

**Contributing Factors to
the Four Corners
Methane Hot Spot
and
Converting Fugitive
Methane Gas Emissions
into a Viable Resource**

**Fruitland Formation Outcrop,
San Juan Basin, Colorado.**



LT Environmental, Inc.
COMPLIANCE / ENGINEERING / REMEDIATION



MEET OUR TEAM

Methane Seep Monitoring and Capture – La Plata and Archuleta Counties, Colorado



ASHLEY AGER, M.S., P.G.
Senior Geologist

Manager of Four Corners office with 14 years of environmental consulting experience in CO, NM, and UT.



CHRIS SHEPHARD, P.E.
Senior Design Engineer

Design Engineer for coal bed gas mitigation, collection and cogeneration.



DAN MOIR, P.G.
Senior Geologist

Technical lead for outcrop monitoring in Archuleta, La Plata, and Las Animas counties, Colorado.



DEVIN HENCMANN
Project Manager/Field Staff

Implements project and in charge of all data collection and operations and maintenance.



BIG NEWS

Why is there a huge methane hotspot in the American Southwest?

By LAURA SANTHANAM
Published: June 3, 2015



Delaware-Size Gas Plume Over West Illustrates
the Cost of Leaking Methane

The Washington Post

By Joby Warrick
Published: December 29, 2014

America's Tiny Four Corners Region is an
Outsized Methane Hotspot

By Elizabeth Barber
Published: October 10, 2014

TIME

America's Massive Methane Mystery: NASA Set to
Investigate Unexplained Hotspot over the Four Corners

Daily Mail
.com

Intersection in Southwest
By Mark Prigg
Published: April 8, 2015.

What's Causing the Hot Spot?

By Peter Marcus
Published: June 3, 2015

THE DURANGO HERALD
Since 1881

Satellite Sees Hot Spot of Methane in US Southwest

THE DENVER POST

By Seth Borenstein
Published: October 9, 2014

Mysterious Methane Mass Hovering over Southwest

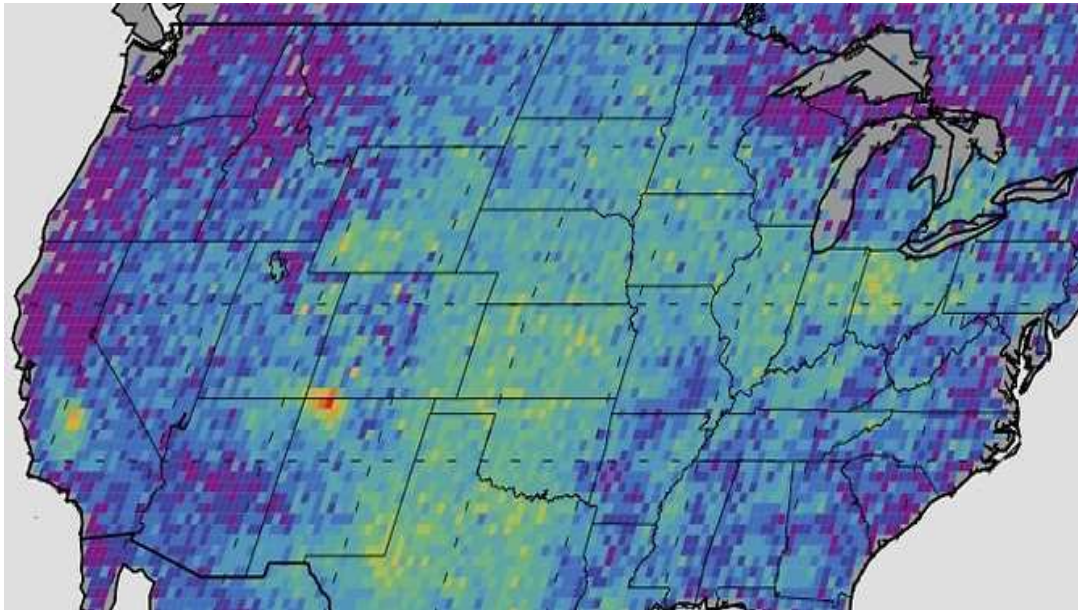
By Associated Press
Published April 9, 2015.

CBS NEWS

Methane Hot Spot Prompts Delegation to Ask for Quick Action

**ALBUQUERQUE
JOURNAL**

By Susan Montoya Bryan
Published: July 20, 2015



FOUR CORNERS HOTSPOT

- Joint study by NASA's Jet Propulsion Laboratory and University of Michigan in *Geophysical Research Letters*
- Satellite Spectrometer from 2003 - 2009
- Largest concentration of methane in the United States (concentrations, not emissions)
- Supported by ground-based testing by Los Alamos National Laboratory conducted at the San Juan Generating Station

155,000-ton gap between reported emissions and amount estimated to produce the concentrated plume.

