Bioreactors & Landfill Gas Emissions

Susan A. Thorneloe
Office of Research and Development
National Risk Management Research Laboratory
Research Triangle Park, North Carolina

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US EPA Office of Research and Development

Presentation Outline

- Potential Issues & Environmental Concerns
- Ongoing Field Test Evaluations
- Updates & Next Steps

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Background – What is the Interest in Landfill Gas Emissions?

- Landfills are identified for evaluating residual risk under CAA Section 112 (f)
  - » EPA has identified ~30 hazardous air pollutants (HAPs) in landfill gas (LFG)
  - » Persistent bioaccumulative toxics (PBTs) include Hg and dioxins/furans and are linked to LFG
- Existing emission factors are for conventional landfilling operation and do not reflect bioreactor operations
- Data being collected through ongoing field test programs will help in
  - » Updating existing AP42 LFG emission factors
  - » Developing LFG emission factors for bioreactors (to include in AP42) and
  - » Evaluating residual risk.

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Potential Issues In Regard to Air Emissions

- Bioreactor operation can result in increased environmental impact if –
  - » There is no LFG collection & control
  - » There is a delay in installation & operation of LFG collection & control from onset of liquid additions
  - » No cover material in place to help contain the gas
  - » Presence of cracks & fissures in existing LFG cover and/or cap
- Bioreactor operation can result in decreased environmental impact if LFG collection and control is designed to minimize fugitive emissions

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Potential Issues In Regard to Air Emissions (Cont.)

- Existing requirements are for sites that contain at least 2.5 millions tons of waste
  - » No Clean Air Act LFG collection/control requirements for smaller sites
- Potential increase in air toxic emissions?
  - » Sewage sludge is often part of liquid additions; transport & fate of mercury in sludge and potential formation of organo-mercury is not understood
  - » If a landfill fire were to occur, cause for concern for dioxin/furan emissions and other impacts to local air and water sheds

Potential Issues In Regard to Air Emissions (Cont.)

- Must closely monitor to ensure that landfill fires do not occur
  - » Aerobic Operations
    - — May be more of an issue because of the high temperatures that are experienced within the site (will also need adequate supply of liquid/water for length of time that site is operated as aerobic bioreactor)
  - » Anaerobic/Hybrid Operations
    - — Air intrusion can lead to landfill fires; operators must balance maximizing LFG control while avoiding air intrusion

Potential Issues In Regard to Air Emissions (Cont.)

- Tradeoff in maximizing liquid infiltration and minimizing fugitive emissions
  - » Operators typically want to delay installation of cap or cover material to allow for more infiltration
  - » Often substitute materials for cover are chosen because of their permeability and ability to maximize airspace
- Leaky caps typically result in higher level of fugitive gas emissions
  - » Is compost effective in minimizing LFG emissions for any fugitive LFG?
  - » Are there geo-textiles that could be used that would allow for infiltration while minimizing LFG emissions?
  - » Are there data available to compare effectiveness of alternative cover material (over short term and long term)?

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Potential Issues In Regard to Air Emissions (Cont.)

- Lack of long-term data to help characterize LFG emissions
  - » Very limited data exist for anaerobic operations
  - » Even less data available for aerobic/hybrid operations

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Technology for Measuring Area Source Emissions

- Beam Configuration: Open-path Fourier Transform Infrared Spectroscopy (OP-FTIR) multiple beams to determine vertical and horizontal gradients
  - » Uses radial scanning technique to locate potential hot spots
  - » Vertical gradient measurements used for determining mass flux rates
- Smooth basis function minimization (SBFM) algorithm to directly reconstruct the mass equivalent plume downwind from the source
- No need for tracer release or inverse dispersion modeling approach for plume characterization (although we have included this as part of QA/QC)
- (Plane-integrated concentration) times (wind speed) yields emission flux

