Evaluating Older Landfills Using Open-Path Technologies

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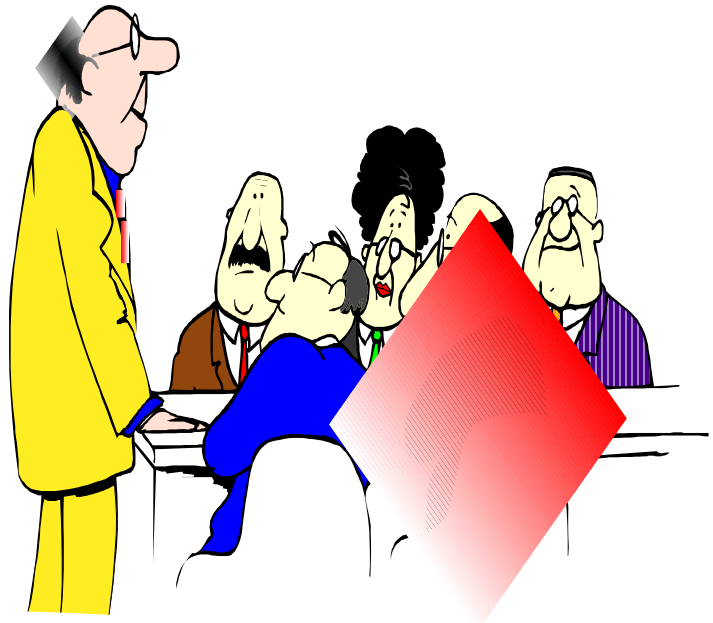
Presentation to NATO/CCMS Pilot Study –
Prevention and Remediation in Selected Industrial Sectors:
Rehabilitation of Old Landfills
Cardiff, Wales
May 23 - 26, 2004

Outline

- Landfill Gas (LFG) Emissions
  - Health and environmental concerns
  - Trends in the U.S.
- Evaluating Old Landfills
- Open Path Technologies
- Application to Old Landfills
- Next Steps



LFG – Health and Environmental Concerns

- Landfill gas
  - Contains 40-60% methane, 60-40% CO_2, and trace constituents of VOC, HAPs, and PBTs
- Included in the Urban Air Toxic Strategy
  - More than 30 HAPs detected in LFG
- Concern for
  - Explosive potential of gas
  - Odor nuisance
- Largest source of methane in the U.S.

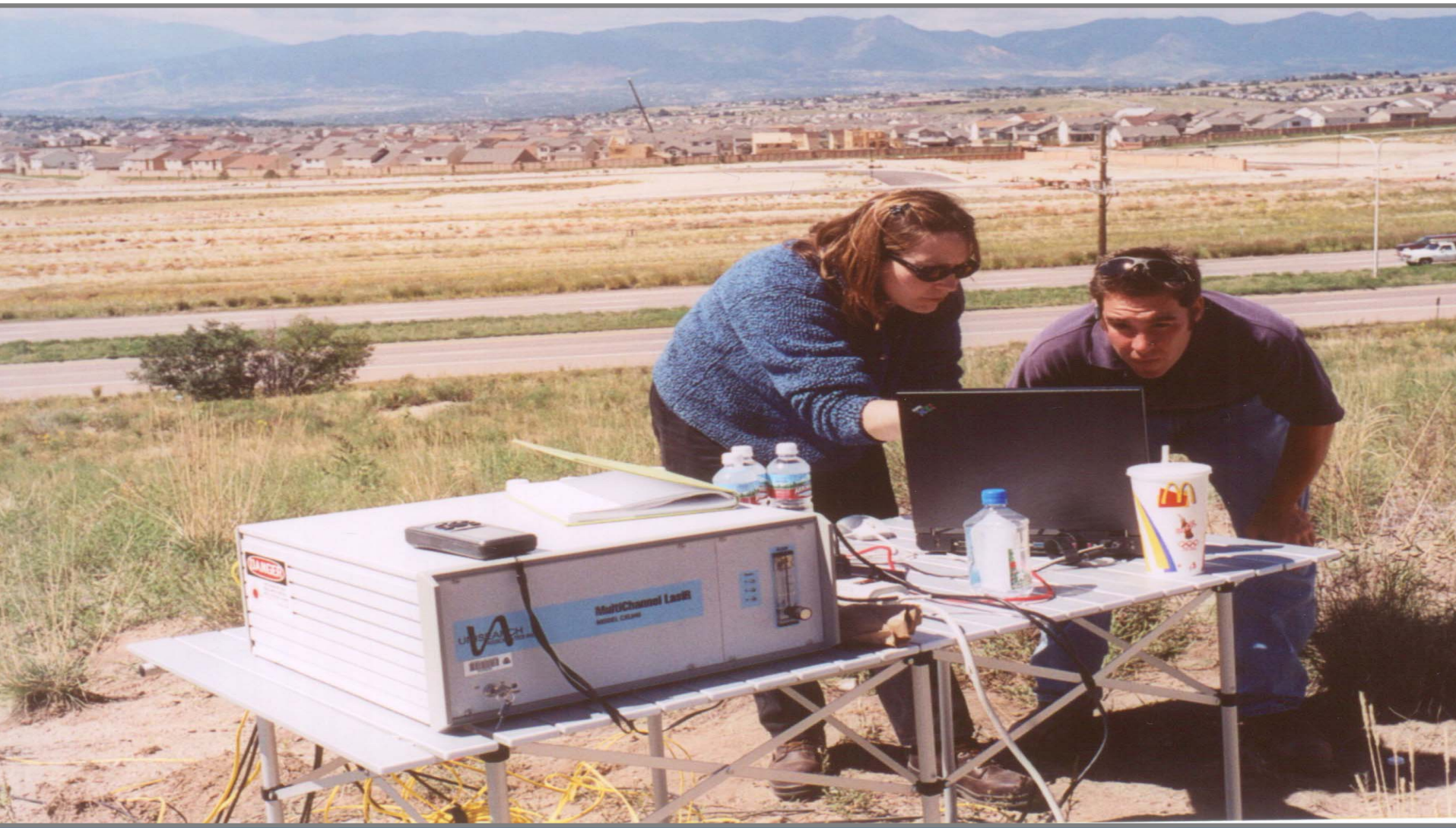
Increasing interest in re-use and development of old sites…..

Recreational Use……

On-Site Structures…..

This is a gym with an “Absolutely No Smoking” sign

Encroaching Development…



Recreational Use & Nearby Structures

Settlement Issues…..

Off-Site Gas Migration….

Gas Migration under Highway…

Old Landfills

- Currently no available guidance for how to evaluate air pathway
- Emissions are very difficult to model because
  - Limited data on which to characterize emissions
    - Waste composition and quantities are unknown
  - Temporal and spatial variability
    - From site-to-site
    - Within a site
- Often co-disposal of hazardous and municipal waste

Old Landfills

- Desire is to turn over the site to developer or community (along with any future liability claims)
- Typically there is minimal funding available for –
  - Evaluating environmental impacts (often air impacts are not considered);
  - Installing and maintaining landfill cap; and
  - Installing, operating, and maintaining gas control (either passive or active).

If LFG Is Determined to be a Concern?

- Need to provide for
  - Operation and maintenance of well field
  - Monitoring and maintenance of cap

Trends Impacting Emissions- Wet Landfill Operation

- Decomposition of waste is accelerated, resulting in increased gas emissions. Will result in increased environmental impact if
  - There is no LFG collection & control
  - There is a delay in LFG capture/control from onset of liquid additions
  - Use of porous material for promoting infiltration results in larger loss of fugitive LFG emissions
  - There are of cracks & fissures in existing cover and/or cap (worsens with droughts)

Surface Cracks

Trends Impacting Emissions- Increased Potential for Air Toxics?

- Increased metals content resulting from additions of leachate, sewage sludge, and industrial wastes
- Increased potential for landfill fires which emit dioxin/furans and other toxics
  - Aerobic Operations - May be more of an issue because of the high operating temperatures and high demand for liquid additions
  - Anaerobic
    - Larger quantity of gas to manage
    - Increased difficulty with maintaining cover or cap
    - Increased effort to effectively collect LFG and avoid air intrusion

Picture of Aerobic Landfill*

*Aerobic operation at this site has been discontinued.

Guidance for Evaluating Old Landfills

- Guidance has been
  - Developed for evaluating air pathway at old landfills;
  - Applied at 5 landfills; and
  - Submitted for Agency review.
- Expect release of guidance by Jan 2005.

Guidance for Evaluating Old Landfills – Tiered Approach

- 1st Tier
  - Serpentine pattern sampling of surface emissions using PID/FID
  - Sampling of any existing
    - perimeter wells
    - passive vents
  - Use results to develop site map of methane concentrations

Tier 1 Sampling

Contour Plots of Methane Concentrations (ppm) for Rhode Island Landfill (Tier 1)

Contour Plots of Methane Concentrations (ppm) for New Hampshire Landfill (Tier 1)

Guidance for Evaluating Old Landfills – Tiered Approach

- 2nd Tier
  - Provides software (obtained from project web site) that uses Tier 1 data to determine sampling points. This is a statistical calculator that tests for homogeneity using the Wilcoxon Rank Sum Test Procedure.
  - Comprehensive analysis is conducted of gas samples obtained through punch probes. Samples are collected in either tedlar bags or canisters depending upon if analysis is conducted on- or off-site.
  - Results are used in emission and dispersion models as inputs to health risk evaluation

Tier 2 Sampling

On-Site Mobile Lab – Trace Atmospheric Gas Analyzer Unit

Summa Canister and Tedlar Bags

Summa Canisters (Duplicate Samples)

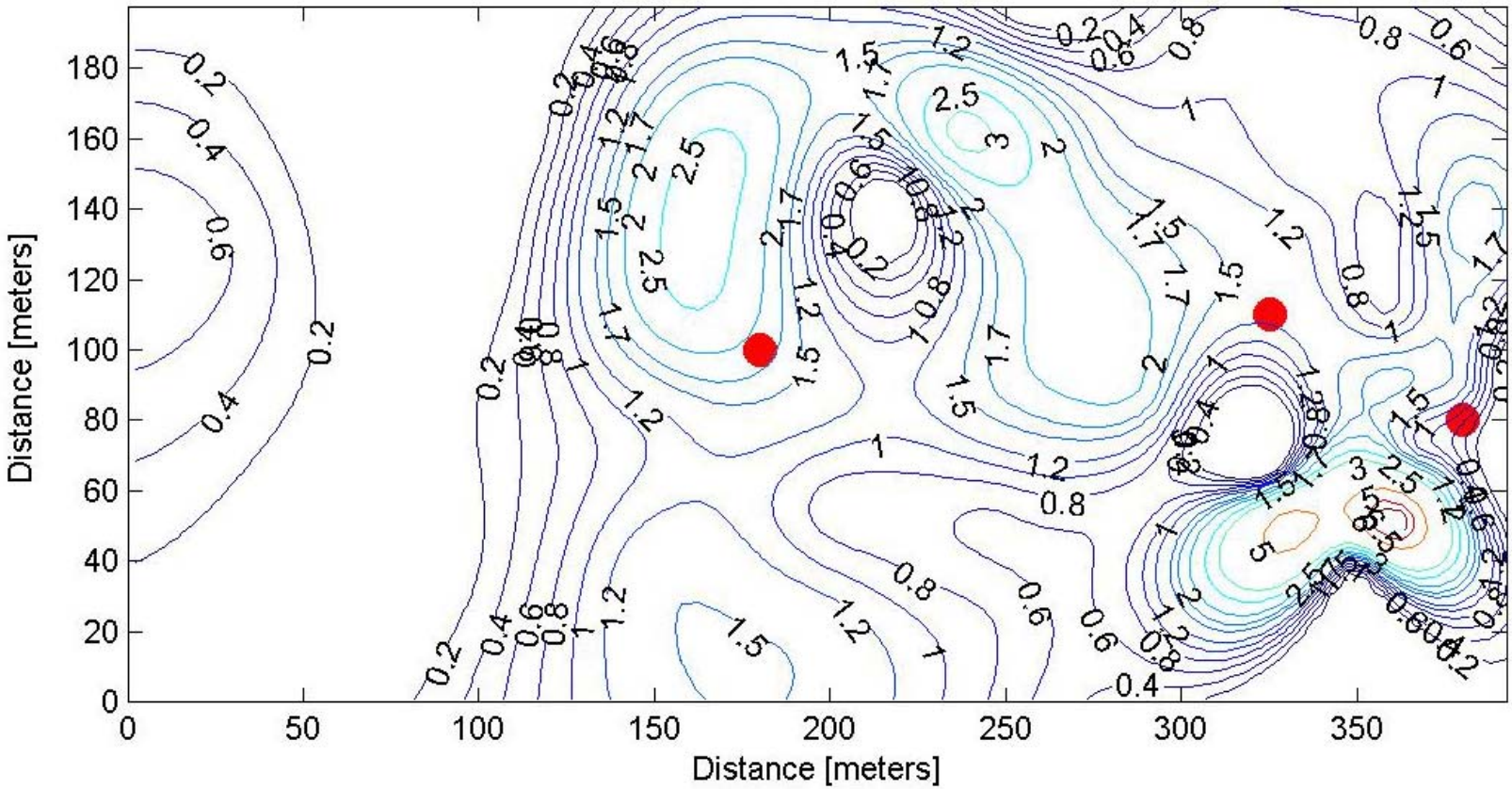
Guidance for Evaluating Old Landfills – Tiered Approach (cont.)