METHANE HOT SPOT

#1 CBM Production Basin in US

CBM wells account for 45% of production in San Juan Basin.

EMISSIONS

Research team indicated oil and gas production in the DJ Basin emitted three times more methane than the EPA inventory showed; tends to be 1.5 times nationwide.

TOPOGRAPHY

Isolated location and local winds

UNKNOWN SOURCE

Spectrometry data shows all methane from all sources.

COAL MINES, POWER PLANTS

Other sources - underground mine vents methane for safety.

GEOLOGIC SEEPS

Directly from the Fruitland Outcrop.

GEOLOGIC SEEPS

Dead Vegetation, Grayish Colored Soil



CREEK SEEPAGE

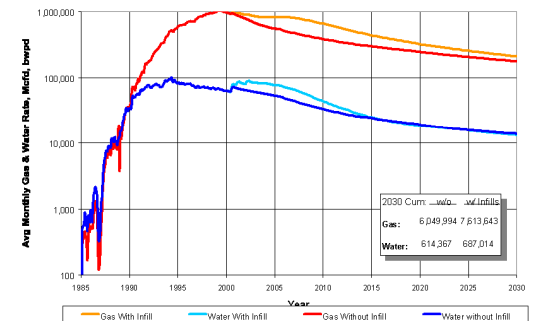


4M PROJECT

Mapping, Monitoring, Modeling, and Mitigation



Figure 80: 3M Projections with and without Infill Wells



COGCC established the 3M (Mapping, Monitoring, and Modeling) Project to develop a more comprehensive understanding of outcrop seepage.

