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Global Waste Management Symposium 2012
Presentation Topics on Landfill Gas

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Methane Emission, Oxidation and Collection Efficiency at a Southeastern USA Landfill

Global Waste Management Symposium 2012

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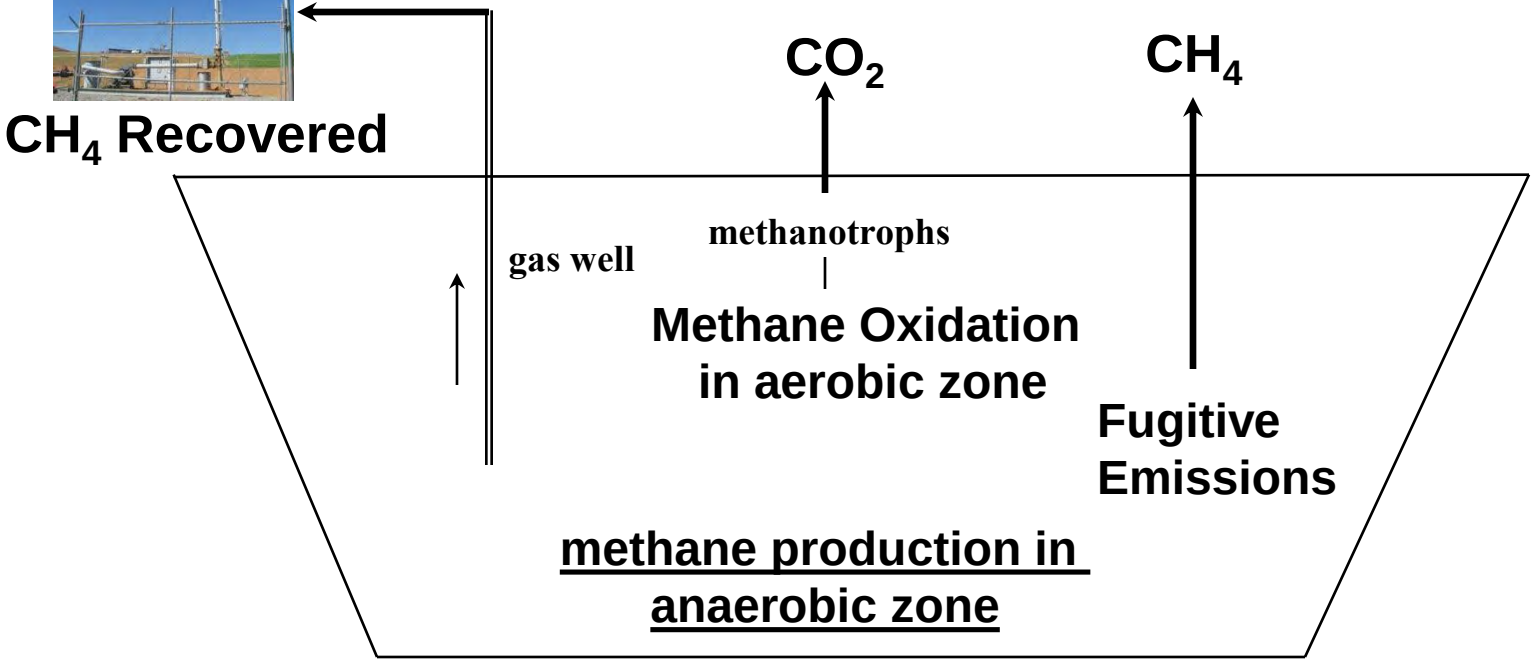
Landfill Methane Mass Balance



Methane [CH_4] produced = Σ (CH_4 recovered + CH_4 emitted + CH_4 oxidized

Objectives of Study

- Quantify and Compare approaches to measure landfill methane emissions
- Determine landfill cover methane oxidation
- Determine LFG Collection Efficiency prior to Final Cover Placement

Fugitive Landfill Methane Emissions

- **Determined two ways:**
  - **Tracer Plume Correlation Approach – Feb. 2011**
    - **Cavity Ring-Down Spectroscopy (CRD) provides simultaneous analysis of methane and tracer**
  - **Chamber Approach – Sept. 2011**
    - **Methane Oxidation by Carbon Isotope Fractionation**

Tracer Plume Correlation Method

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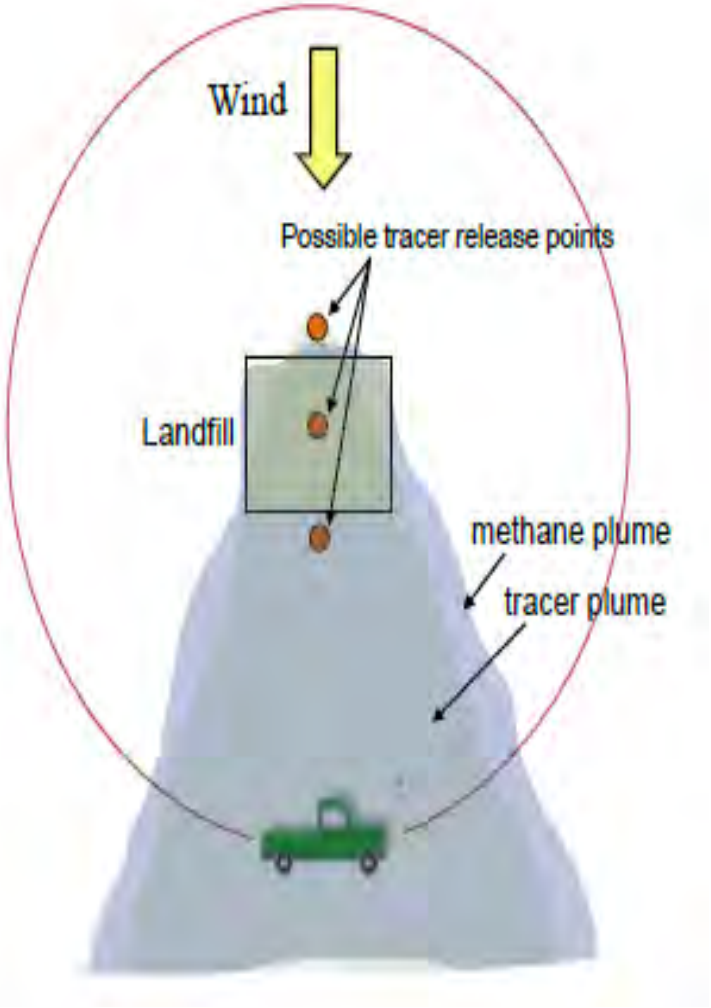
$M = T * Cm/Ct$