- 3rd Tier –
  - Use Optical Remote Sensing measurements which
    - Identify potential hotspots or areas of concern
    - Determine mass flux rate
    - Develop inputs that can be used directly in risk models

Technology for Measuring Fugitive LFG Emissions

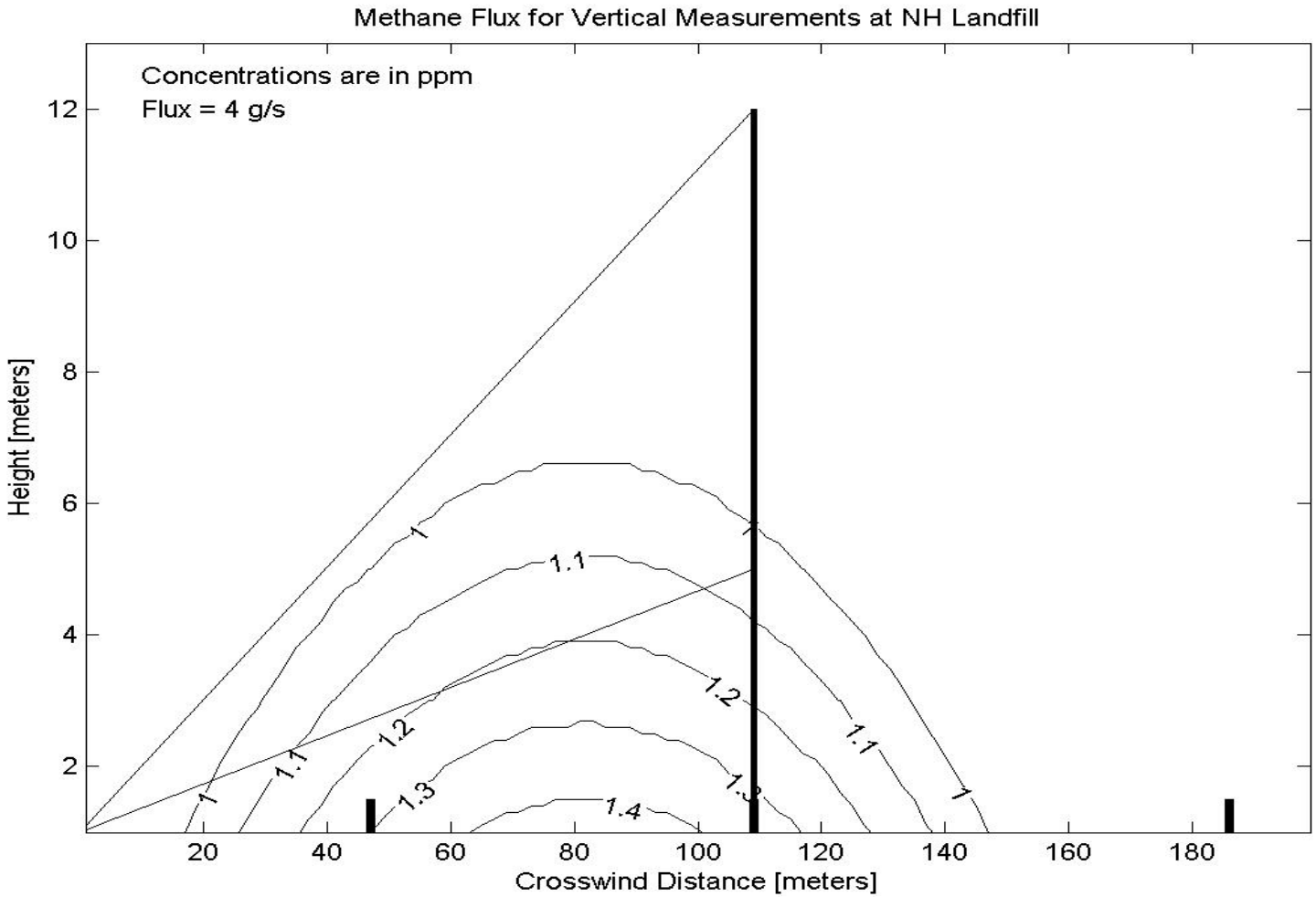
- Ground-Based Optical Remote Sensing (ORS) using Open-path Fourier Transform Infrared (OP-FTIR) Spectroscopy and Open-path Tunable Diode Laser Absorption Spectroscopy (OP-TDLAS)
  - Technology developed in partnership between ARCADIS and EPA with extensive quality assurance and field validation
  - EPA's preferred approach to evaluating area source emissions
- Multiple beam configuration
  - Horizontal scans detect any potential hot spots
  - Vertical scans determine mass flux
- Radial plume mapping to reconstruct plume downwind from source
  - (Plane-integrated concentration) times (wind speed) yields emission flux

Horizontal Scan Results at New Hampshire Landfill (Tier 3)



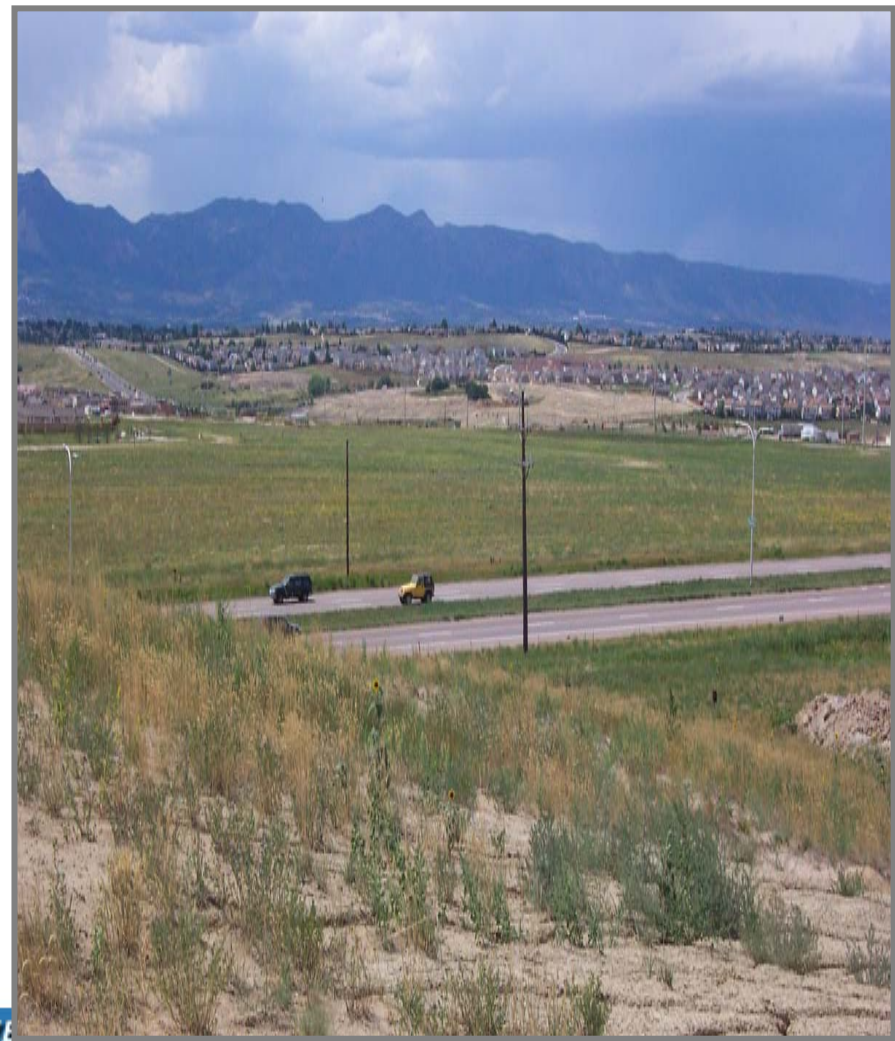
Radial Averages of Methane Concentration (ppm)

Vertical Scan Results of Methane Flux at N.H. Landfill (Tier 3)



ORS Technologies for Measuring Area Source Emissions

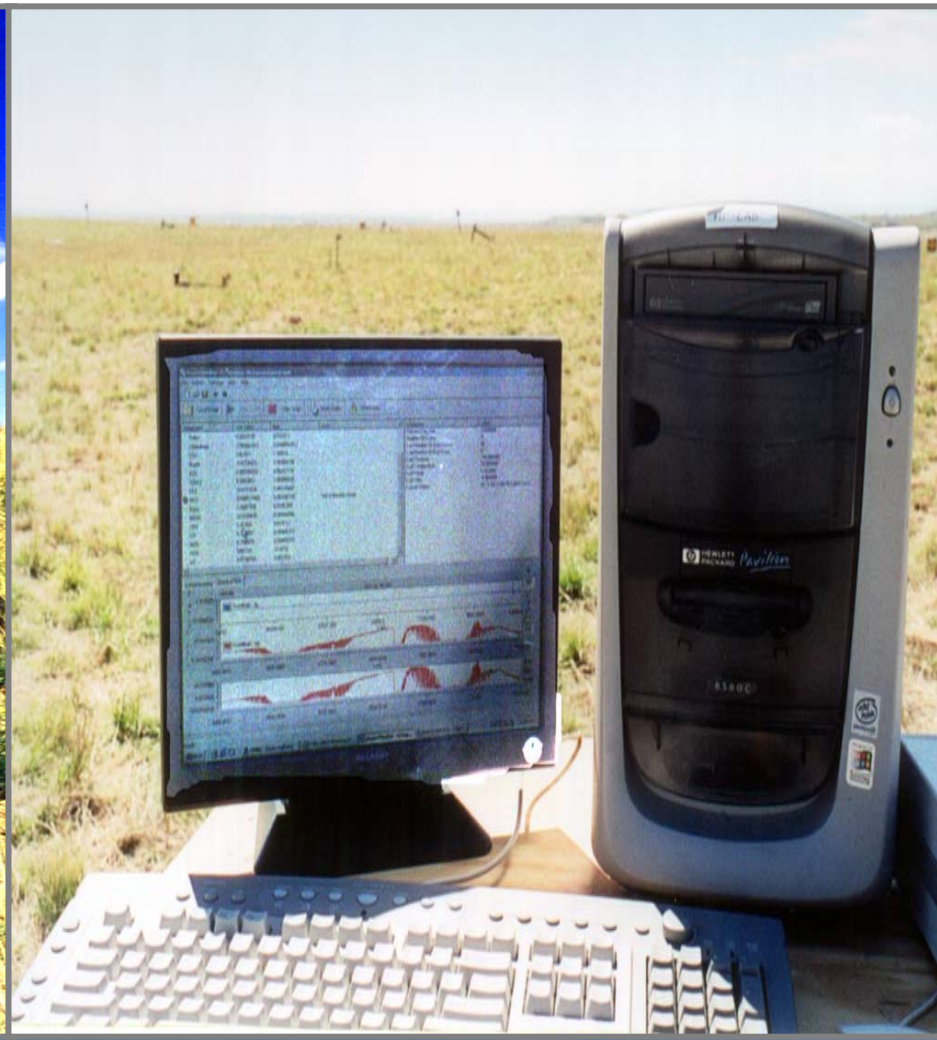
- Used to detect potential hot spots and determine mass emission rates using radial plume mapping (RPM)
- Major advantages over previous approaches, which relied more on modeling and were unable to account for spatial variability
- Range of
  - Pollutants include VOC, HAPs, NH_3 & CH_4
  - Technologies include OP-FTIR, OP-TDLAS, and UV-DOAS