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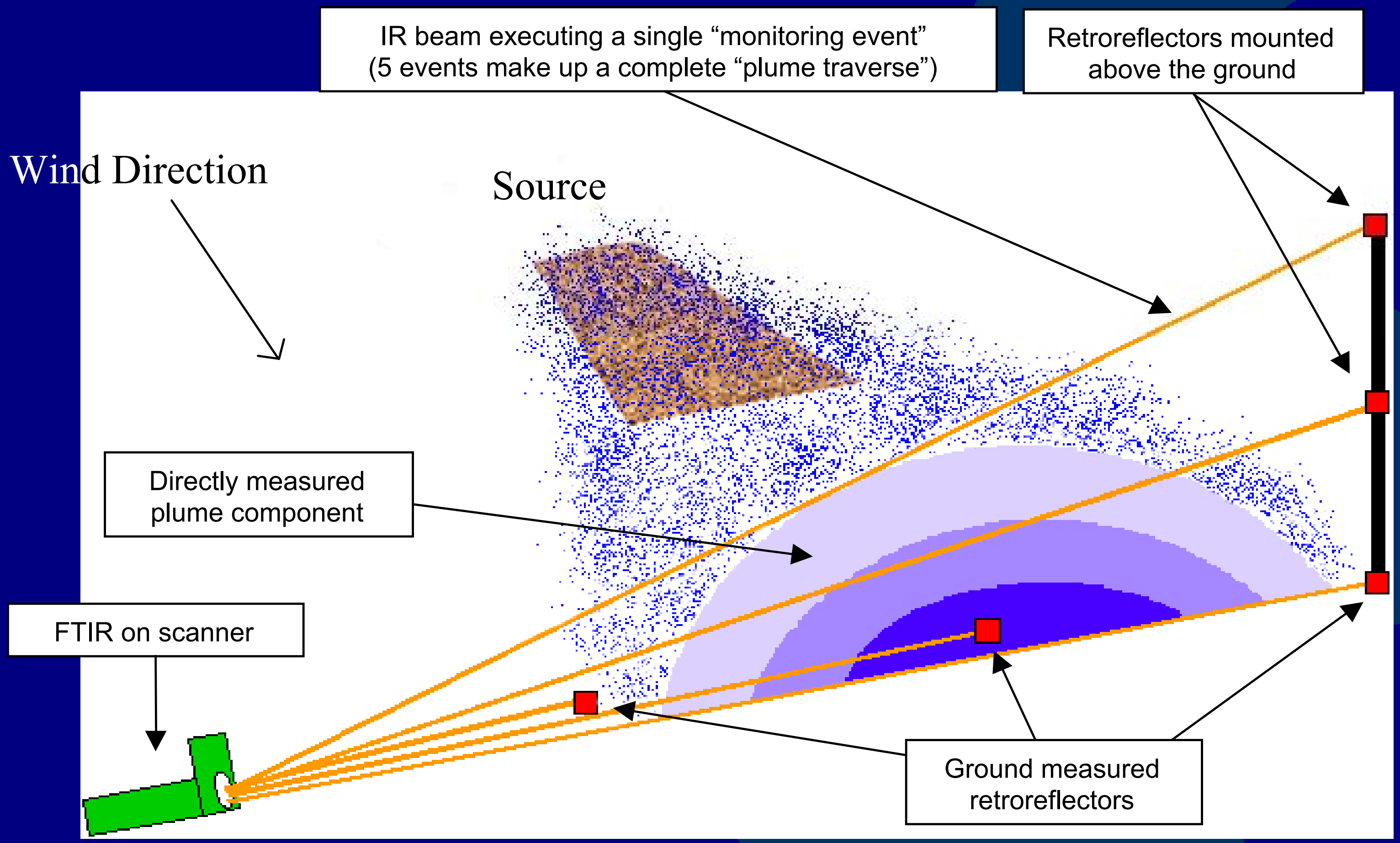
Schematic of OP-FTIR Technology