M = CH_4 emission rate

T = Tracer gas release rate

Cm = Concentration (above bkgd) of CH_4 observed in the plume

Ct = Concentration of tracer (above bkgd) in the plume



Challenges

- **Road access**
  - 1 – 5 km downwind for proper mixing
  - > 6 times the LF radius
- **Other nearby sources**
  - Landfills
  - WWTP
  - Farms / Manure

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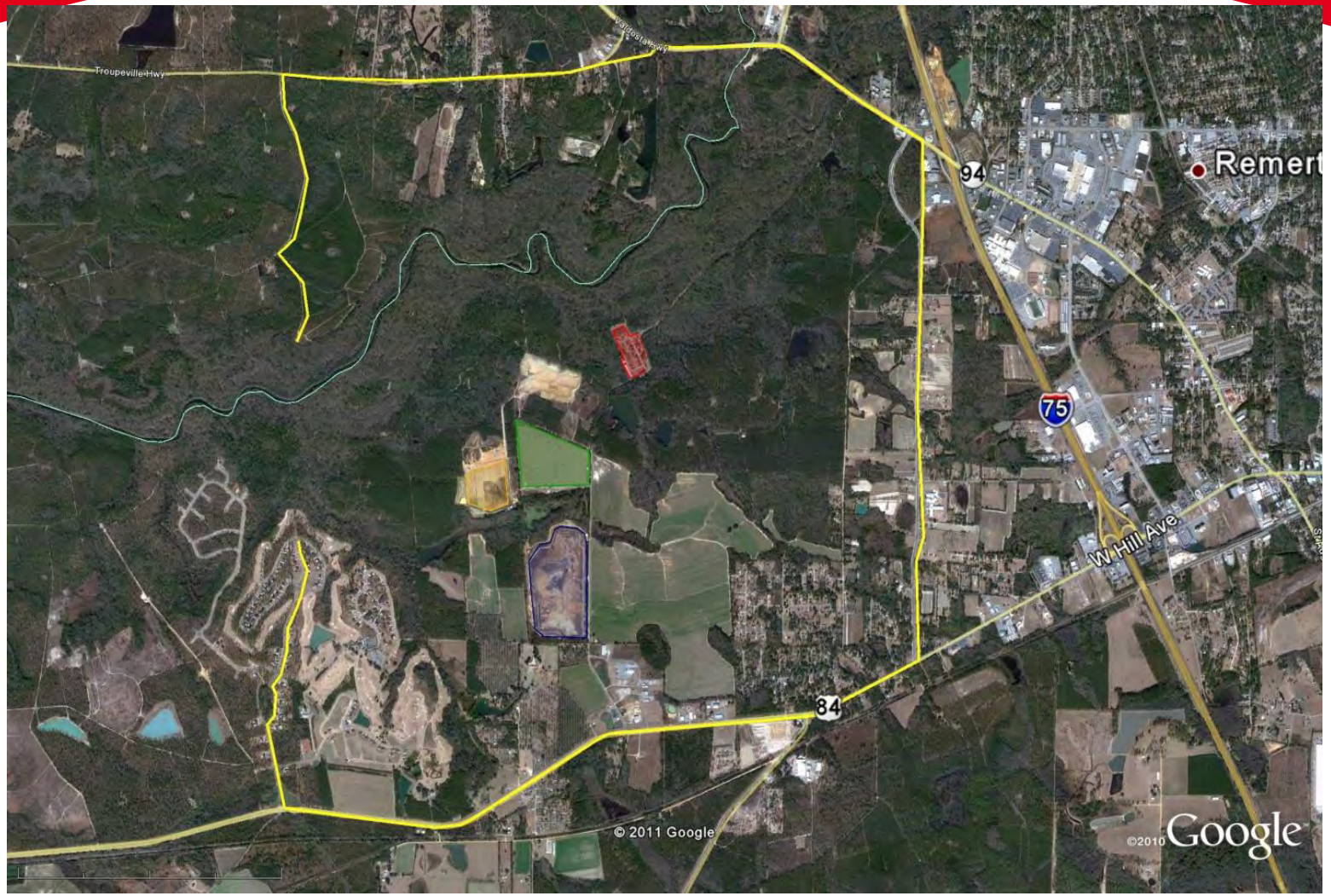

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Tracer gas release point and weather station