OP-FTIR


IMACC

OP-TDLAS



UV-DOAS

Optical Remote Sensing – OP-FTIR & OP-TDLAS

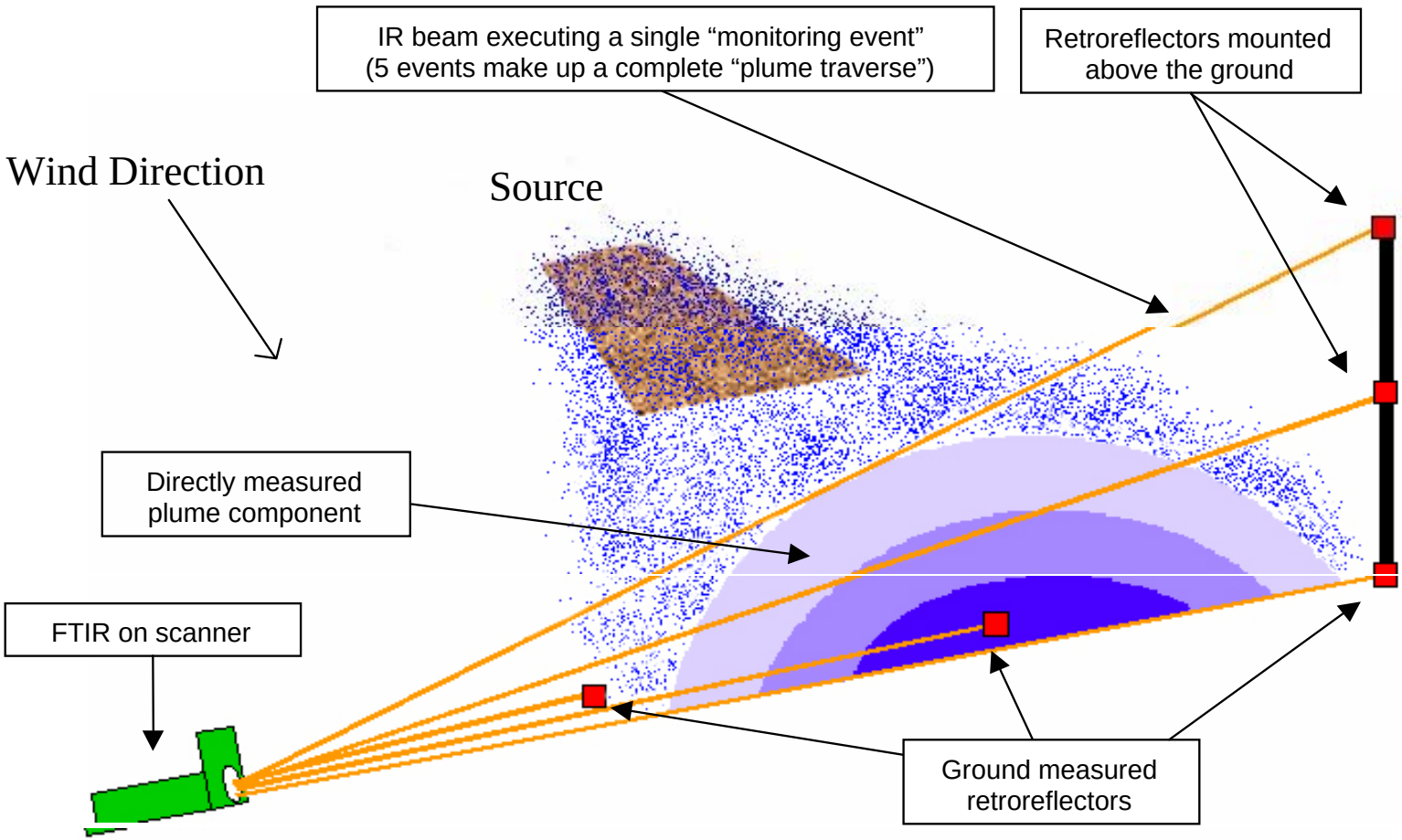
Optical Remote Sensing – OP-FTIR and OP-TDLAS

RESEARCH & DEVELOPMENT

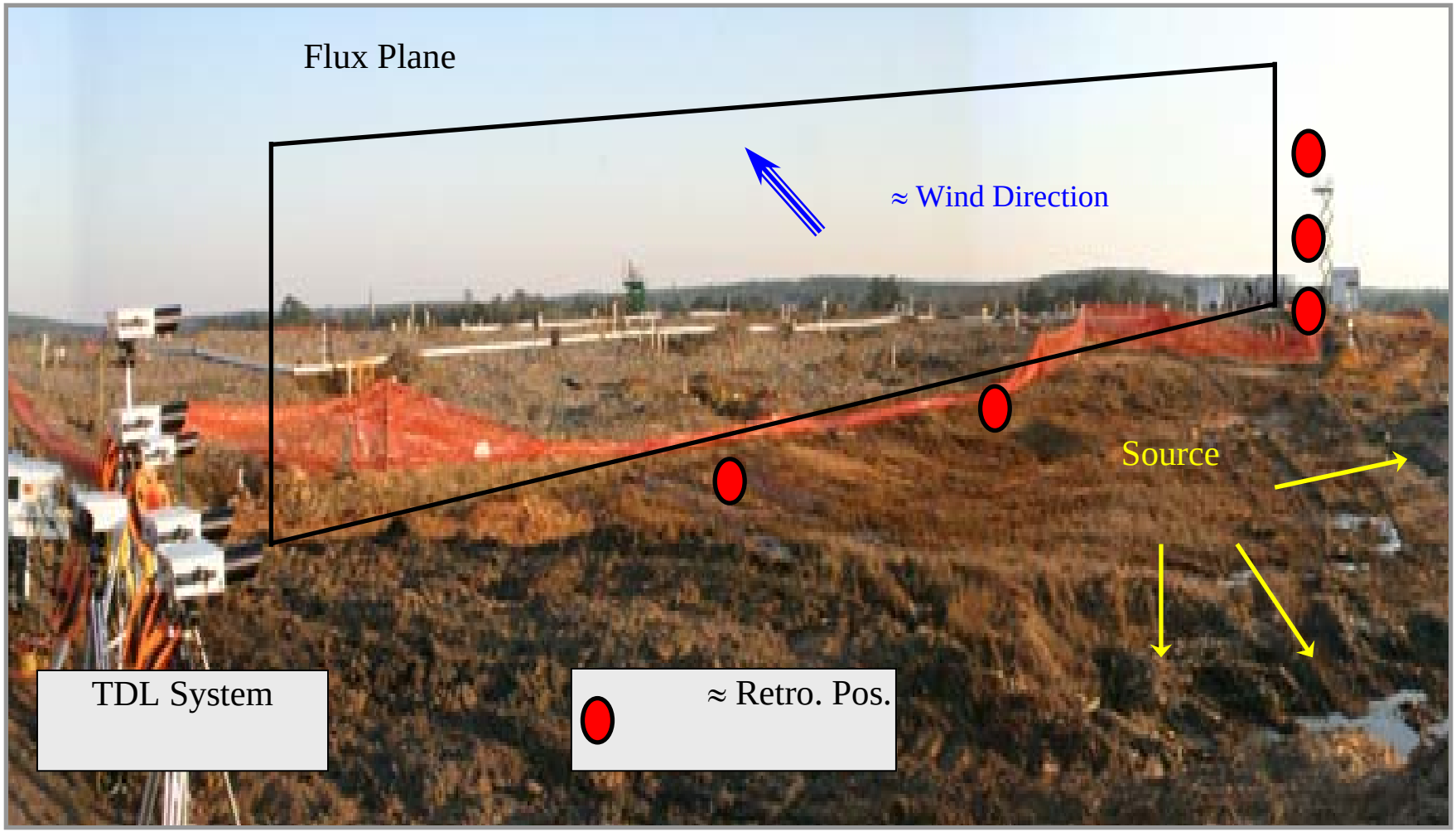
Building a scientific foundation for sound environmental decisions