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Scanning OP-FTIR

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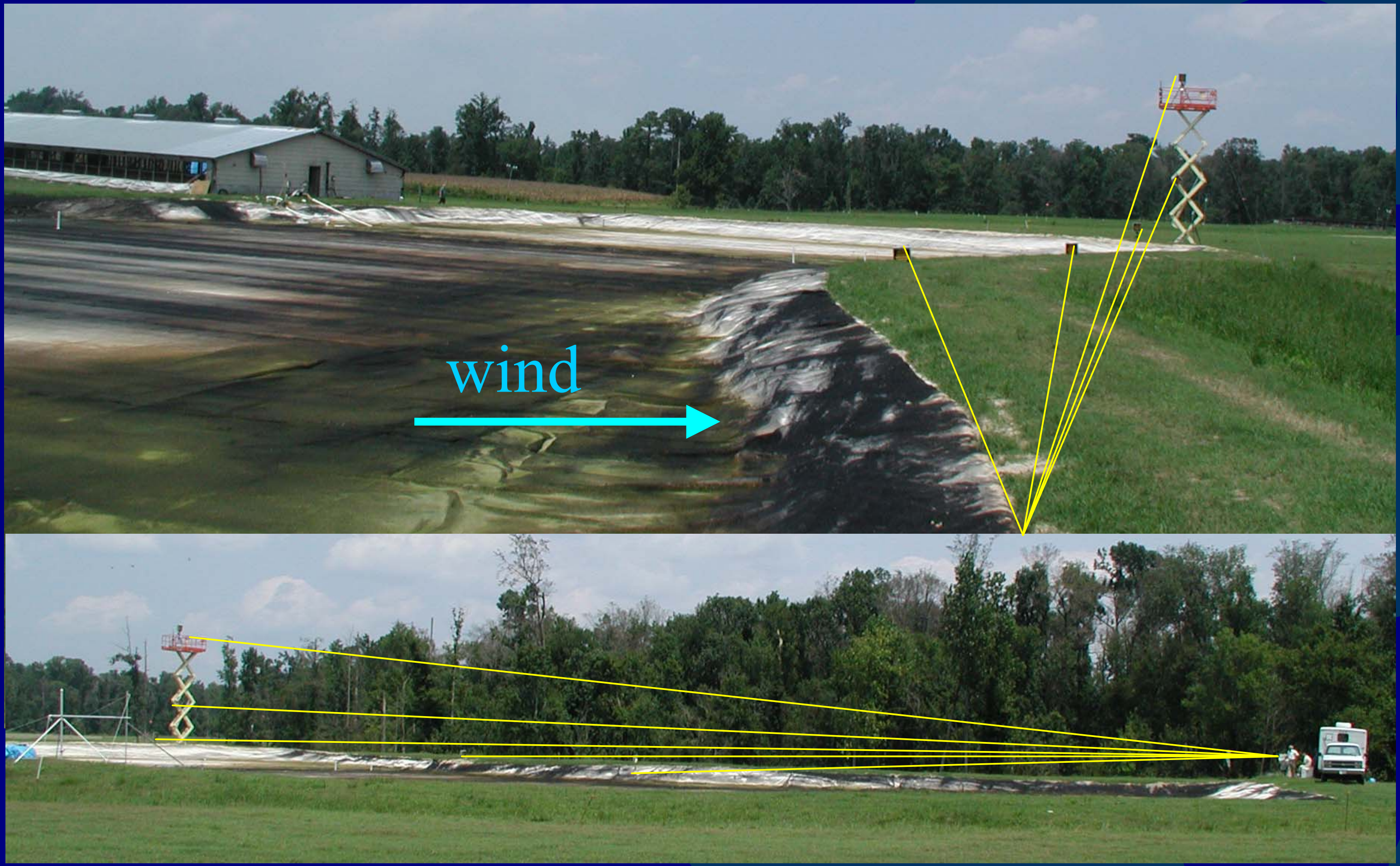
OP-FTIR Measurement Paths at Swine Waste Lagoon