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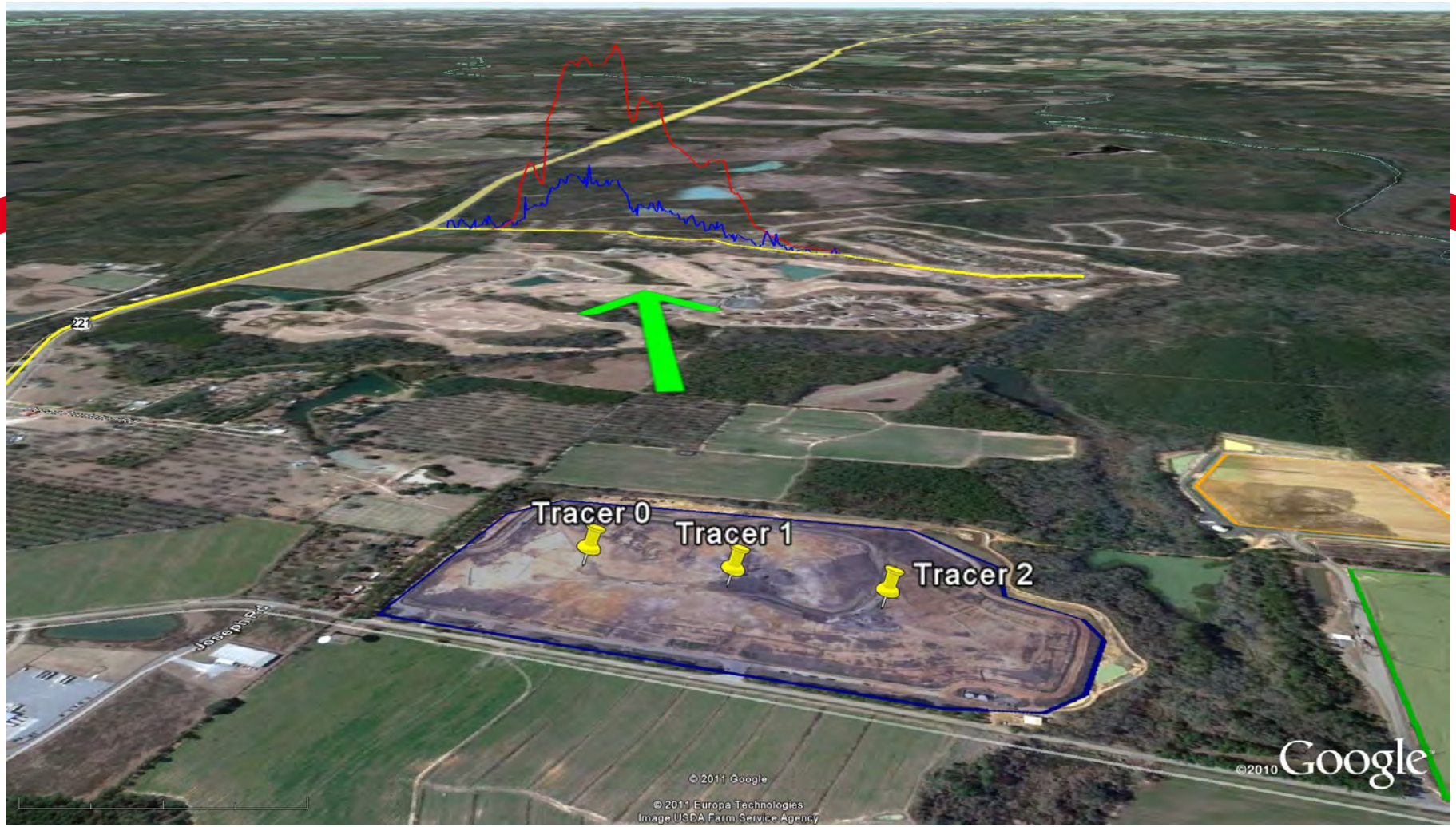