Expanded to 4M (Mitigation) in 2007

MAPPING AND MONITORING



GPS/Geologic Mapping



Vehicle



Slide Hammer/LEL Meter



Probes



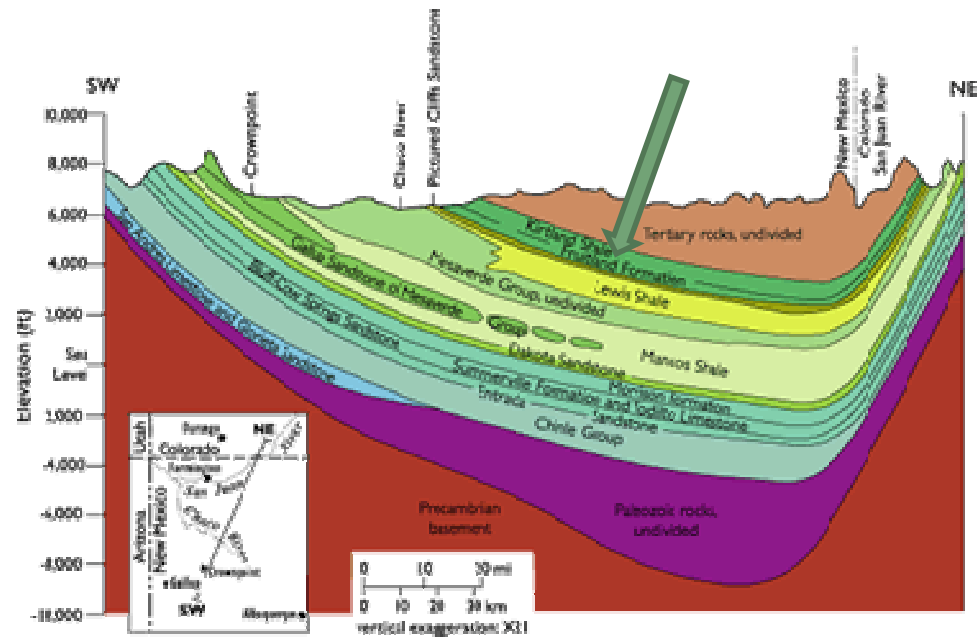
Flux Chambers



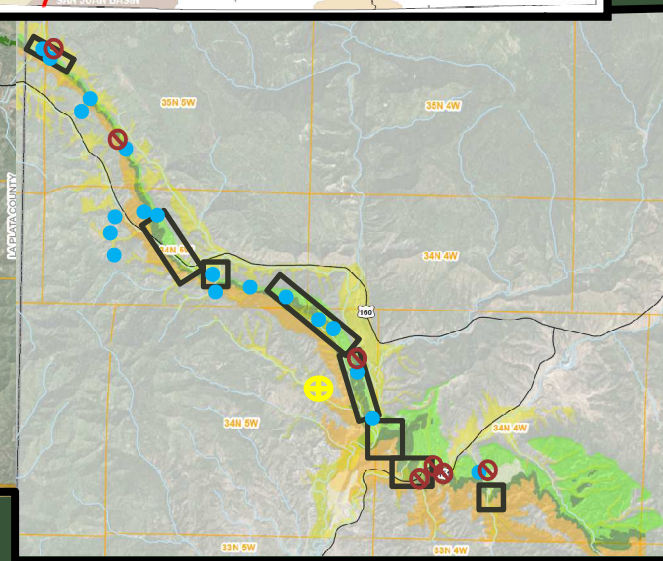
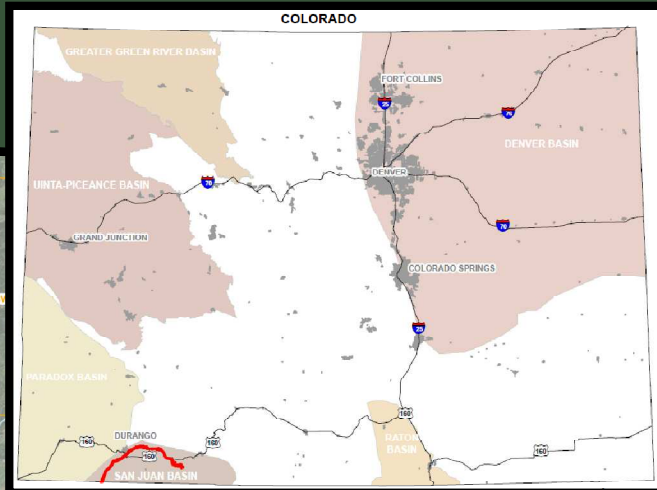
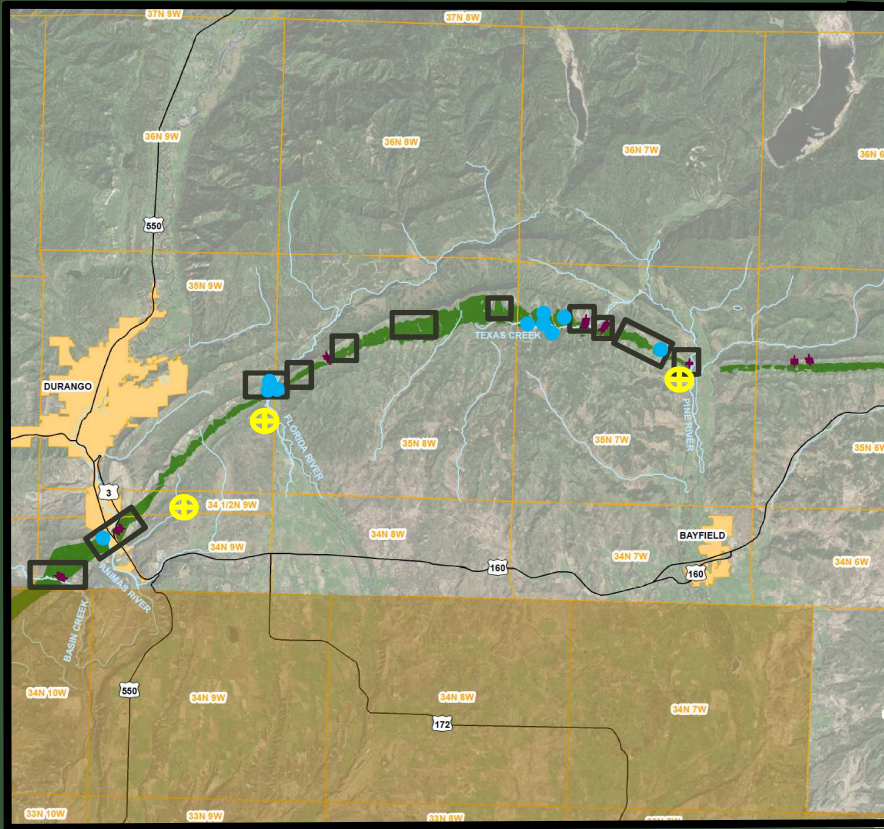
Flux Mapping
Flux Meter since 2007