Vertical and Horizontal Radial Plume Mapping

Schematic of ORS Technology

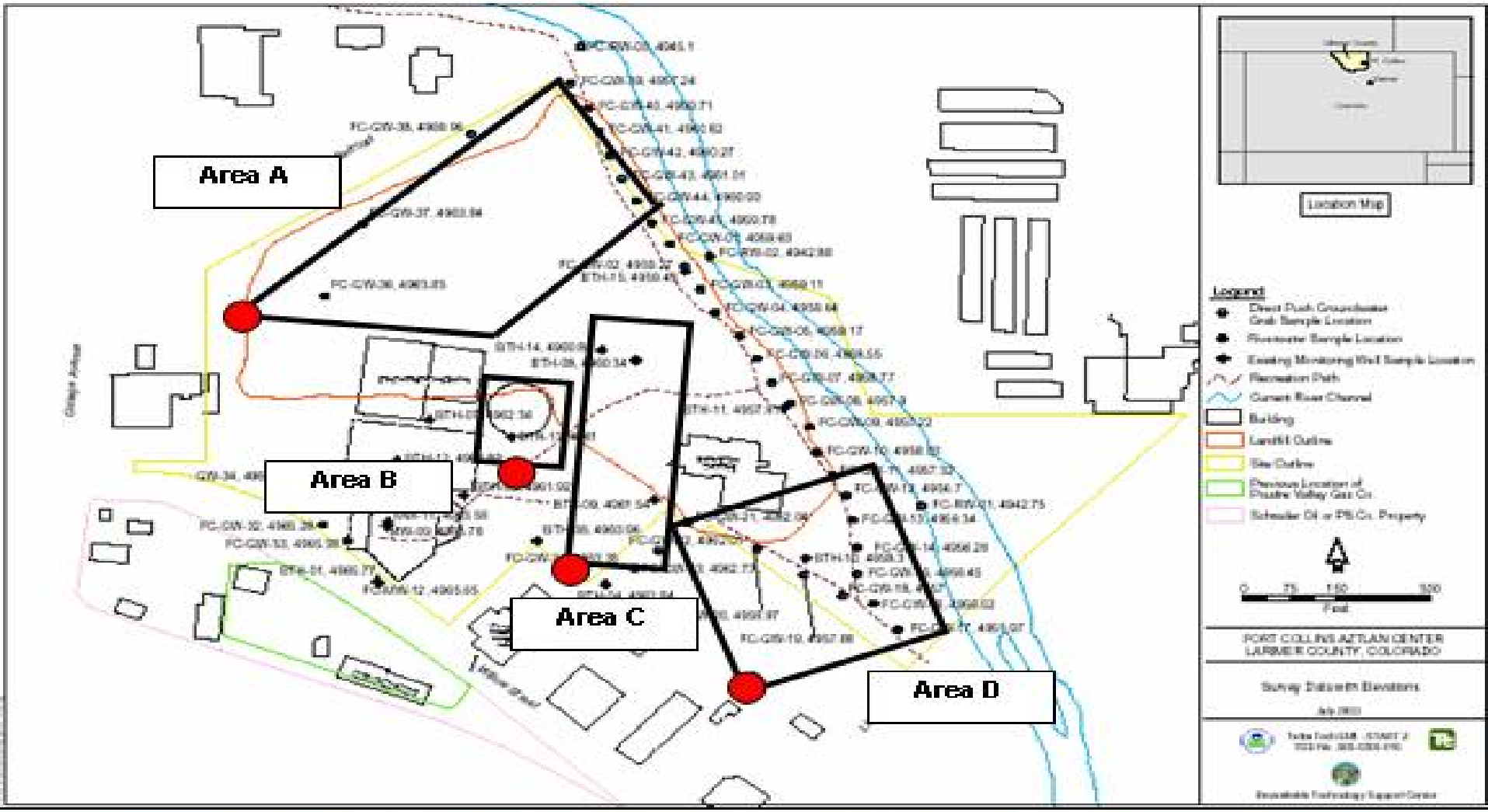


Vertical Radial Plume Mapping at Aerobic Bioreactor

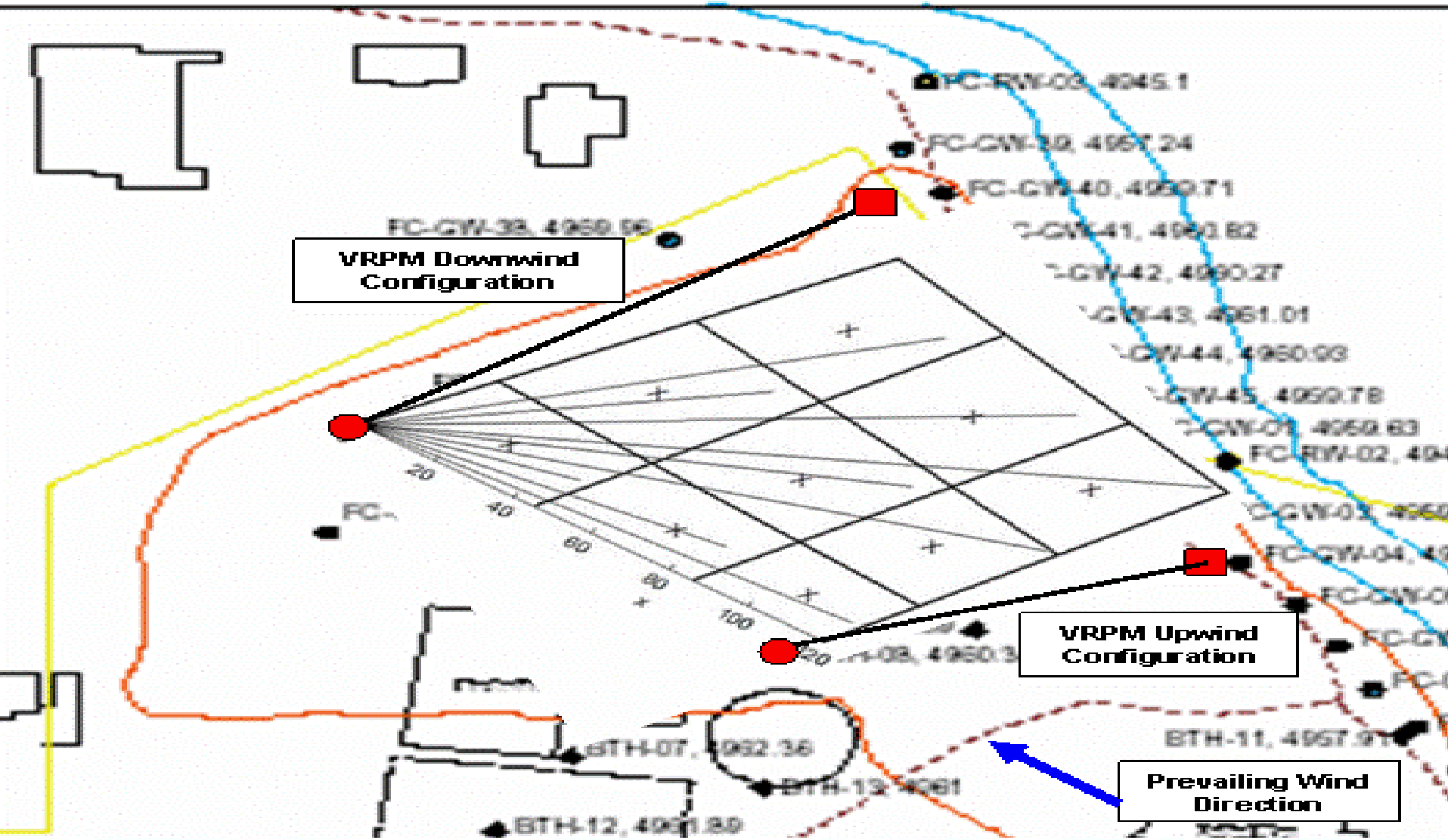


Evaluation of Landfill in Ft. Collins, Colorado

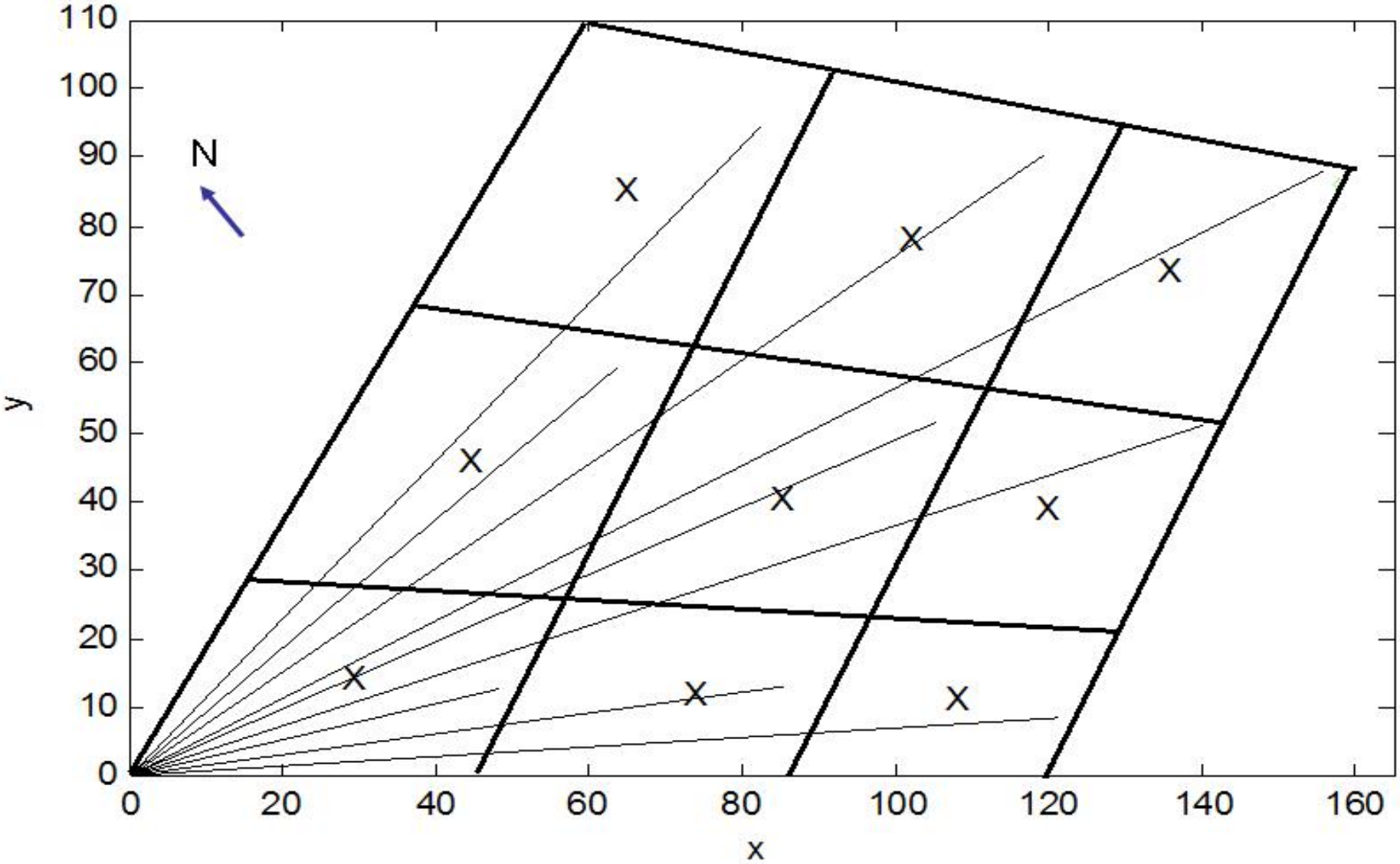
Horizontal Radial Plume Mapping (RPM) Configurations



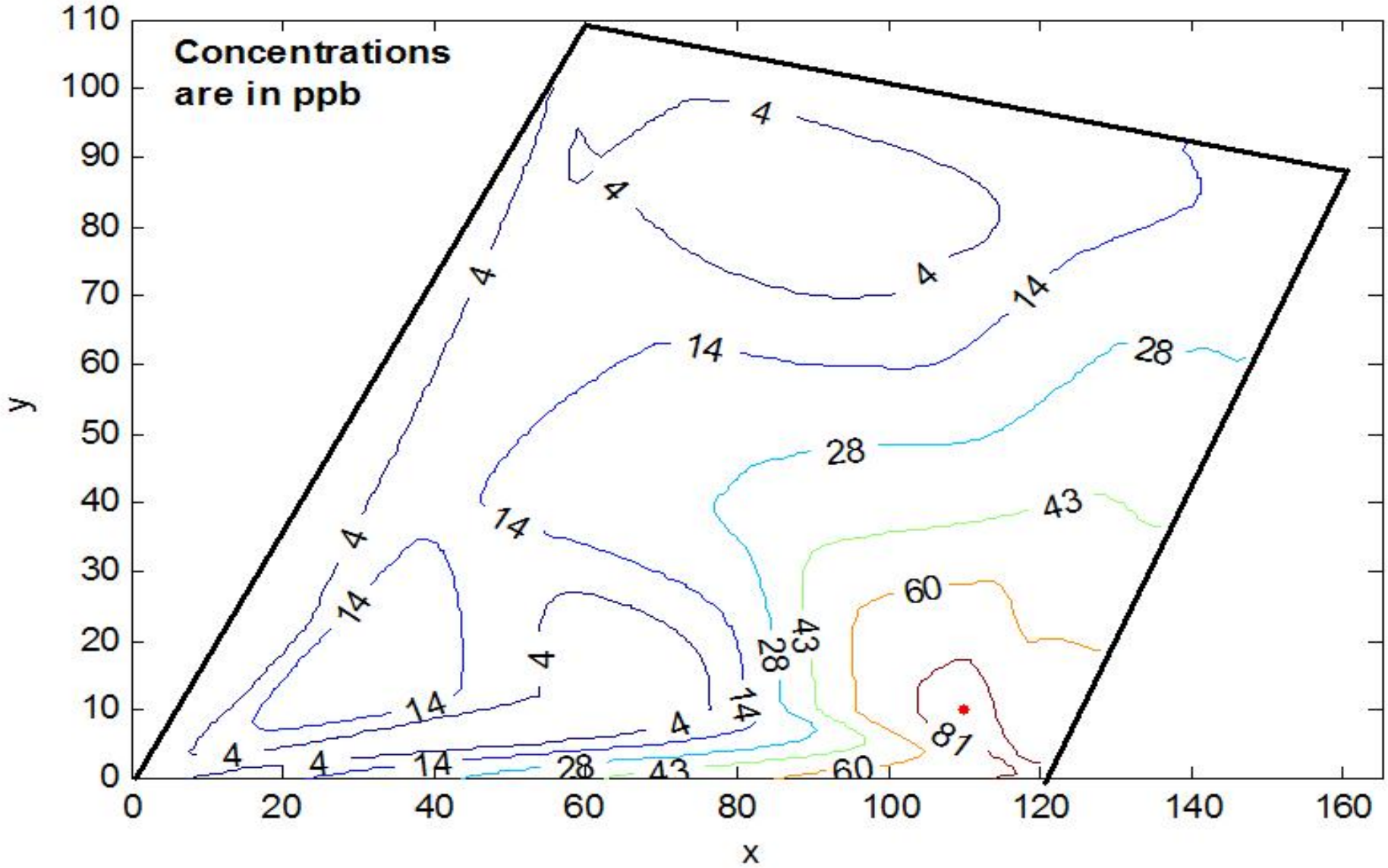
Vertical and Horizontal RPM Configurations at Area A