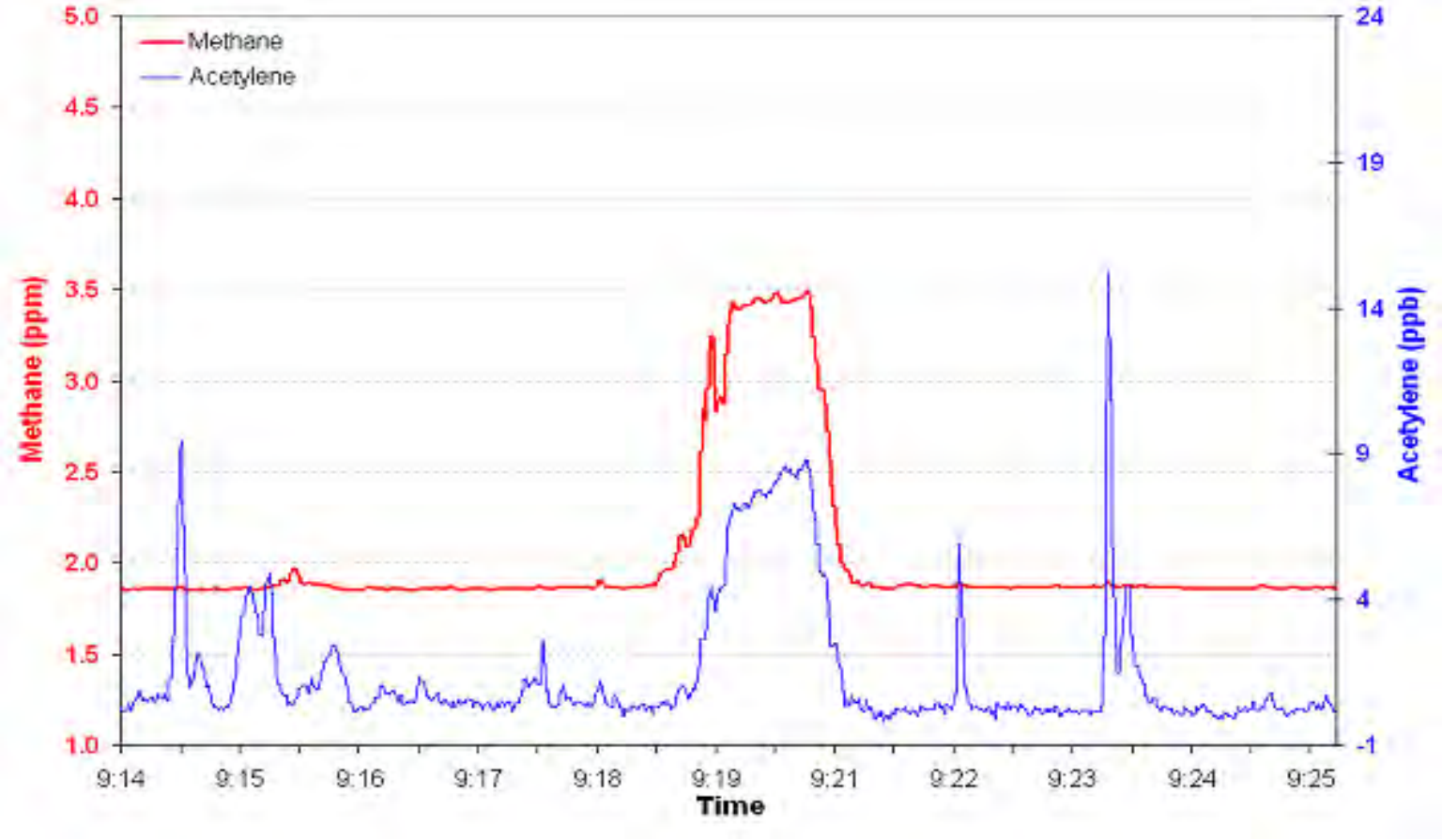
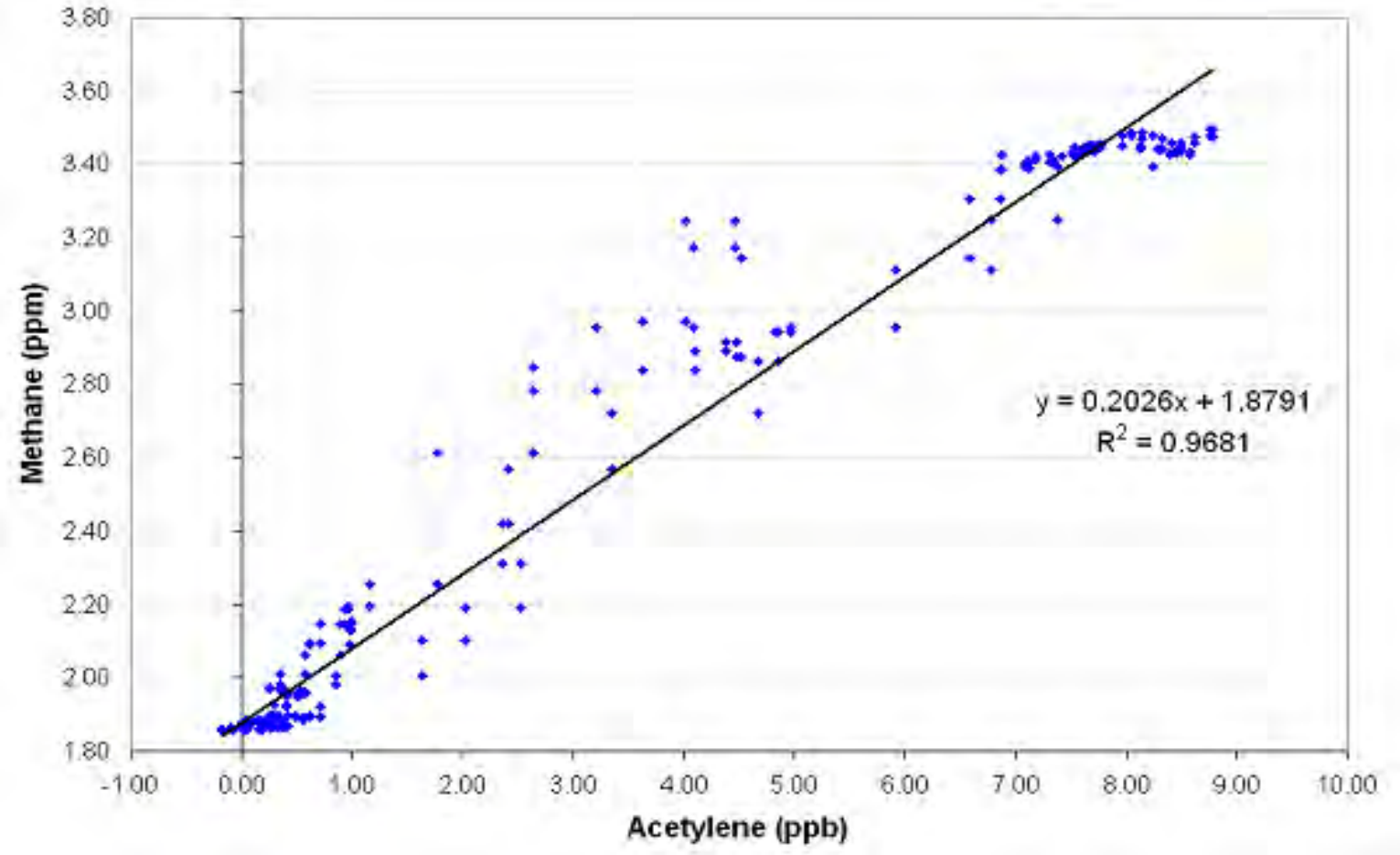