FRUITLAND OUTCROP

ERA PER	EPOCH	DEPOSITION TIMES IN MILLIONS OF YEARS AGO	SOUTHEASTERN SAN JUAN BASIN		
			FORMATION	MEMBER	
GENOZOIC	HOLOCENE		Terrace and piedmont deposits		
	PLEISTOCENE		Volcanics		
				Santa Fe Group	
	NEOGENE	PLIOCENE			
		MIOCENE			
	PALEOGENE	OLIGOCENE			
		EOCENE	54 - 38	SAN JOSE	Yagoum Mbr. Alvex Mbr. Regina Mbr. Cuba Mesa Mbr.
			64 - 60	NACIMIENTO	
	PALEOCENE	65 - 64	OJO ALAMO		
	MESOZOIC	CRETACEOUS	LATE	73 - 70	KIRTLAND
75 - 73				FRUITLAND	
					Pictured Cliffs Sandstone
					Lewis Shale
					Cliff House Sh.
					Mesaverde Group
					Point Leavitt Sh.
					Manitou Tongue
					Hoopa Tongue
					Mulatto Tongue
				Manitou Shale	
				Crevasse Canyon Fm.	
				Gallup Sandstone	
				Unnamed Shale	
			94 - 80	MANCOS	
			Samalia Ss. Mbr.		
			Rio Salado Tongue		
			Tapeats Ss. Tongue		
			Whitewater Argill. Sh. Mbr.		
			Prague Tongue		
			City Mesa Tongue		
			Luftlof Tongue		
			Oak Canyon Mbr.		
			Encinal Canyon Mbr.		
	EARLY				
JURASSIC	LATE	150 - 144	MORRISON		
	MIDDLE		Summerville Formation		
	EARLY		Todilite Formation		
TRIASSIC	LATE	230 - 213			
	MIDDLE		Chinle Group		
	EARLY		Paria Sandstone		