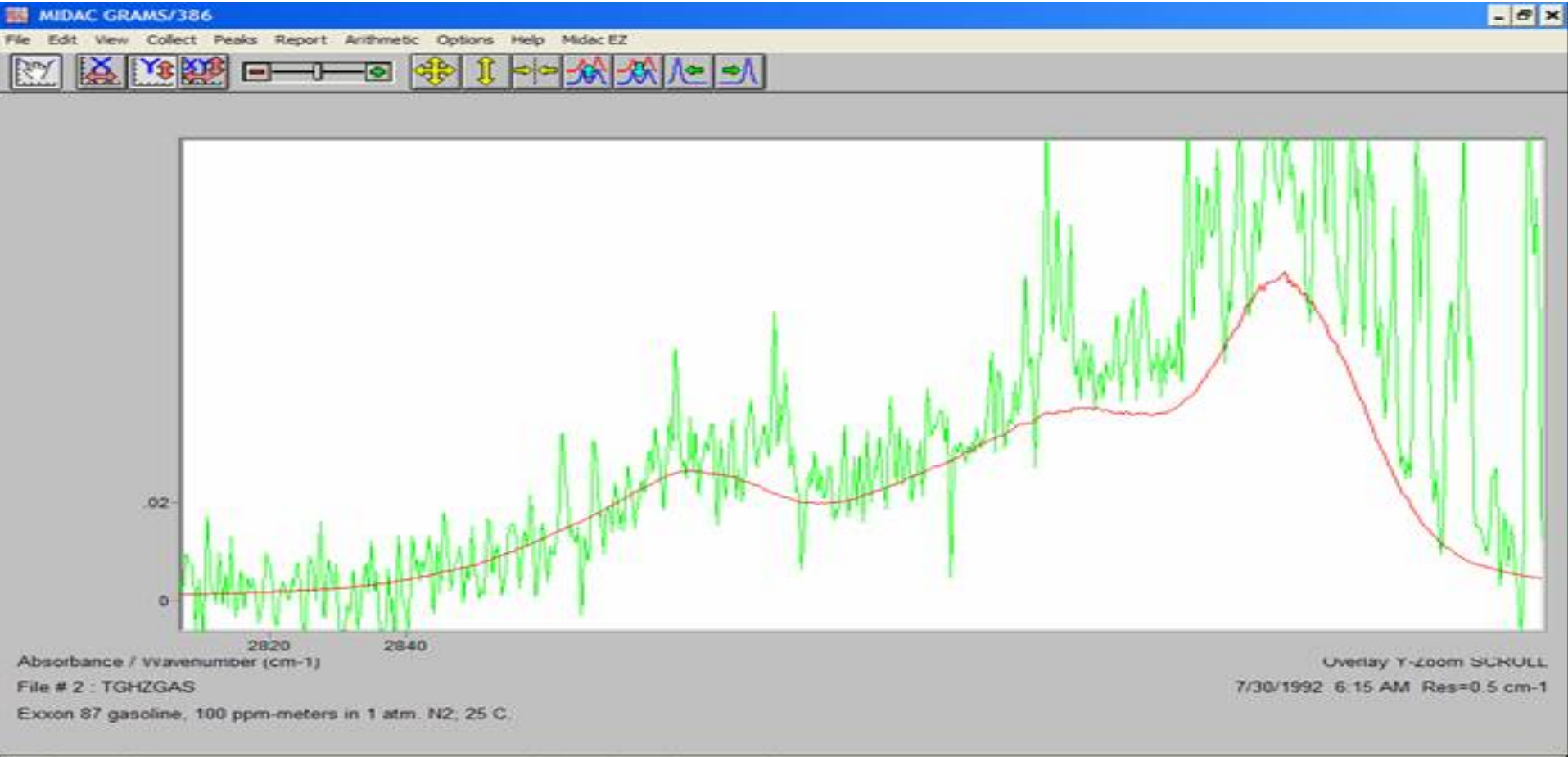
Ft. Collins Area - A. Geometry



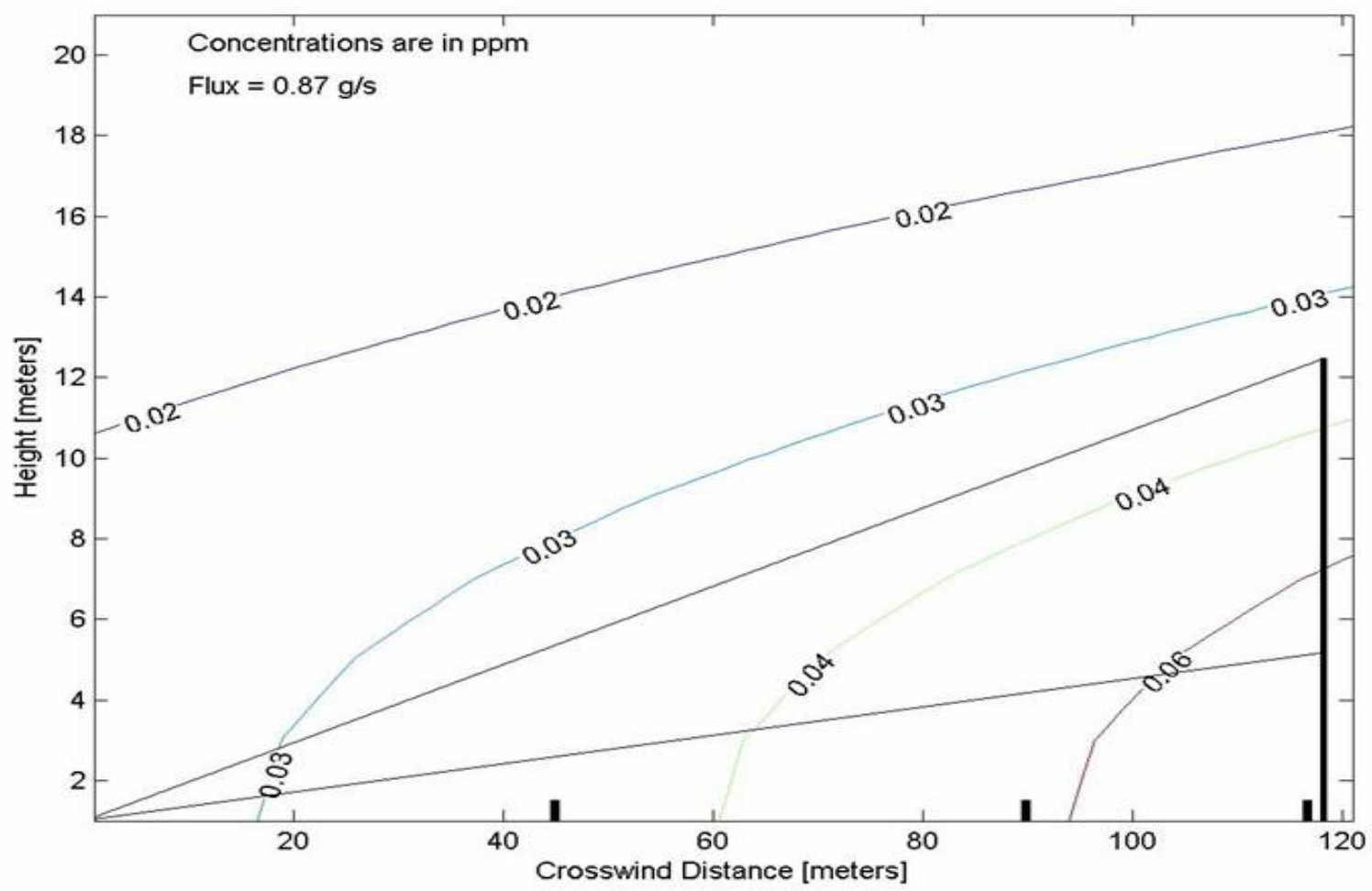
Ft. Collins Area-A. Gasoline Source Location



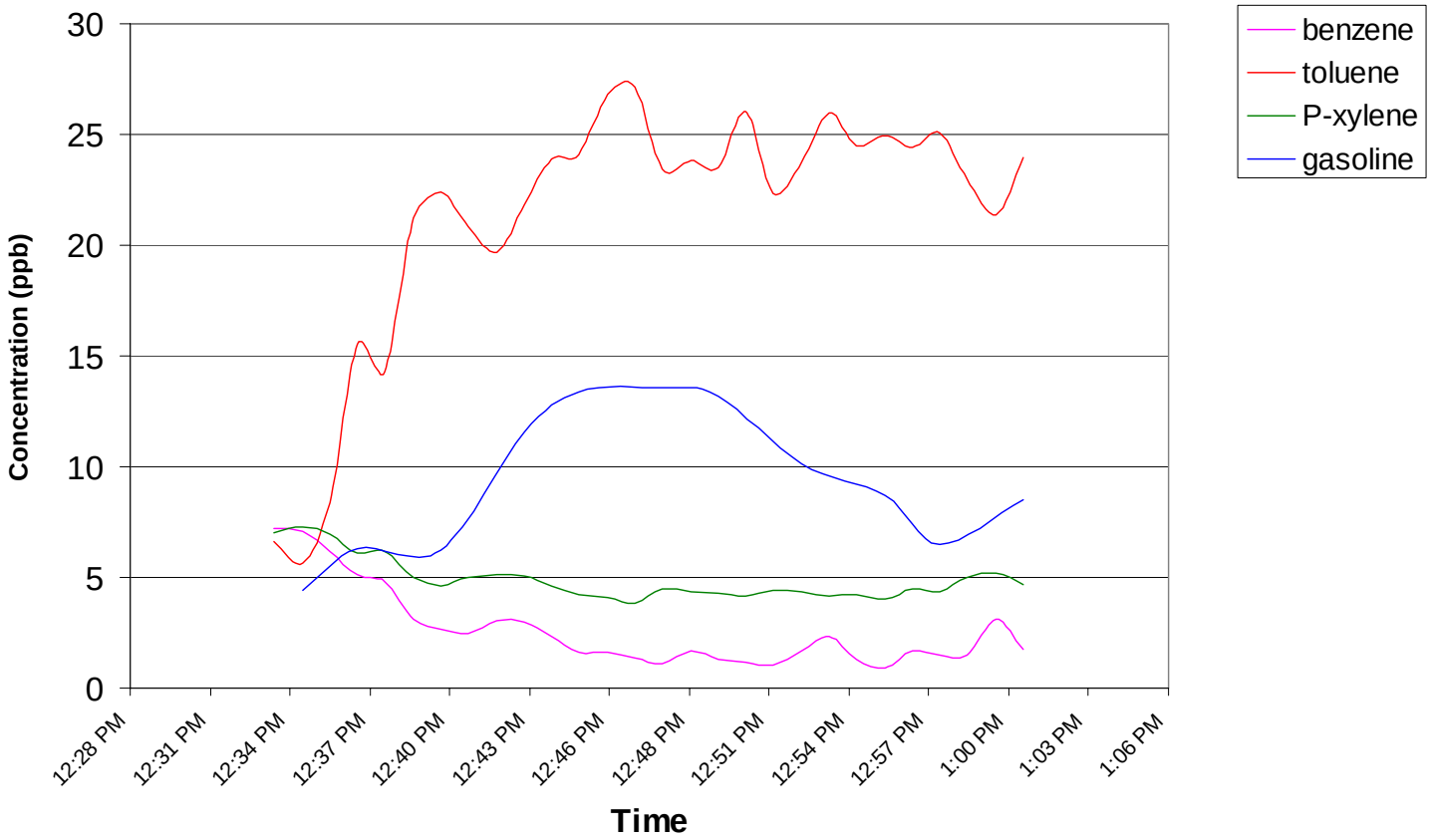
Validation of Gasoline Detected with the OP-FTIR Instrument using Reference Spectrum



Results from Vertical RPM Survey of Gasoline Plume



Time Series of Path-Averaged Concentrations of Benzene, Toluene, and P-Xylene (in ppb) Measured with the DOAS Instrument, and Gasoline (in ppb) Measured with the OP-FTIR in Area A



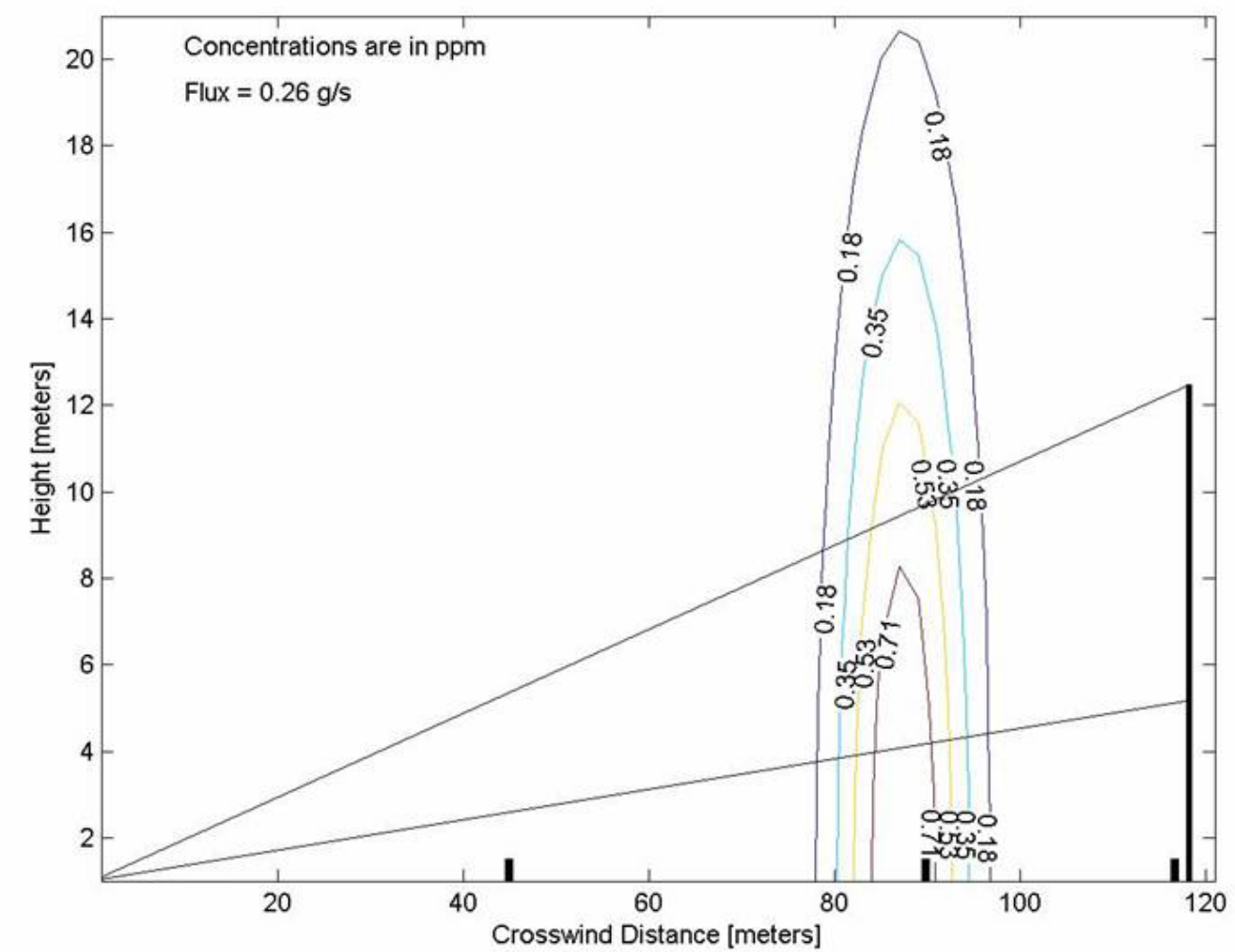
Average Flux of BTX Compounds and Gasoline

Compound	Average Concentration (ppm)	Flux (g/s)
Benzene	0.00263	0.29
Toluene	0.0212	2.4
P-Xylene	0.00490	0.49
Gasoline	**0.00933**	**0.87**

