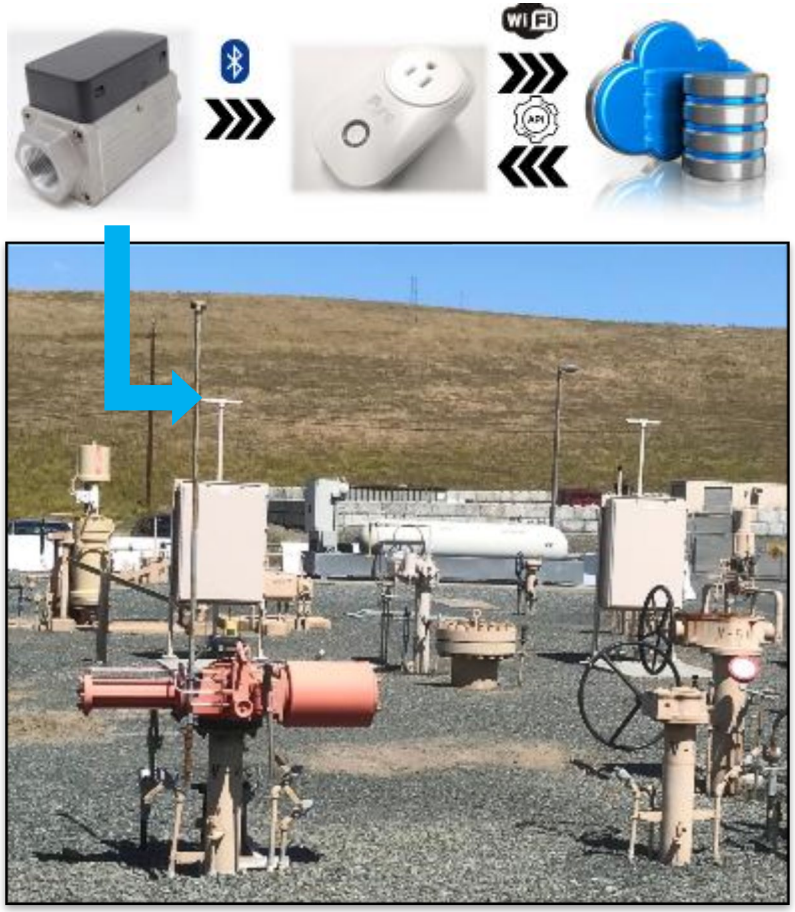
SeekOps: Results

Station	Emissions (scfh)
Sheridan Road Station	27.4
Vargas Station	0
Fontanoso Road Station	0
PLS7_San Jose	8.3
Tracy Station	2.0
Gigling Road Station	1.9
Sanitary Fill Road Station	3.0
Gonzales River Station	0
San Vincente Station	0

Results:

- Very low emissions for majority of stations
- Sheridan Rd has intermittent bleed controllers
- Sheridan Rd emissions are relatively small compared with EFs and large emitting stations

Dexen Industries Gas Flow Meter



Use:
- Currently undergoing lab testing
- Future installs at M&R stations on vents

Pros:
- Get continuous vented emissions data
- Get direct measurement on vents

Cons:
- Still in testing
- Setup not ideal for remote locations

Configuration	Flow Range (CFH)	Temperature (°C)	Pressure (PSIG)
1/2 " NPT	1.1 - 141	-20 - 60	0 - 1
1" NPT	1.5 - 212	"	"

Picarro Mobile Survey System

Use:

- Annually drive entire service territory
- Inspect large detections

Pros:

- Rapid scan of stations
- Detection within order of magnitude
- Data is already collected on drives for leak detection and can be analyzed for stations