FRUITLAND OUTCROP



DETAILED MAPPING METHODS

WestSystems, LLC

Portable Flux Meter

Measures flux of CH_4 , H_2S , and CO_2 at the ground surface

Flux = Flow Rate per Unit Area

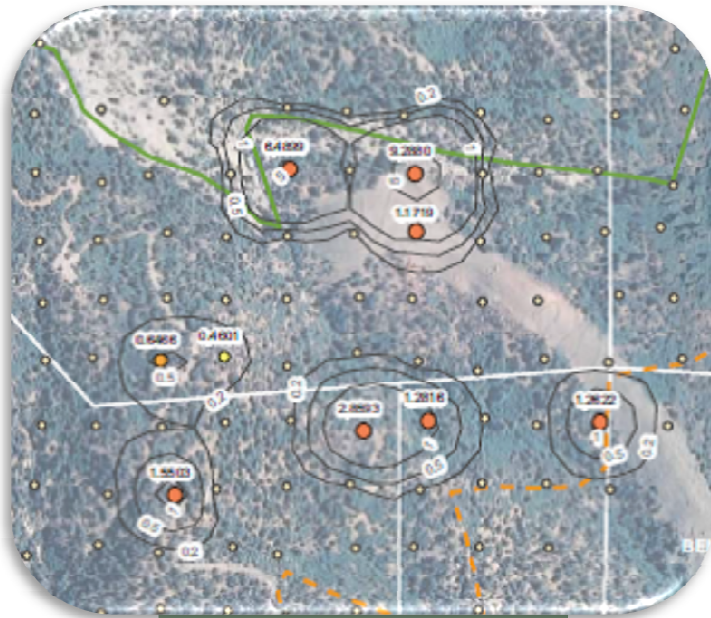
Backpack with detectors

GPS

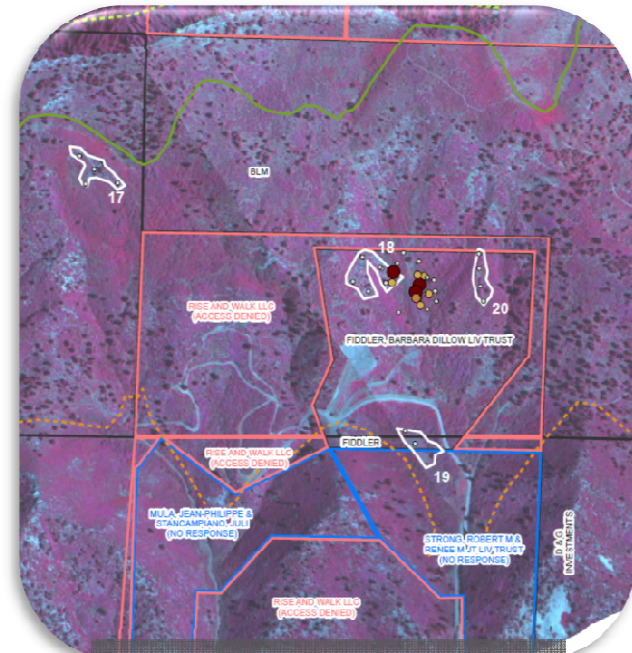
Kettle/chamber



DETAILED MAPPING METHODS



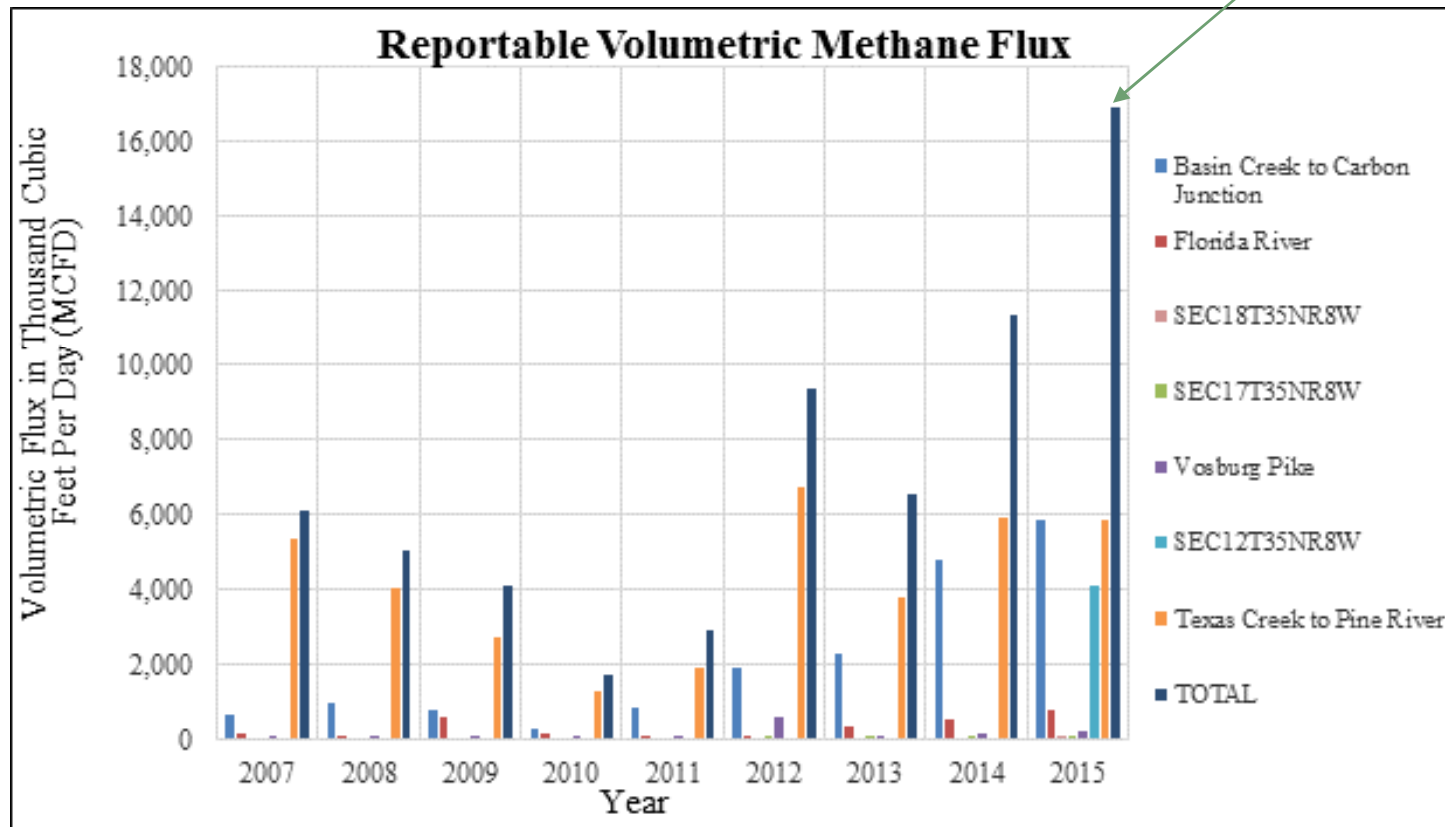
Grid Mapping System



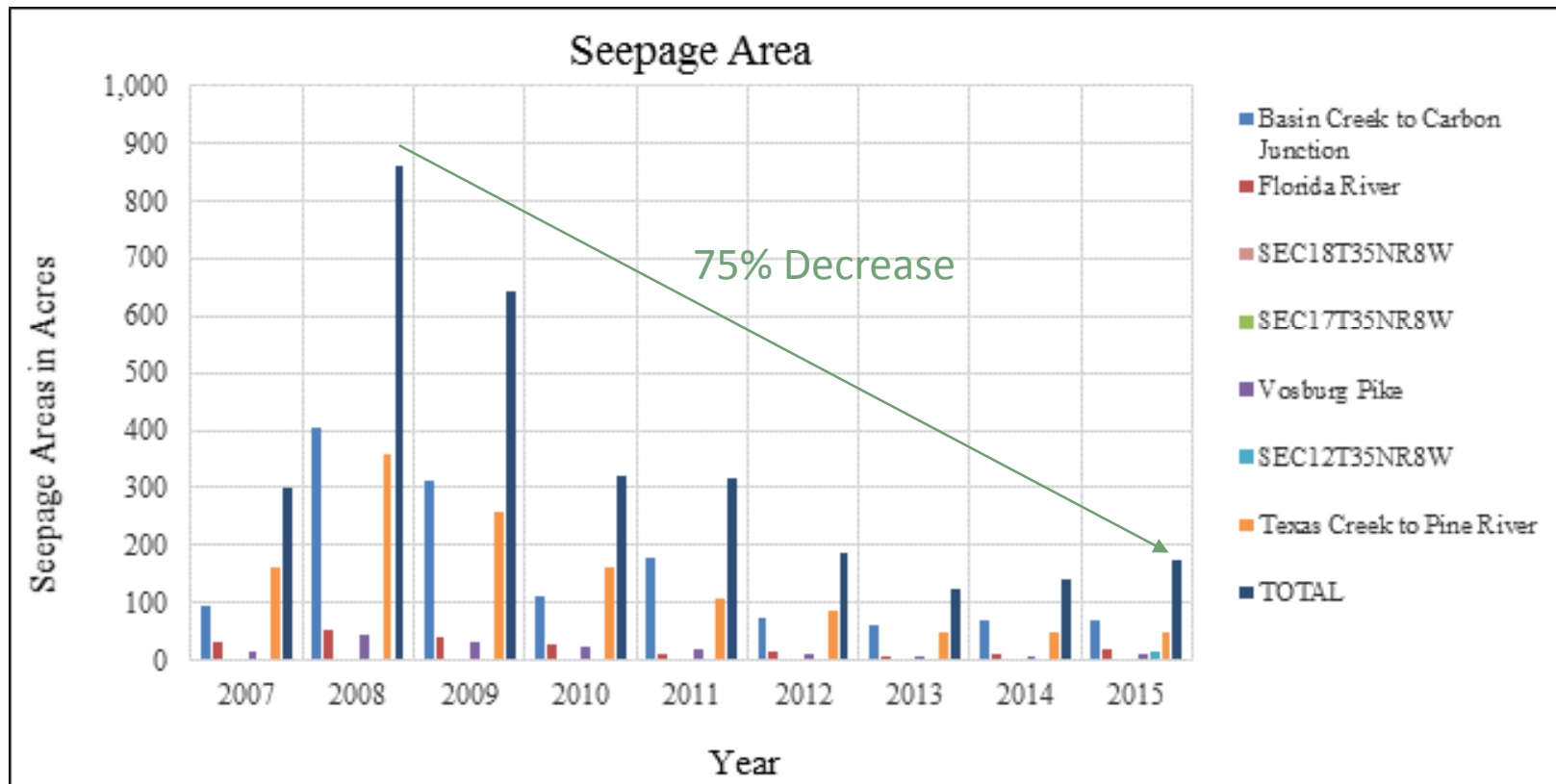