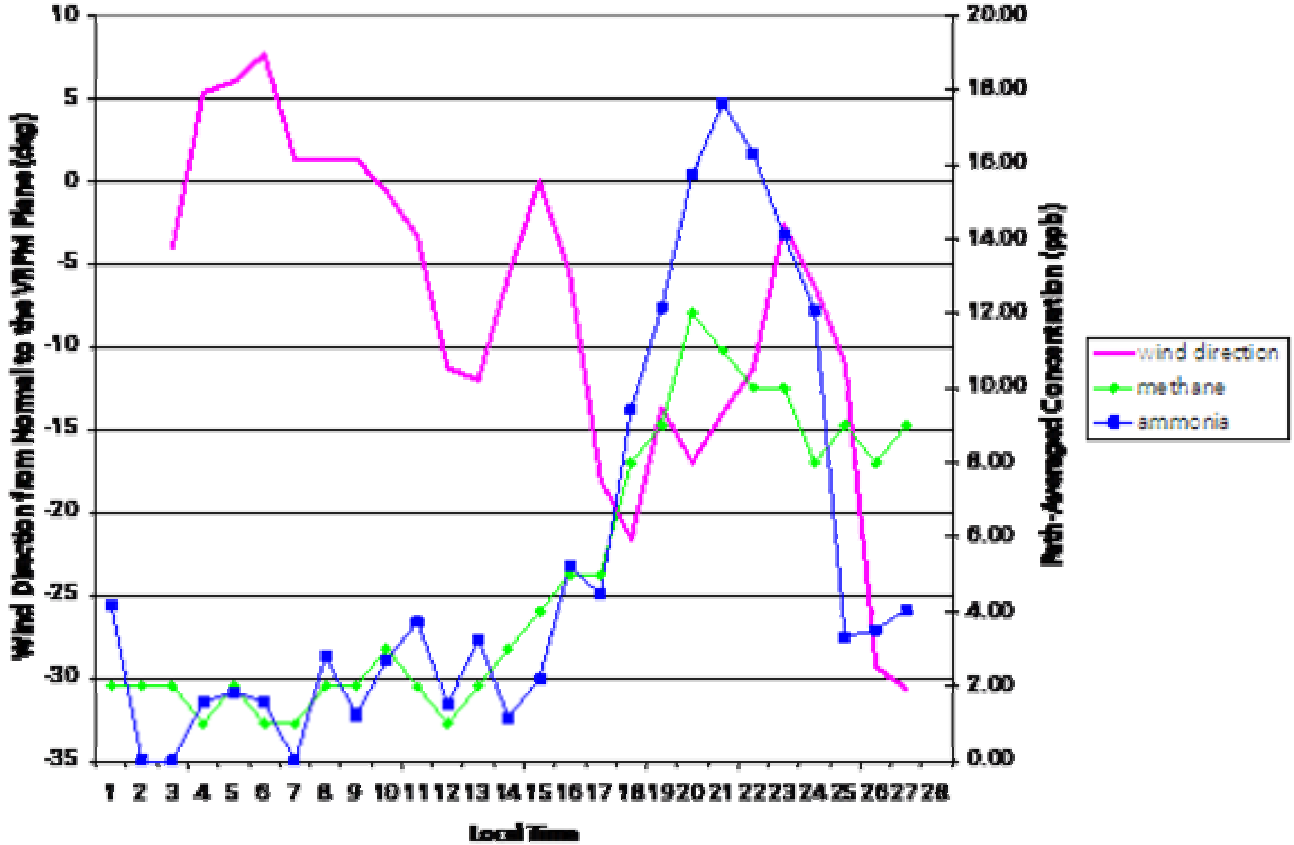
Results for Horizontal RPM of Area A – Path-Averaged Methane Concentrations (in ppm)

Loop	Mirror 1	Mirror 2	Mirror 3	Mirror 4	Mirror 5	Mirror 6	Mirror 7	Mirror 8	Mirror 9
1	1.81	1.83	1.81	1.81	1.81	1.81	1.86	1.83	1.83
2	1.81	1.83	1.81	1.81	1.82	1.80	1.84	1.81	1.82
3	1.80	1.82	1.78	1.79	1.80	1.79	1.83	1.80	1.79
4	1.79	1.82	1.80	1.80	1.80	1.78	1.83	1.80	1.80
5	1.79	1.81	1.78	1.79	1.79	1.78	1.83	1.79	1.78
6	1.79	1.81	1.78	1.76	1.79	1.77	1.83	1.79	1.78
7	1.78	1.80	1.78	1.77	1.79	1.77	1.82	1.78	1.79
8	1.78	1.80	1.78	1.77	1.78	1.71	1.82	1.78	1.78
9	1.80	1.79	1.78	1.77	1.77	1.76	1.82	1.78	1.78
10	1.77	1.79	1.77	1.77	1.78	1.76	1.83	1.78	1.78
11	1.77	1.79	1.78	1.78	1.80	1.77	1.81	1.78	1.78
12	1.78	1.80	1.78	1.78	1.79	1.77	1.83	1.80	1.79
13	1.78	1.79	1.77	1.78	1.78	1.77	1.81	1.79	1.77
14	1.78	1.80	1.77	1.78	1.79	1.77	1.82	1.78	1.77
15	1.77	1.79	1.78	1.78	1.78	1.76	1.81	1.78	1.78
Average	**1.79**	**1.80**	**1.78**	**1.78**	**1.79**	**1.77**	**1.83**	**1.79**	**1.79**
Std. Dev.	**0.014**	**0.015**	**0.013**	**0.014**	**0.013**	**0.022**	**0.012**	**0.014**	**0.016**

Results from Vertical RPM Survey for Methane Plume



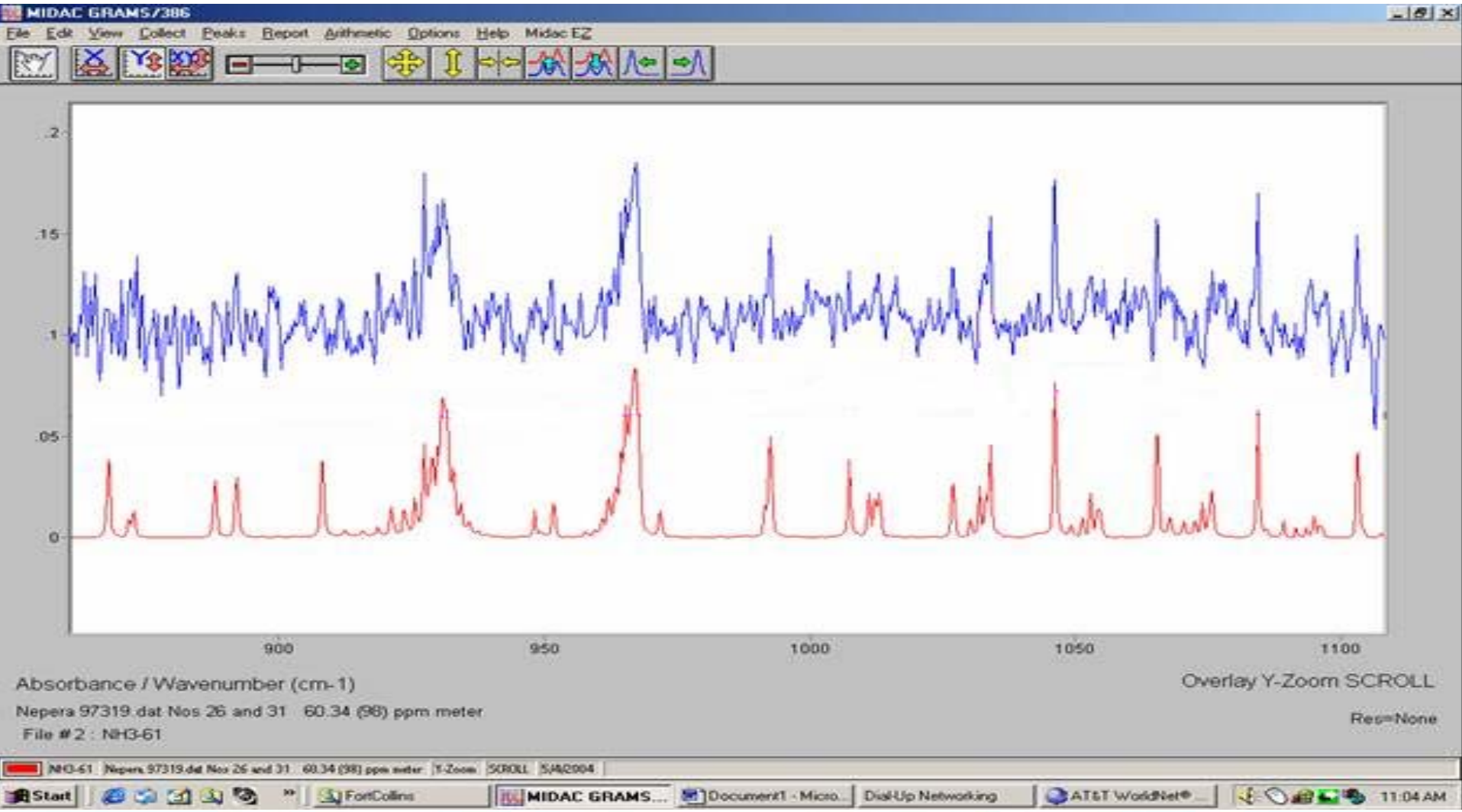
Results from Vertical RPM Survey of Mirror 5 in Area A - Time Series of Wind Direction, and Methane and Ammonia Concentrations



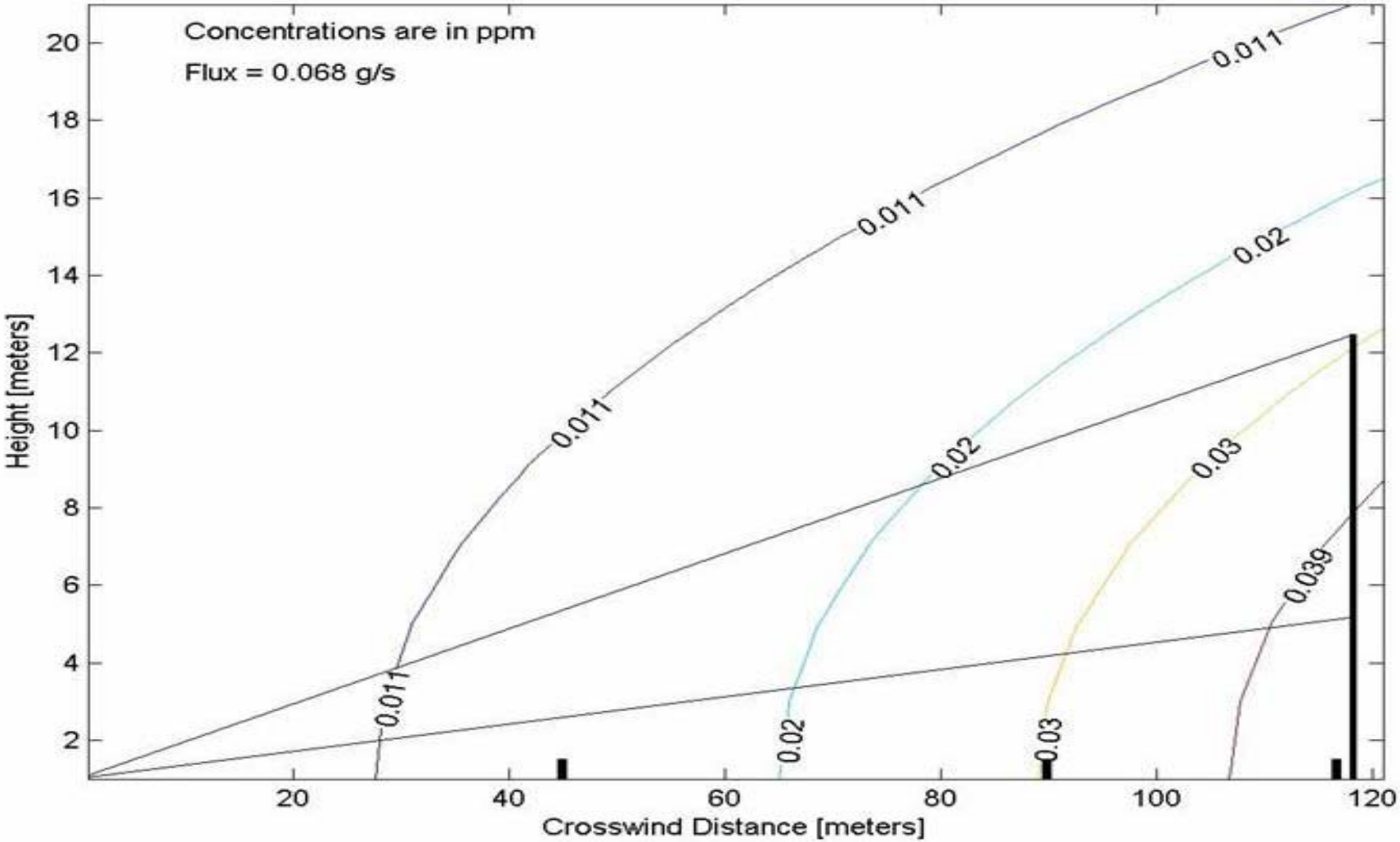
*In order to fit the scale of the graph, the methane concentrations reported are in ppb/10. The methane concentrations reported are values above ambient background

Validation of Ammonia Detected with OP-FTIR Instrument.