Subject Landfill Transect PR-1. In this satellite image created using Google Earth, the measured methane plume (in ppm) is in bright red, the measured acetylene plume (in ppb) is in blue. Note that the height of the plume shapes is not relative to any scale. The measured wind direction is indicated by the light green arrow and the locations for where the acetylene tracer gas was released are indicated by yellow push pins.



Time series example transect data



Correlation plots of transect data

Test Date	Measurement Type	Time Start	Time Stop	Transect CH_4 Emission Est. (g/min)	Simulated Stationary CH_4 Emission Est. (g/min) CSlope	Simulated Stationary CH_4 Emission Est. (g/min) USlope	Correlation	CH_4 Emission Est. ($g/m^2/day$)
2/15/11	Mobile	10:30:26	10:34:16	**10469.33**	**9681.84**	**9012.77**	0.92	**55.68**
2/15/11	Mobile	10:40:17	10:42:59	**11612.25**	**9533.79**	**7822.84**	0.86	**61.76**
2/15/11	Mobile	10:44:53	10:49:34	**9394.05**	**8559.60**	**7794.89**	0.91	**49.97**
2/15/11	Mobile	10:53:35	10:56:26	**6188.53**	**5835.84**	**5076.45**	0.81	**32.92**
2/15/11	Stationary	11:06:00	11:16:05	**5811.13**	**5861.32**	**6094.17**	0.82	**32.41**
2/15/11	Mobile	11:33:44	11:36:08	**7924.40**	**7360.70**	**5079.72**	0.84	**42.15**
2/15/11	Mobile	11:48:37	11:54:38	**5628.97**	**5482.04**	**6579.38**	0.82	**29.94**
2/15/11	Mobile	12:10:33	12:13:47	**5416.82**	**5903.30**	**6659.11**	0.94	**28.81**
2/15/11	Stationary	12:17:38	12:30:02	**6055.97**	**6124.45**	**6284.91**	0.84	**33.43**

Stationary Average	**32.92**
Mobile Average	**43.03**
Campaign Average	**40.79**

Mean value 40.8 ± 4.1 g $m^{-2}d^{-1}$

Table of qualifying emissions estimates. CSlope and USlope refer to the constrained slope and the unconstrained slope of the data points respectively. Constrained slope refers to the data with background levels included. Unconstrained slope has the background levels removed, and is used to calculate the daily emissions estimate.

Chamber Approach for Methane Oxidation

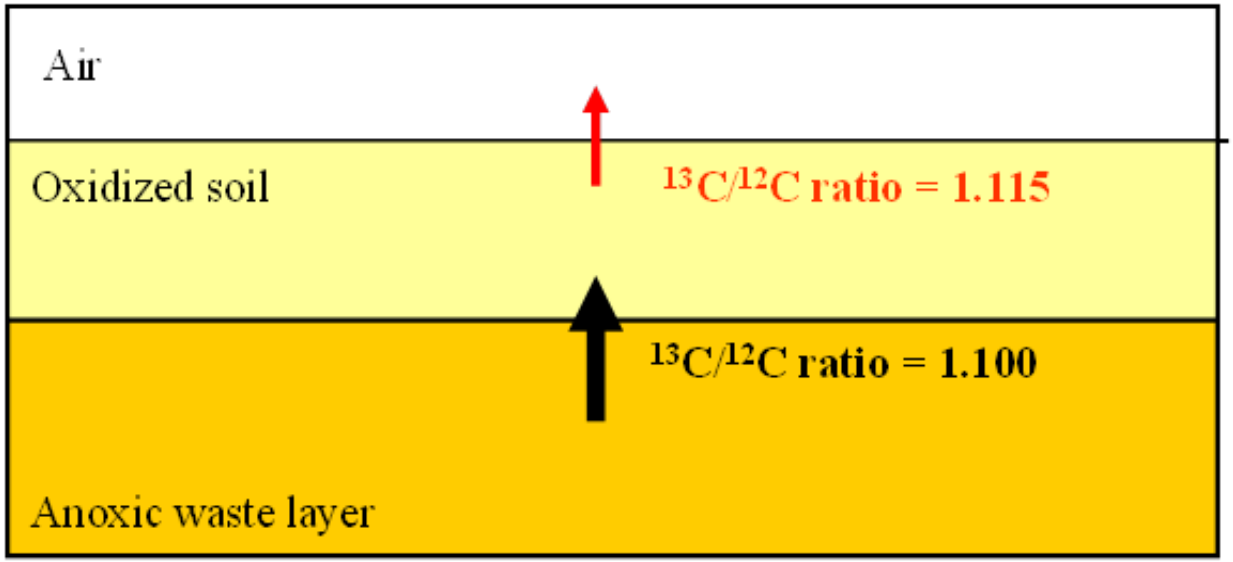
- Methane oxidation reduces emissions
- Quantification of oxidation critical to accurately estimating methane (GHG) emissions
- Bacteria near surface consume methane by reacting with oxygen