Aerial Infrared Survey

RESULTS

16,903 MCFD = 128,600 tons/year



RESULTS



MITIGATION



DESIGN

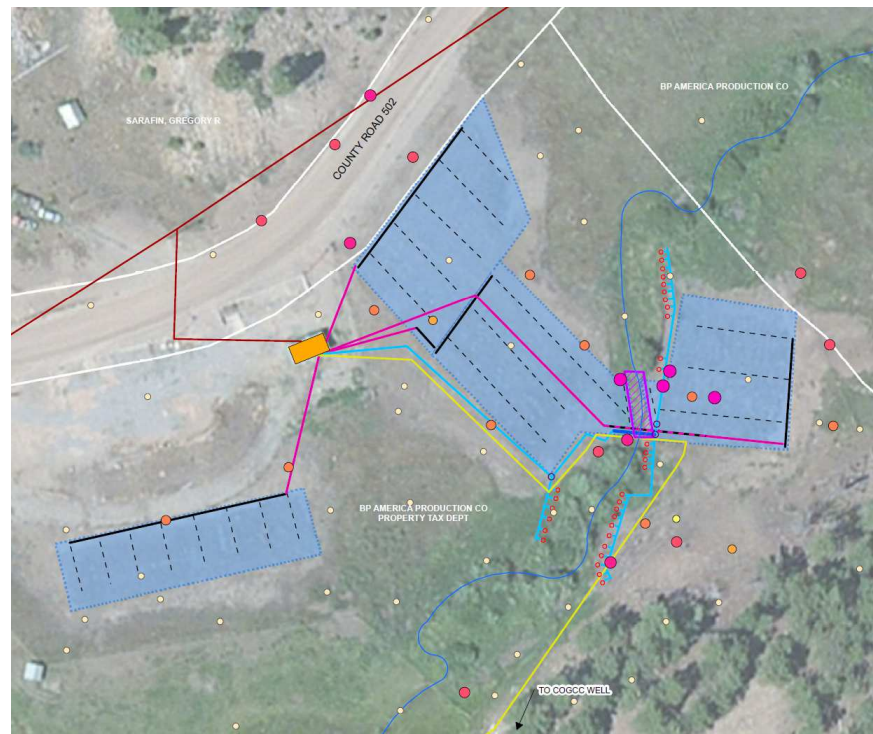
Installed in 2008-2009



4 collection areas initially



Best methane recovery observed near the creek



Subsequently added collection beneath creek with Corps of Engineers approval



0.8 acre collection area

In 2012, BP took over O&M costs

CAPTURE

Captured Gas Routed to a Combustion Chamber

Capture of methane through collection system and manifold

Capture then compress methane to allow for operation of a turbine generator.

Compression

Oilfield gas compression equipment with low vacuum/suction to optimize recovery and minimize oxygen collection.

Microturbine

Microturbine generator used for electrical generation. Spins at 30,000 to 40,000 RPM and requires limited maintenance.