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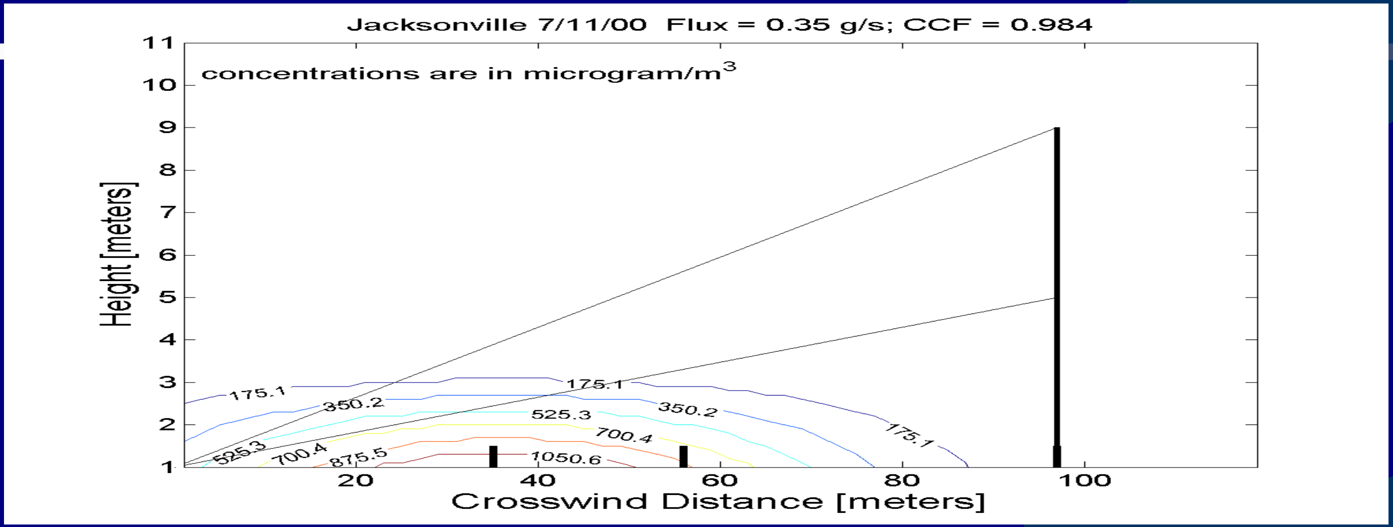
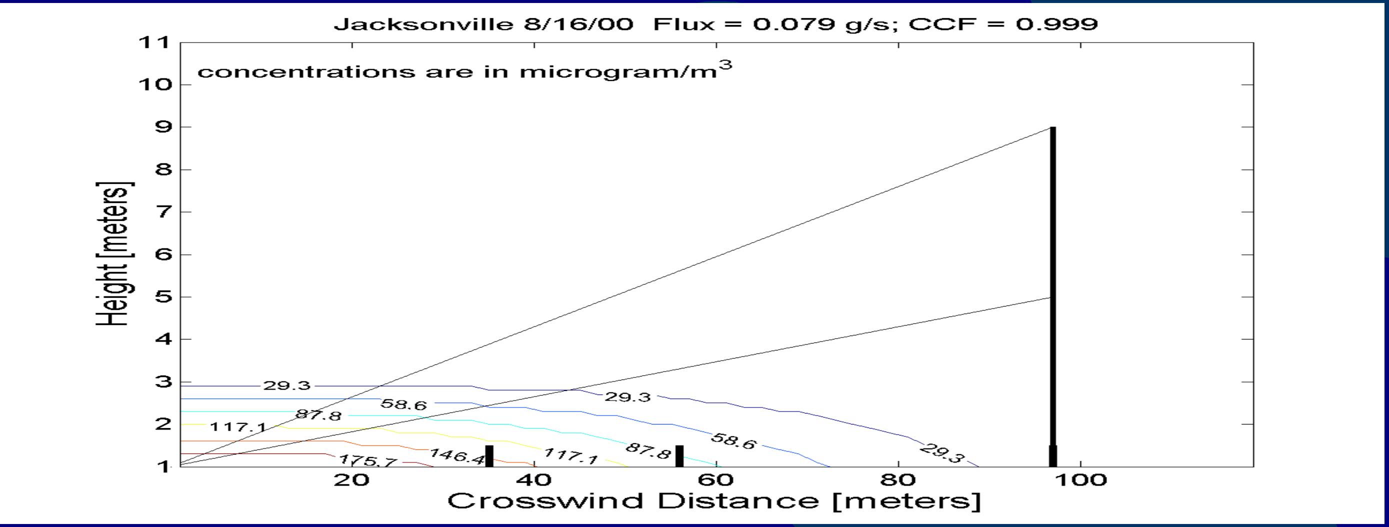
OP-FTIR Determined Ammonia Fluxes from Hog Waste Lagoon





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Conclusions for OP-FTIR Application

- Major advantage of this technology is that emissions are being measured rather than modeled
- Successful demonstration of open-path optical technique to conduct radial scans and measure emission fluxes for multiple pollutants
- Successful application of this technology at different large-area sources including coal mines, landfills, poultry, swine farms, and wastewater treatment facilities