Methane Oxidation

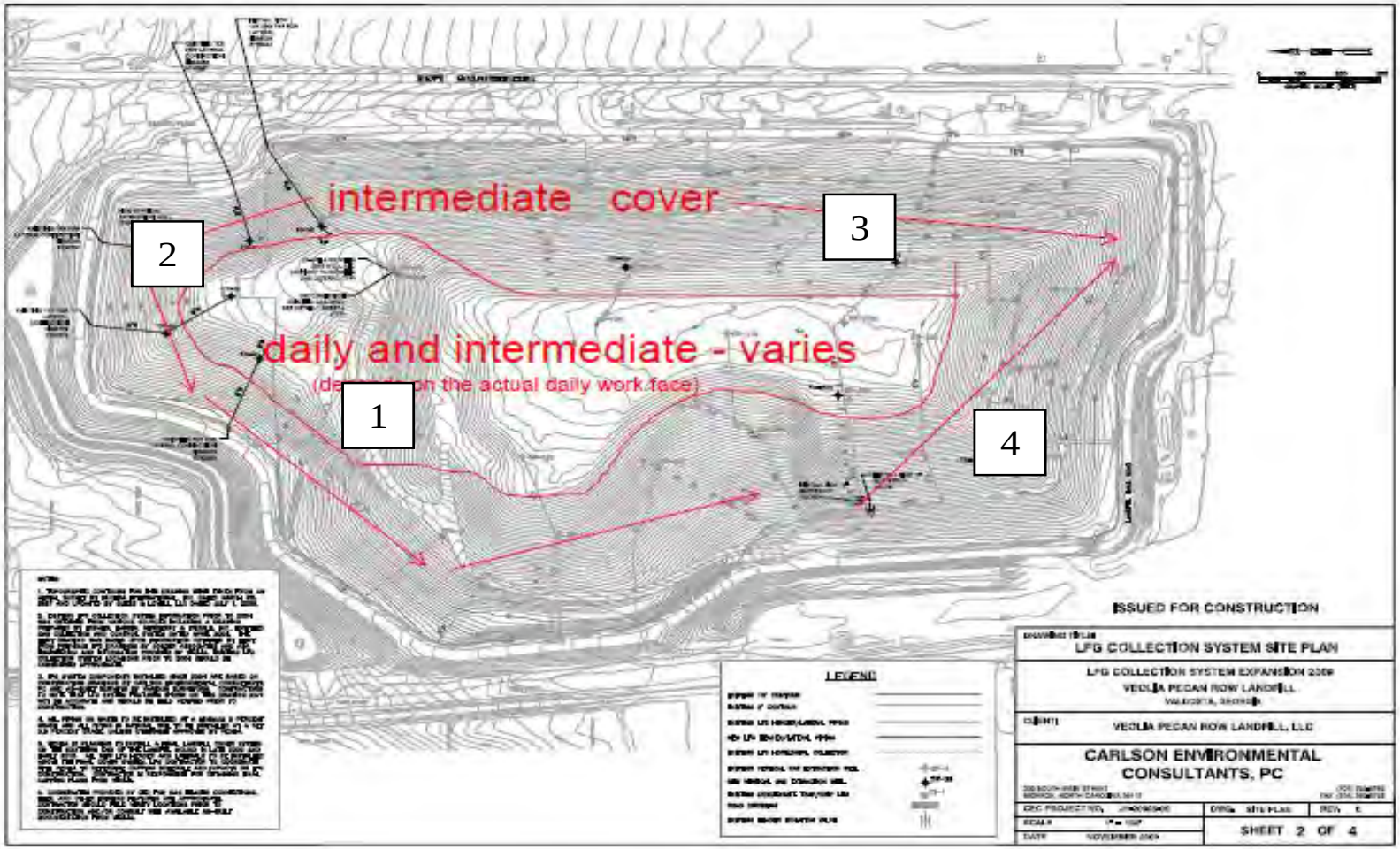
- **Methane Oxidation (methylatrophy)**
  - $CH_4 + 2O_2 \rightarrow CO_2 + H_2O$

- **Methane oxidation within the soil was determined with a stable isotope approach**
  - **Chamber captured emitted methane was used to determine the lower limit of methane oxidation while gas probe captured methane from within the soil was used to determine an upper limit.**
  - **Determine the $\delta^{13}C$ of residual CH4 following oxidation as it passes through the soil beneath the chamber.**

Methane Oxidation



- The chamber flux technique is used to determine the quantity of the red arrow.
- The isotope technique is the only way to determine the quantity of the black arrow


intermediate cover
2
3
daily and intermediate - varies
1
4
ISSUED FOR CONSTRUCTION
LFG COLLECTION SYSTEM SITE PLAN
LFG COLLECTION SYSTEM EXPANSION 2009
VEOLIA PECAN ROW LANDFILL
VEOLIA PECAN ROW LANDFILL, LLC
CARLSON ENVIRONMENTAL CONSULTANTS, PC
SHEET 2 OF 4