Electrical Output

Electrical output is tied to the grid



15,200 MCF recovered



RESULTS

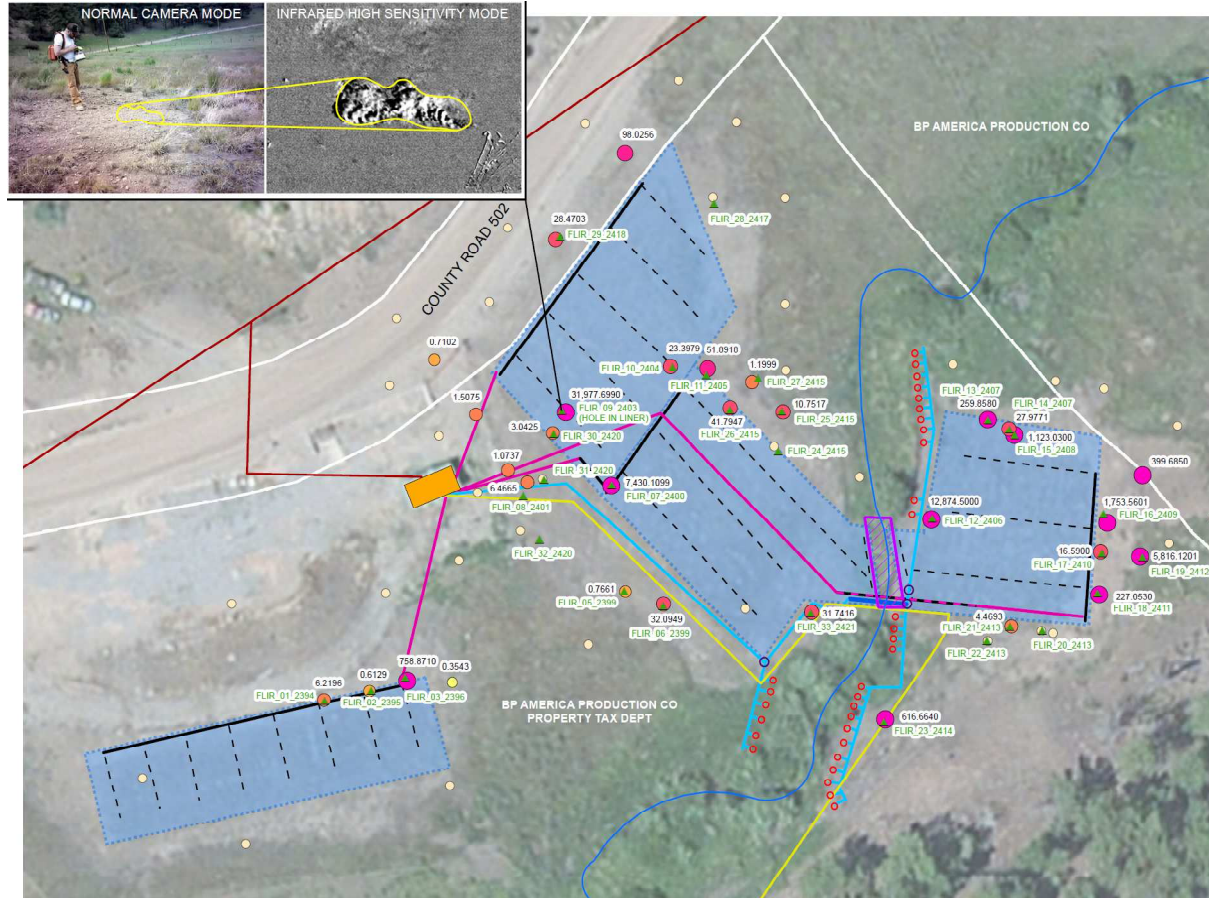


2008



2010

FLIR SURVEY



Forward-looking
Infrared (FLIR)
GF320 OGI camera

Identify leaks and
quantify with flux
meter

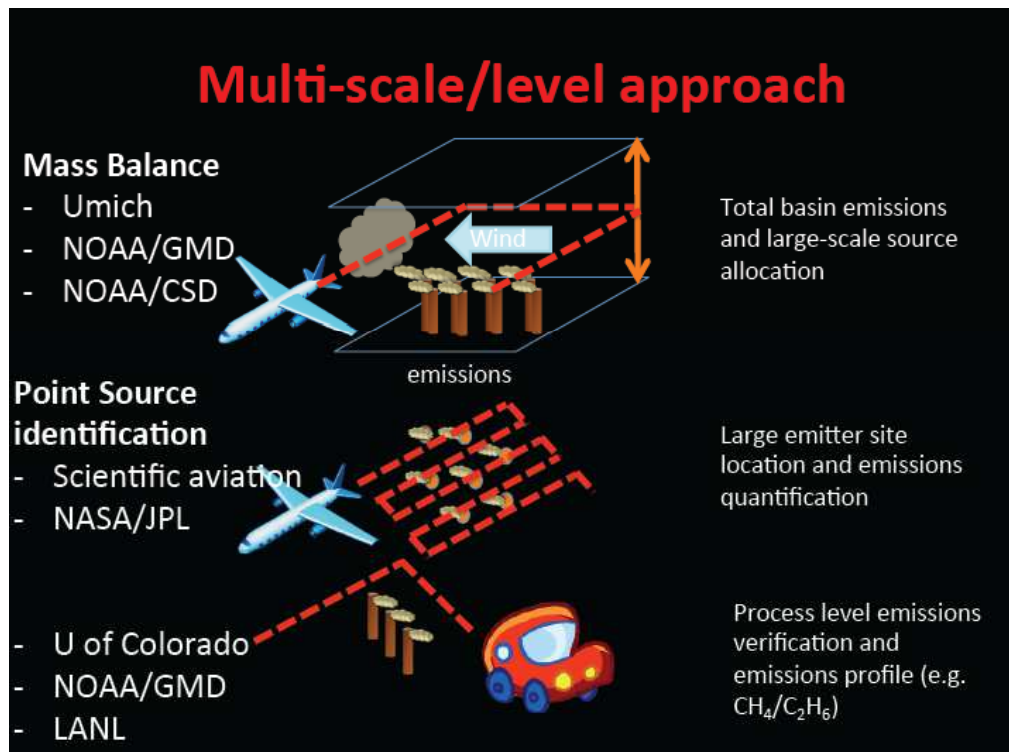
Valuable evaluation
to more accurately
measure flux

Areas of seepage
on the edge of the
liner = higher flux.

EXAMPLE



FUTURE WORK



From:

Using Aircraft for Emissions Verification

Eric Kort, University of Michigan

Russ Schnell, NOAA/GMD

Gaby Petron, **Colm Sweeney**, **Stefan**

Schwietzke, University of Colorado

Steve Conley, Scientific Aviation

Presentation made at Four Corners Air Quality
Group Public Forum

April 17, 2014

Work Conducted Summer 2015

To be published 2016

CONCLUSIONS



SIGNIFICANT SOURCE

A significant portion of the Four Corners Methane Hot Spot is likely contributed by coal bed methane seepage.

SUIT data are not published and NM data have not been gathered.



COLLABORATION

Share data and compare to more detailed source data gathered by NOAA and NASA when published.



TECHNOLOGY

Proven sustainable use of an unconventional resource

Incorporating FLIR camera into seep investigations can be used to better quantify seepage along the outcrop.



FUTURE WORK

Worldwide, many sources of methane seepage exist.

Increase production in the San Juan Basin.

Capture and use system can be more efficient.

Continue to monitor methane seepage as required by COGCC.

THANK YOU!