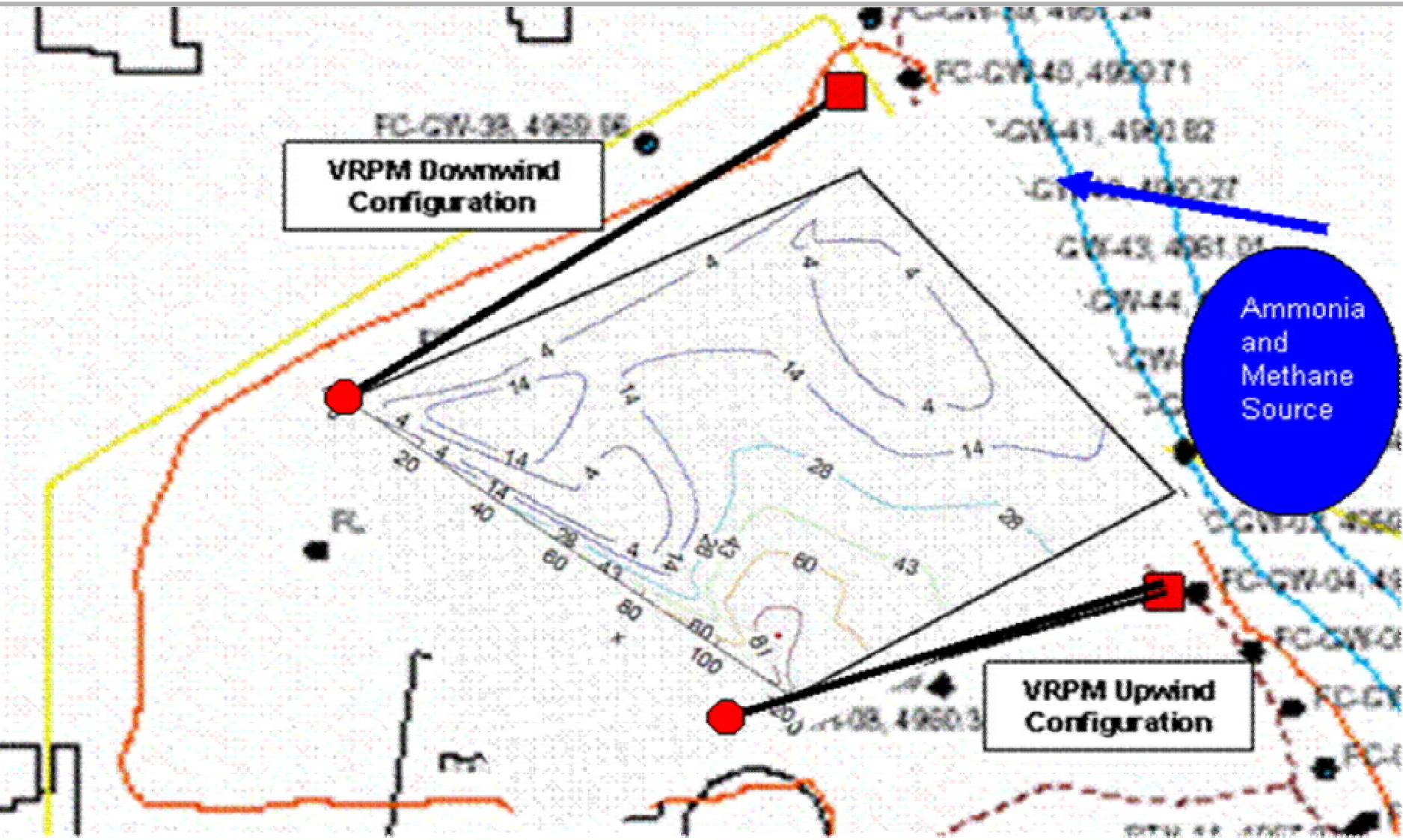
Red Trace is the Ammonia Reference Spectrum and Blue Trace is Actual Spectrum Measurements from Vertical RPM Survey



Results from Vertical RPM Survey - Ammonia Plume



Results Summary Map from Area A Measurements



Since methane and ammonia were not detected during the HRPM survey of Area A, it can be concluded that the source is outside of Area A.

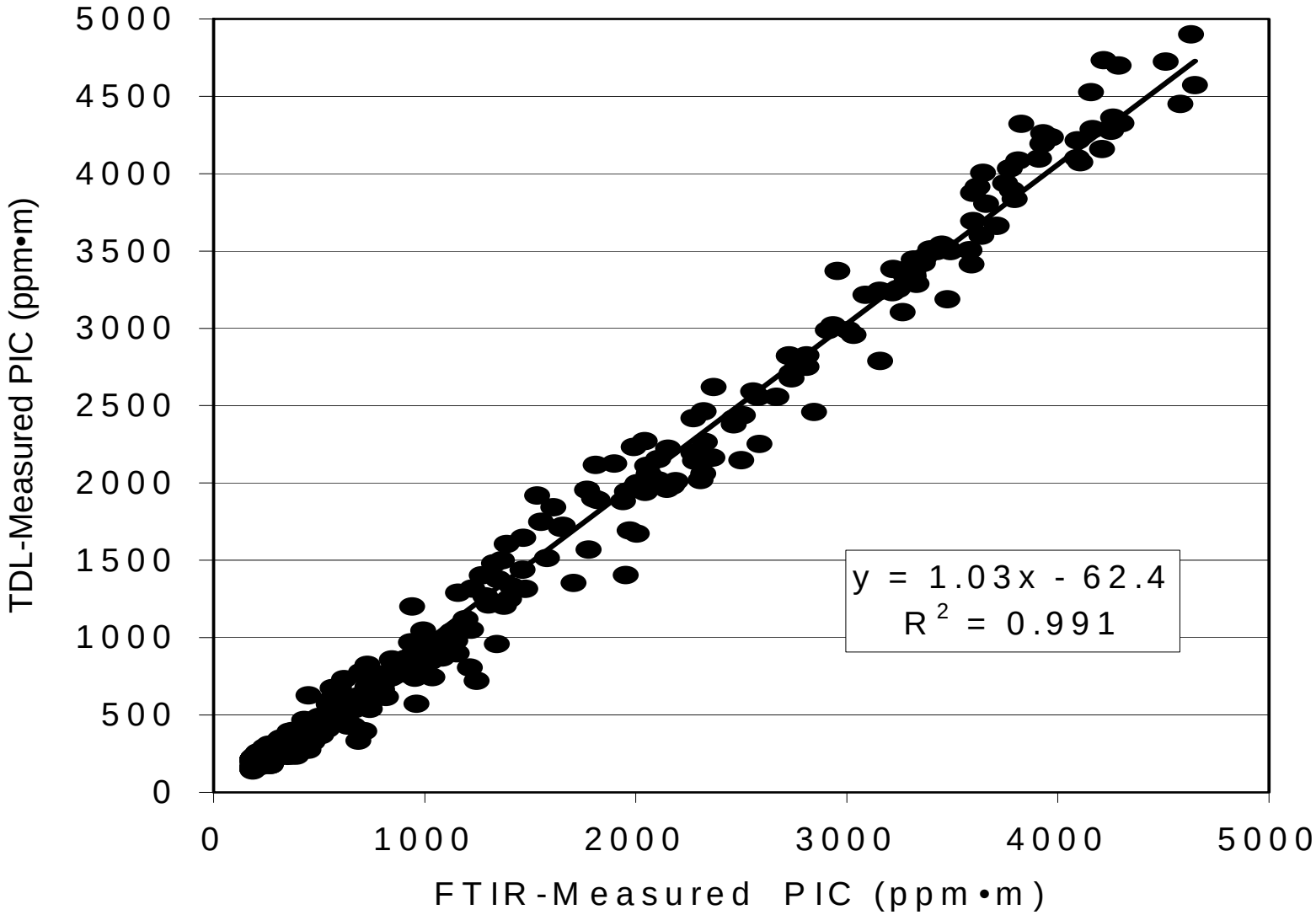
Methane Results from Horizontal RPM Surveys of Each Area – Path Integrated Concentrations (ppmv)

Area		M1	M2	M3	M4	M5	M6	M7	M8	M9
A	Average	1.79	1.80	1.78	1.78	1.79	1.77	1.83	1.79	1.79
	Std. Dev.	0.014	0.015	0.013	0.014	0.013	0.022	0.012	0.014	0.016
B	Average	1.89	1.81	1.89	1.81	1.92	1.82	1.81	1.89	*
	Std. Dev.	0.027	0.008	0.012	0.009	0.012	0.005	0.009	0.009	*
C	Average	1.80	1.76	1.75	1.73	1.73	1.74	1.74	1.78	*
	Std. Dev.	0.011	0.011	0.012	0.010	0.011	0.011	0.010	0.011	*
D	Average	1.80	1.75	1.73	1.77	1.73	1.75	1.72	1.71	*
	Std. Dev.	0.020	0.020	0.017	0.018	0.018	0.018	0.017	0.017	*

* The Horizontal RPM configurations in Areas B, C, and D included 8 mirrors.

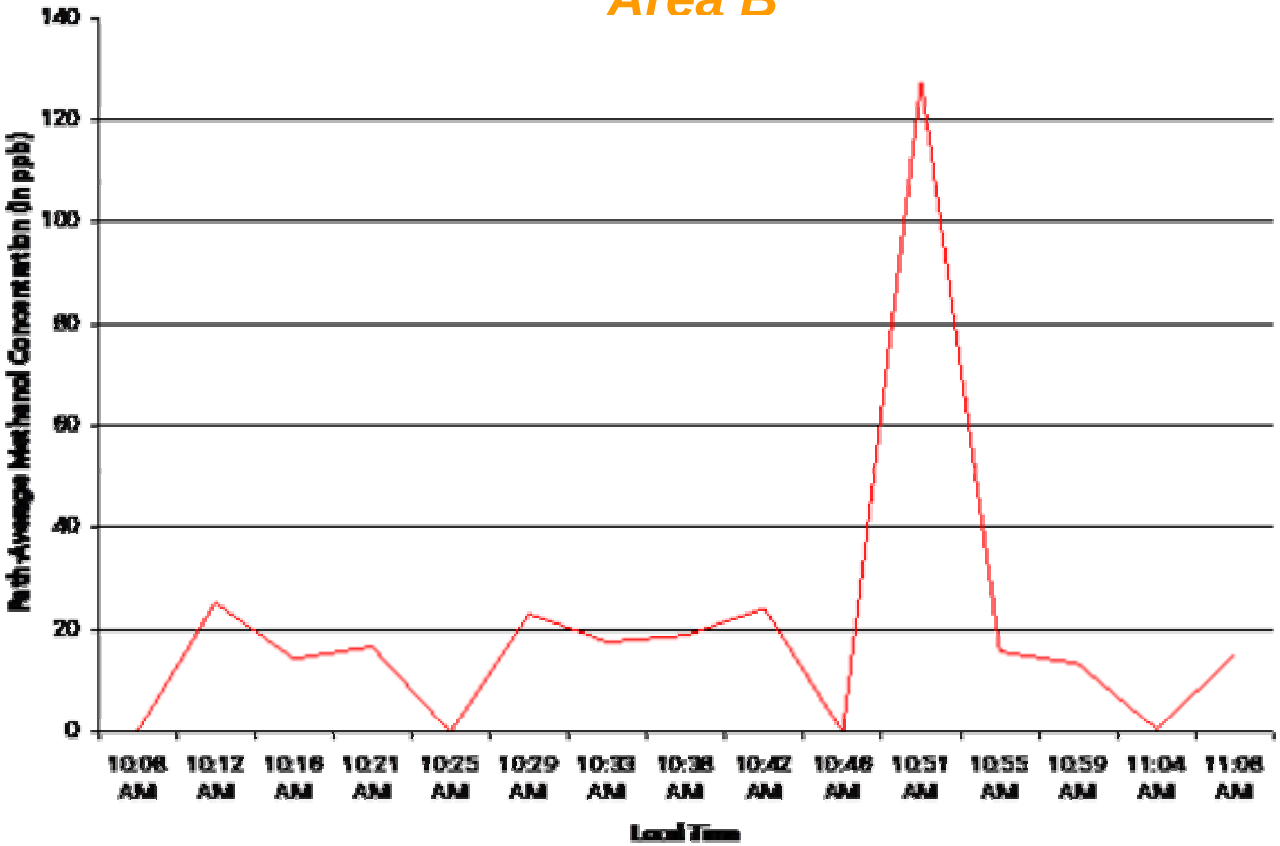
The average surface methane concentrations measured in each area were close to ambient background levels. The results of the horizontal RPM surveys found no methane hot spots at the site. The very small standard deviations that were found support this finding.