Flux Chambers

Flux Chambers

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Flux Chambers

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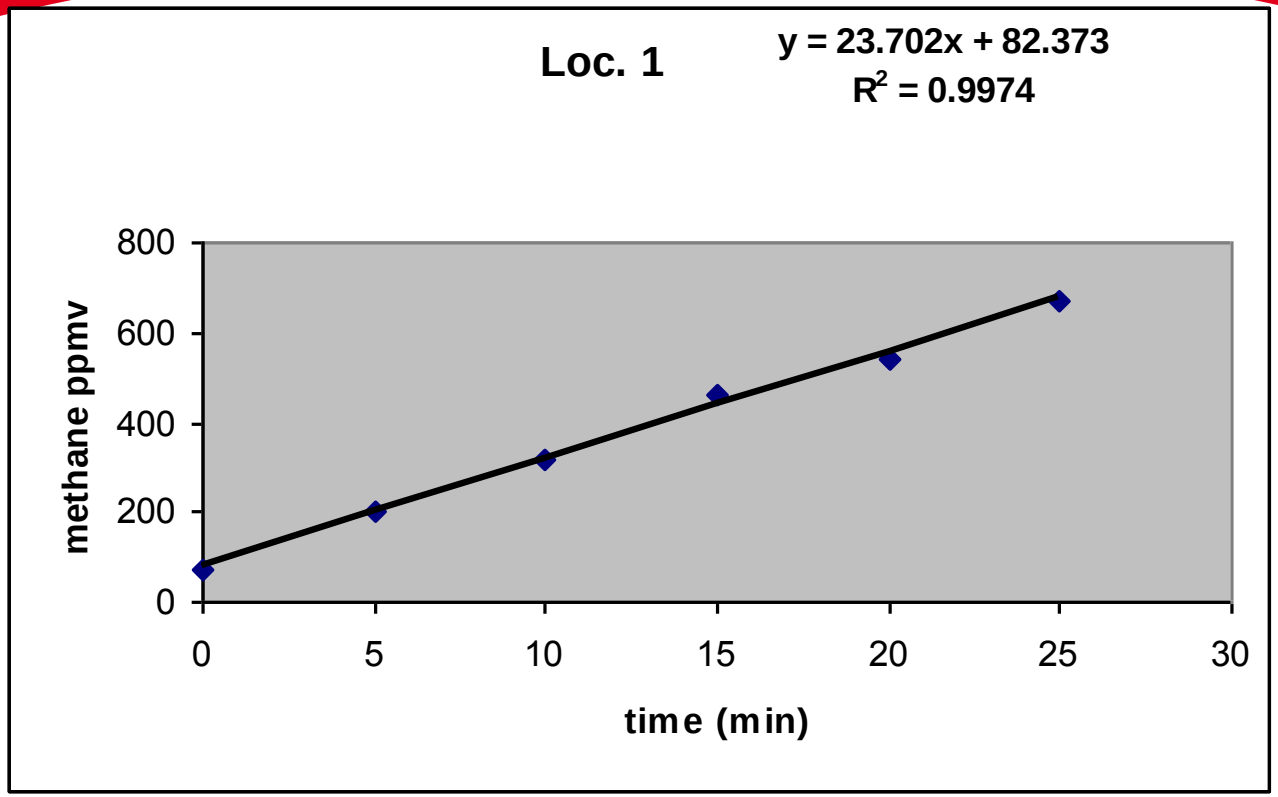
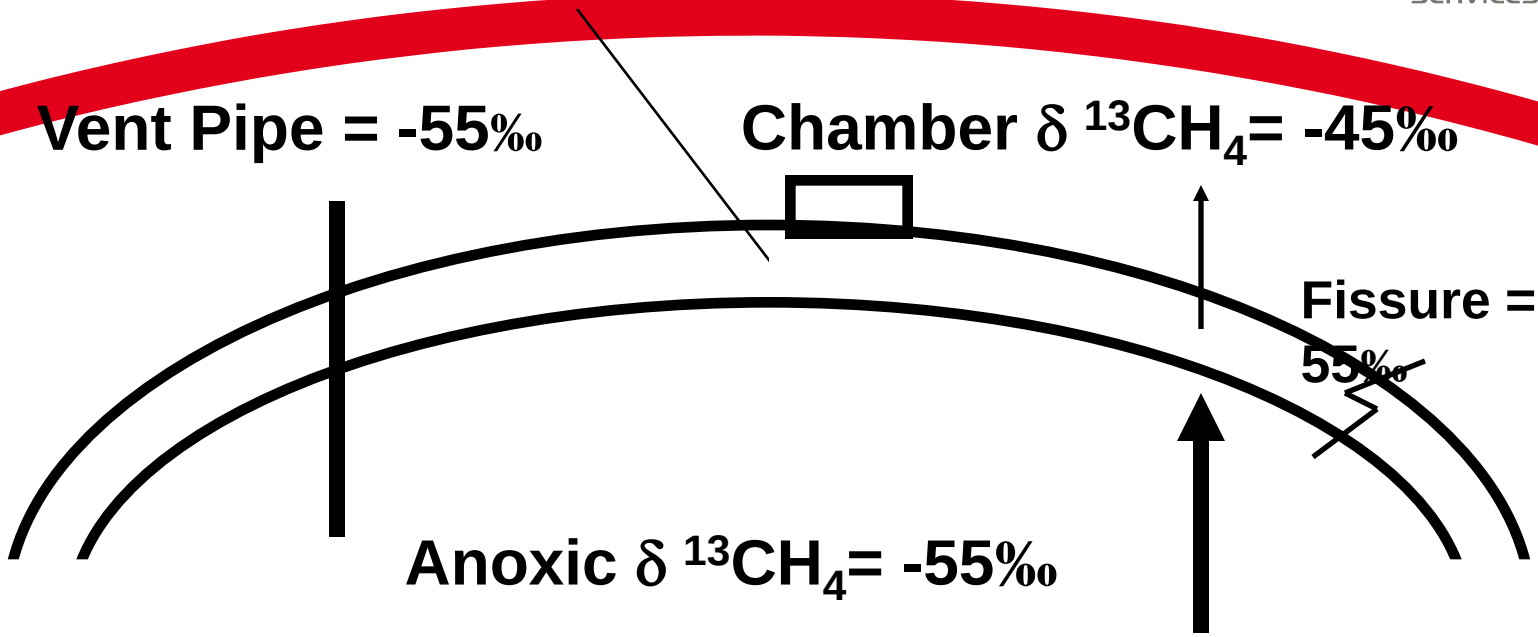


Increase in methane concentration over time in a typical chamber placement at the Subject landfill. Increase in chamber over time (the increase versus time, the slope, is directly proportional to methane emission rate.

Oxic Zone - Methane Oxidation



Anoxic Zone - Methane Production

Assumes gas transport from landfill primarily driven by pressure differential = advection
Diffusion causes lower limit results.

Methane Emission Rates

Site	1	2	3	4
Mean	48.9	44.5	40.8	28
Geospatial Mean	47.8	42.4	45.5	28.5
Median	7.2	4.3	32.3	16.3
n	20	20	20	20
Std. Err.	23.6	23.3	7.9	12.5

Methane emission rates, in g $m^{-2}d^{-1}$ at each of 4 representative sites sampled with static flux chambers.

The simple average of the 4 sites was 40.6 ± 3.9 g $m^{-2}d^{-1}$

Methane Oxidation Results

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Overall oxidation including the soil cover, active tipping face, pipe, wells etc. These results are based on air samples collected at the landfill surface at the initiation of chamber measurements.

	% oxidation	
Site 1	22	± 3
Site 2	30	± 7
Site 3	19	± 4
Site 4	31	± 5
Mean	25.5	± 3.0