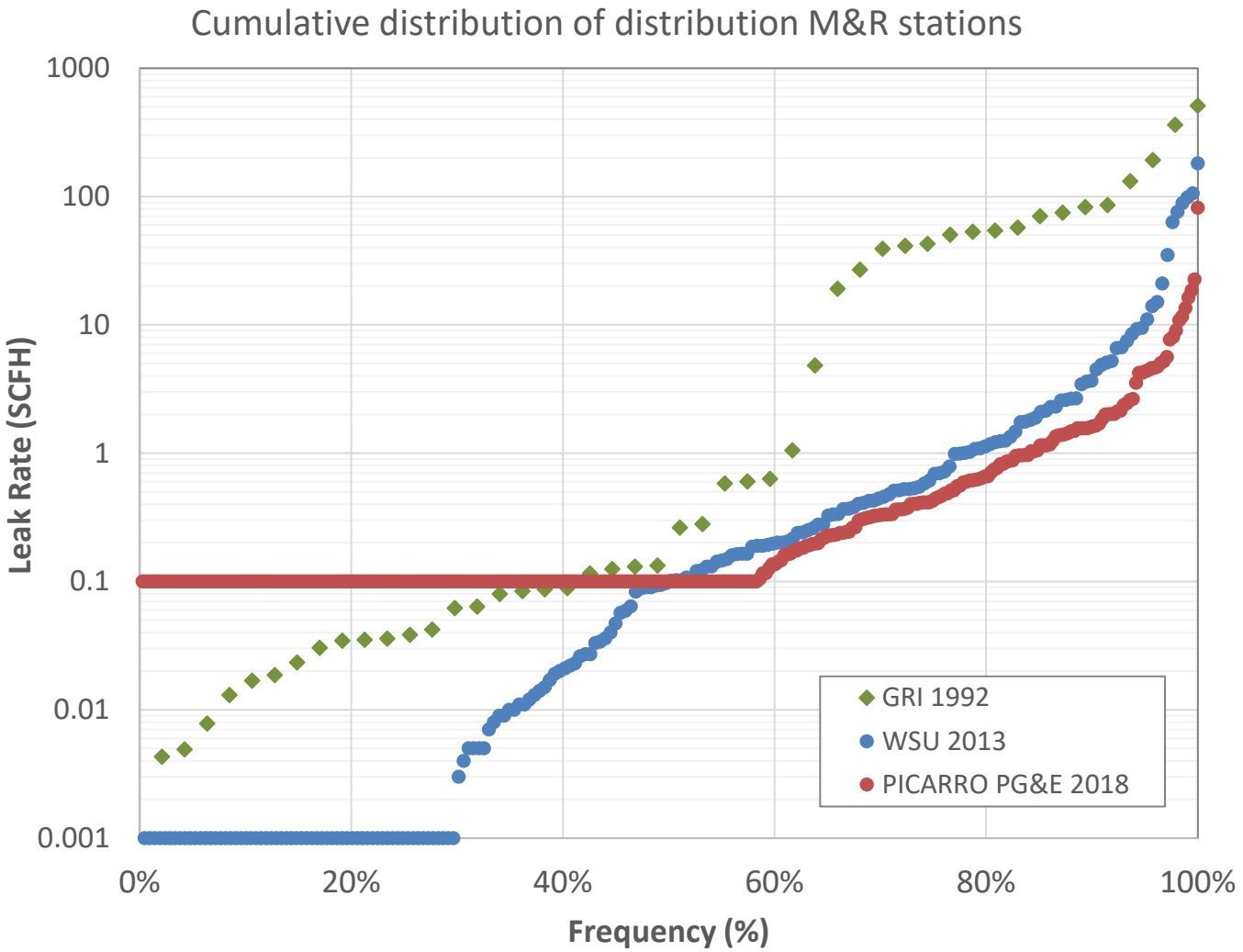
Cons:

- Only covers stations near distribution piping and roads
- Gas inlet is low and might not “see” vent stacks

Takeaways:

- Quickest way to cover stations
- Use data to determine stations with unexpected large emissions

Picarro: Distribution Station Results



Results:

- Analyzed Picarro emissions data from reg stations “seen” by car over the last 3 years
- Stations follow a Super Emitter distribution
- Data close to WSU study
- Show value in using mobile leak detection system to survey for large emitting stations to prioritize for repair

Looking Forward

What we've seen:

- Station emissions are equipment dependent
- Station leaks follow a Super Emitter model

Where we want to go:

- Categorize stations for emissions based on equipment
  - Continuous bleed
  - Intermittent bleed
  - No bleed
- Regularly survey stations with a combination of technology to detect larger leaks
  - Picarro Super Emitter surveys
  - SeekOps flights at larger stations
  - RKI OPLS scans during station maintenance

Thank you!

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