Comparison of Path-Integrated Concentrations of Methane Results for the OP-TDLAS and OP-FTIR

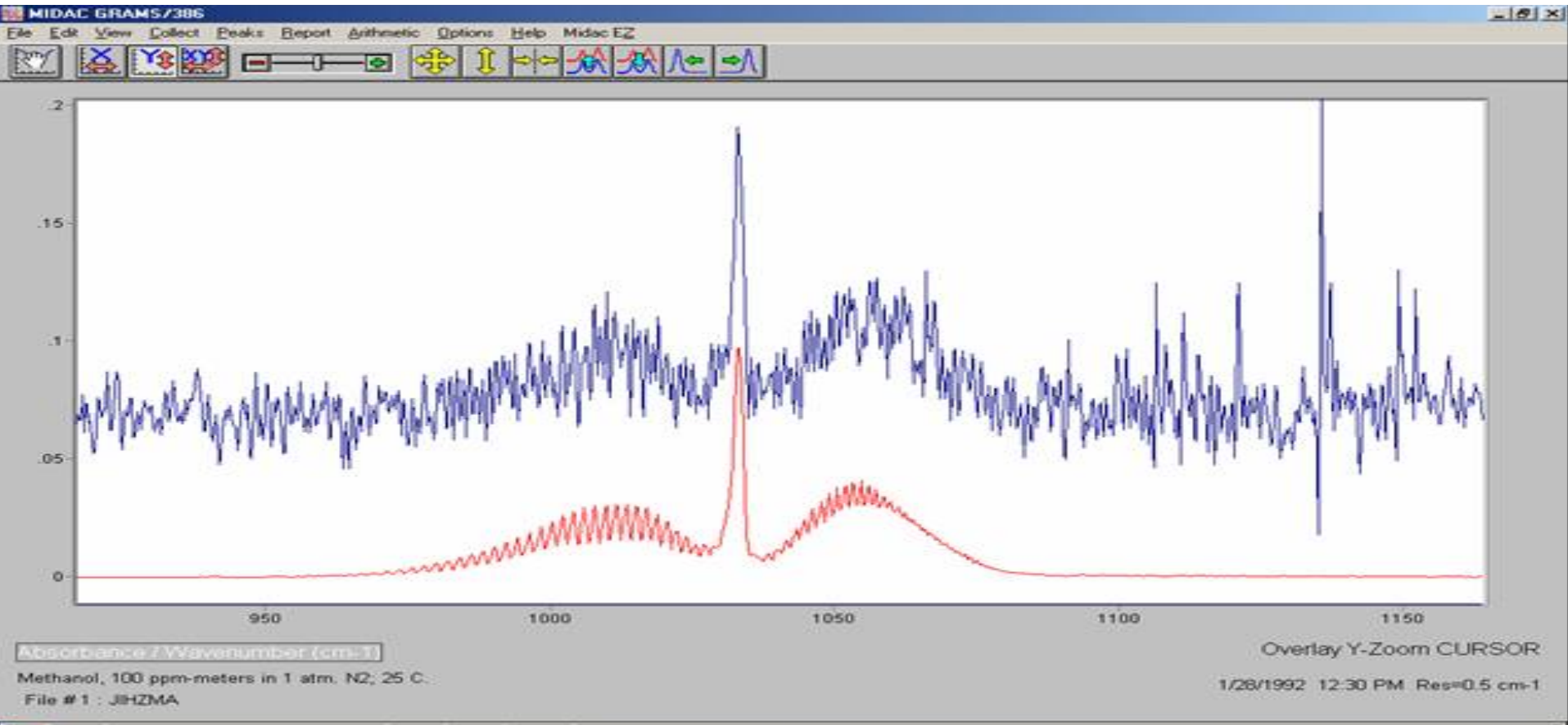


Path-Averaged Methanol Concentrations (in ppb) Detected on Mirror #3 of the HRPM Survey of

Area B



Validation of Methanol Detected with the OP-FTIR Instrument Using Results of the Horizontal RPM Survey of Area B - Red Trace is the Methanol Reference Spectrum, Blue Trace is an Actual Spectrum Measured with the OP-FTIR Instrument

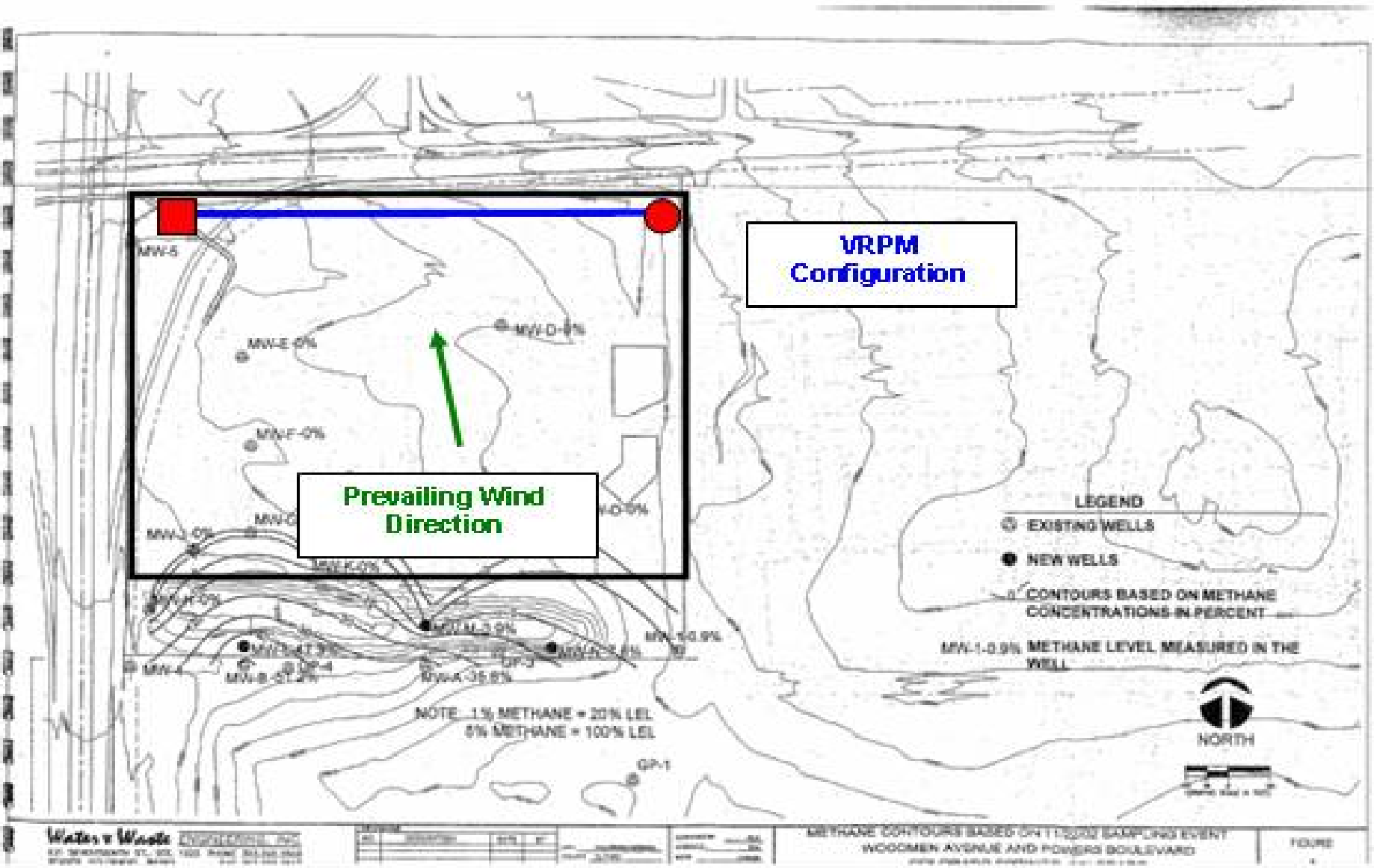


Evaluation of Landfill in Colorado Springs, Colorado

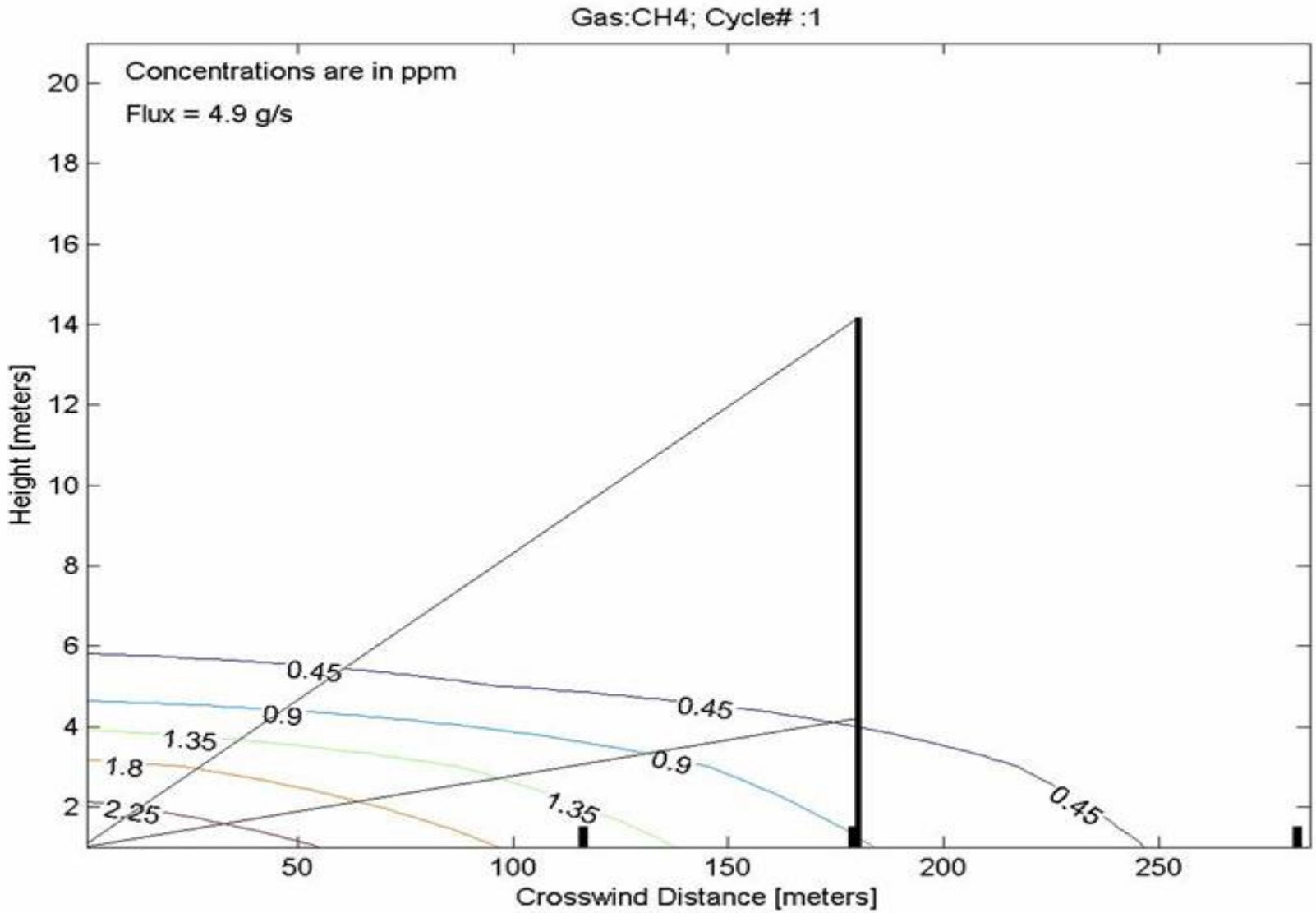
Brownfield Landfill

Horizontal and Vertical RPM Surveys

Vertical RPM Configuration Used at Colorado Springs Site



Results from Vertical RPM Survey – Methane Flux



Methane Flux (in g/s) and Prevailing Wind Direction (in degrees from normal to the VRPM configuration) Measured During the VRPM Survey

Results for Path-Averaged Concentrations of Methane (ppm) from Horizontal RPM Surveys

Area		M1	M2	M3	M4	M5	M6	M7	M8	M9
NW	Average	1.63	1.65	1.61	1.62	1.60	1.66	1.61	1.62	1.60
	Std. Dev.	0.016	0.013	0.016	0.020	0.017	0.017	0.019	0.019	0.019
NE	Average	1.83	1.81	1.87	1.90	1.83	1.82	1.79	*	*
	Std. Dev.	0.066	0.066	0.088	0.119	0.070	0.072	0.071	*	*
SW	Average	1.75	1.76	1.74	1.79	1.74	1.77	1.77	*	*
	Std. Dev.	0.016	0.017	0.015	0.013	0.013	0.015	0.044	*	*
SE	Average	1.83	1.92	1.95	1.81	1.86	*	*	*	*
	Std. Dev.	0.060	0.099	0.137	0.059	0.086	*	*	*	*

*The NE and SW Area surveys included only 7 mirrors. The SE Area survey included only 5 mirrors.

EPA Acknowledgements

- Environmental Response Team
- National Risk Management Research Laboratory
- Office of Air Quality Planning and Standards
- Regions 1, 3, 4, 5, 8, and 9
- Superfund Program
- Technology Innovation Office

Other Acknowledgements

- ARCADIS
- Environmental Quality Management, Inc.
- Tetra Tech EM Inc.
- States of Colorado, Maryland, New Hampshire, Rhode Island, and South Carolina

Next Steps

- Completing test reports for each site
- Developing summary report that will include overview of ORS technology and applications
- Conducting Agency Reviews of Guidance Document (Jan 2005)
- Providing data and information needed to evaluate sites for future use and development