Overall Methane Emission Rates

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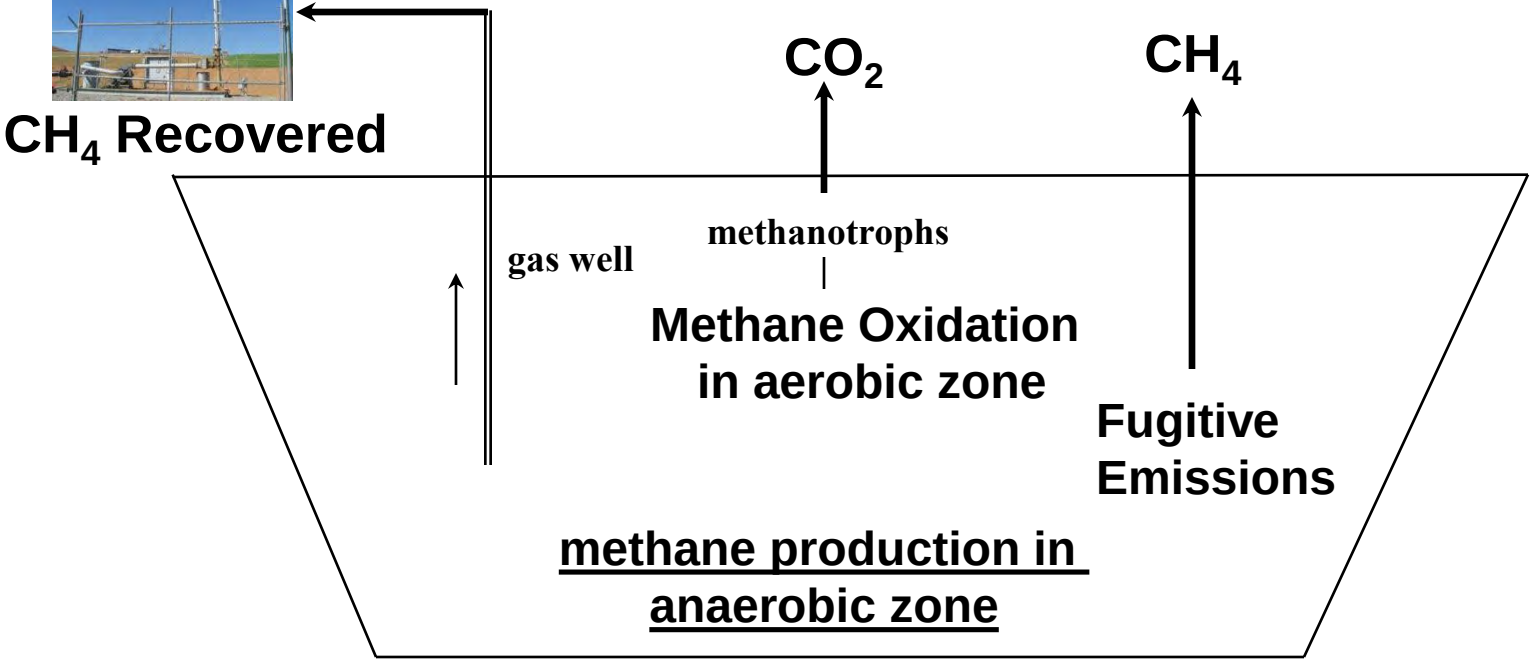
- **Tracer Correlation derived emission rate**

40.8 ± 4.1 g $m^{-2}d^{-1}$

- **Chamber derived emission rate**

40.6 ± 3.9 g $m^{-2}d^{-1}$

Landfill Methane Mass Balance



Methane [CH_4] produced = Σ (CH_4 recovered + CH_4 emitted + CH_4 oxidized

Results

- **Average Methane Emission Rate**

40.7 ± 4.0 g $m^{-2}d^{-1}$

- **Average Methane Oxidation Rate**

25.5 ± 3.0 %

- **Average Methane Collection Efficiency**

February 2011 – 55%

September 2010 – 48%

Landfill Gas Modeling

Modernizing Methane Generation Models and Data from U.S. Landfills.

Xiaoming Wang, North Carolina State University

Evaluating the Historical Performance of Landfill Gas Projects Developed Under the CDM.

Alex Stege, SCS Engineers

Hydrogen Sulfide Production from Different Sulfur-Containing Material Under Anaerobic Conditions.

Florentino De la Cruz, North Carolina State University

Modeling Hydrogen Sulfide Generation from Landfilled Drywall.

Amro El Badawy, University of Cincinnati

Landfill Gas Quantification Methods

Quantifying Gas Emissions from Landfills – Which Methodologies Can Be Used?

Peter Kjeldsen, Technical University of Denmark

Development of the Mobile Tracer Correlation Method for Qualification of Emissions from Landfills and Other Large Area Sources.

Richard Shores, U.S. Environmental Protection Agency

Assessing Landfill Gas Collection Efficiency with Gas Tracers and Numerical Modeling.

Paul Imhoff, University of Delaware

Development of a Quantification Tool for Greenhouse Gas Monitoring Using OP-TDLS Systems.

Marlies Hrad, University of Natural Resources and Life Sciences

Methane Emission Measurements I

Landfill Methane Emission Variability on Time Scales.

Nathan Swan, Cygnus Environmental Group

Impact of Changes in Barometric Pressure on Landfill Methane Emissions.

Liukang Xu, LI-COR Biosciences

Measured and Modeled Methane Emissions at MSW Landfills Prior to Gas Collection System Installation.

Roger Green, Waste Management, Inc.

GHG Emissions and Mitigation / Methane Emission Measurements II

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GHG Emissions and Mitigation

Measured and Modeled Methane Emissions at Closed MSW Landfills Without Gas Collection.

Roger Green, Waste Management, Inc.

Methane Emission Measurements II

Using Surface Ambient Methane Concentrations to Estimate Methane Emissions from Old Closed Landfills.

Tarek Abichou, Florida State University

Results from Six Years of Emission Studies on U.S. Based Landfills.

Gary Hater, Waste Management, Inc.

Methane Oxidation

A New Modeling Approach to Assess the Effects of Soil Defects in Landfill Cover Soils on Percent Methane Oxidation.

Tarek Abichou, Florida State University

Use of Green Material as a Landfill Cover Material to Enhance Methane Oxidation.

Ramin Yazdani, County of Yolo, California

Measurements of Whole Landfill Oxidation.

Jeffrey Chanton, Florida State University

Methane Emission, Oxidation and Collection Efficiency at a Southeastern USA Landfill.

Todd Watermolen and Ron Strube, Veolia Environmental Services – Solid Waste

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Questions? Thank You.

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