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Overview of Research to Evaluate LFG Emissions from Bioreactors

- Characterizing emissions from 2 different types of landfill "bioreactors" as part of partnership with Waste Management for large-scale operation in Kentucky [CRADA w/ Waste Management, Inc. (WMI)]
  - » Evaluating fugitive emissions & mercury
    - — One round of sampling was completed in 2002; Two rounds planned for 2003
      - – Sampling header pipes (raw LFG) for total, elemental, and organo-mercury
      - – Using open-path Fourier Transform Infrared (OP-FTIR) Spectroscopy for measuring fugitive emissions including speciated VOC, methane, HAPs, NH_3
  - » WMI is sampling header pipes for methane, carbon dioxide, NMOC, and speciated organics including list of "AP42" LFG constituents

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Overview of LFG Field Tests - Bioreactors

- Considering sampling other types of bioreactors using OP-FTIR including aerobic
- Results from field tests will be documented in EPA reports and summarized in peer-reviewed journal publications
- Gathering all available LFG data for bioreactors (D. Reinhart) to develop appropriate defaults/models for bioreactors

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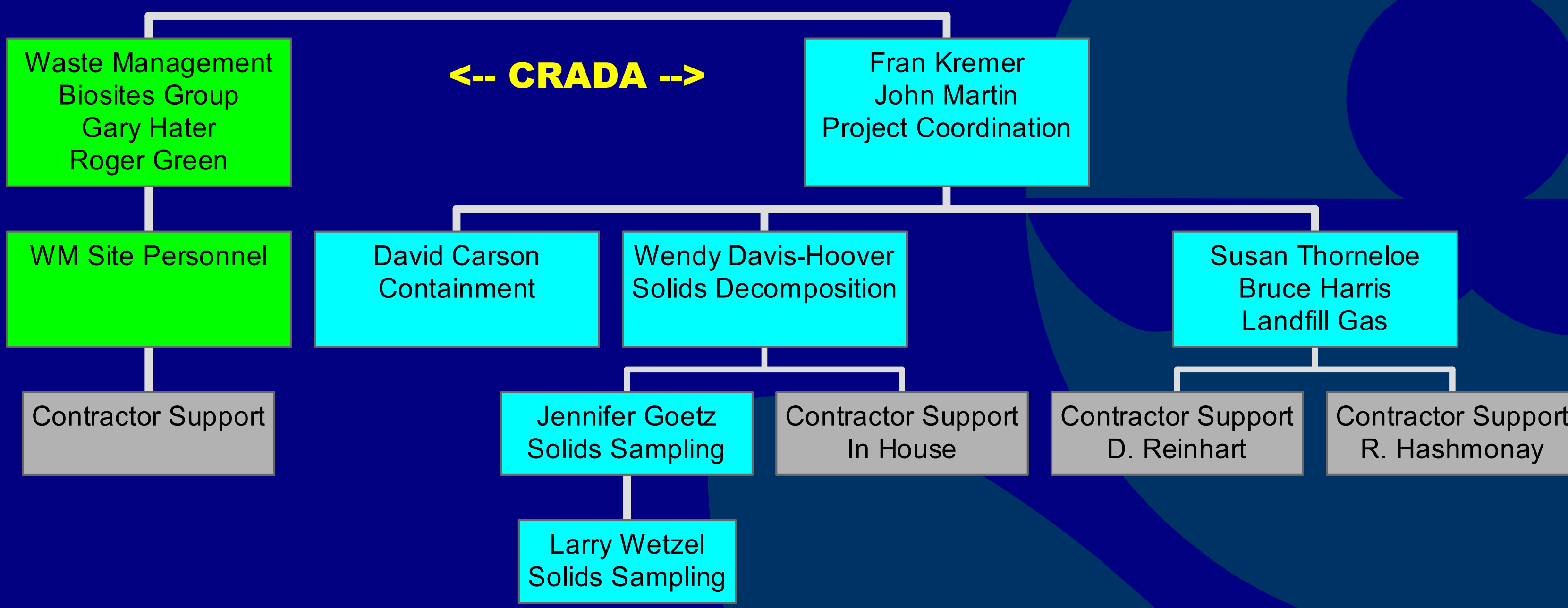
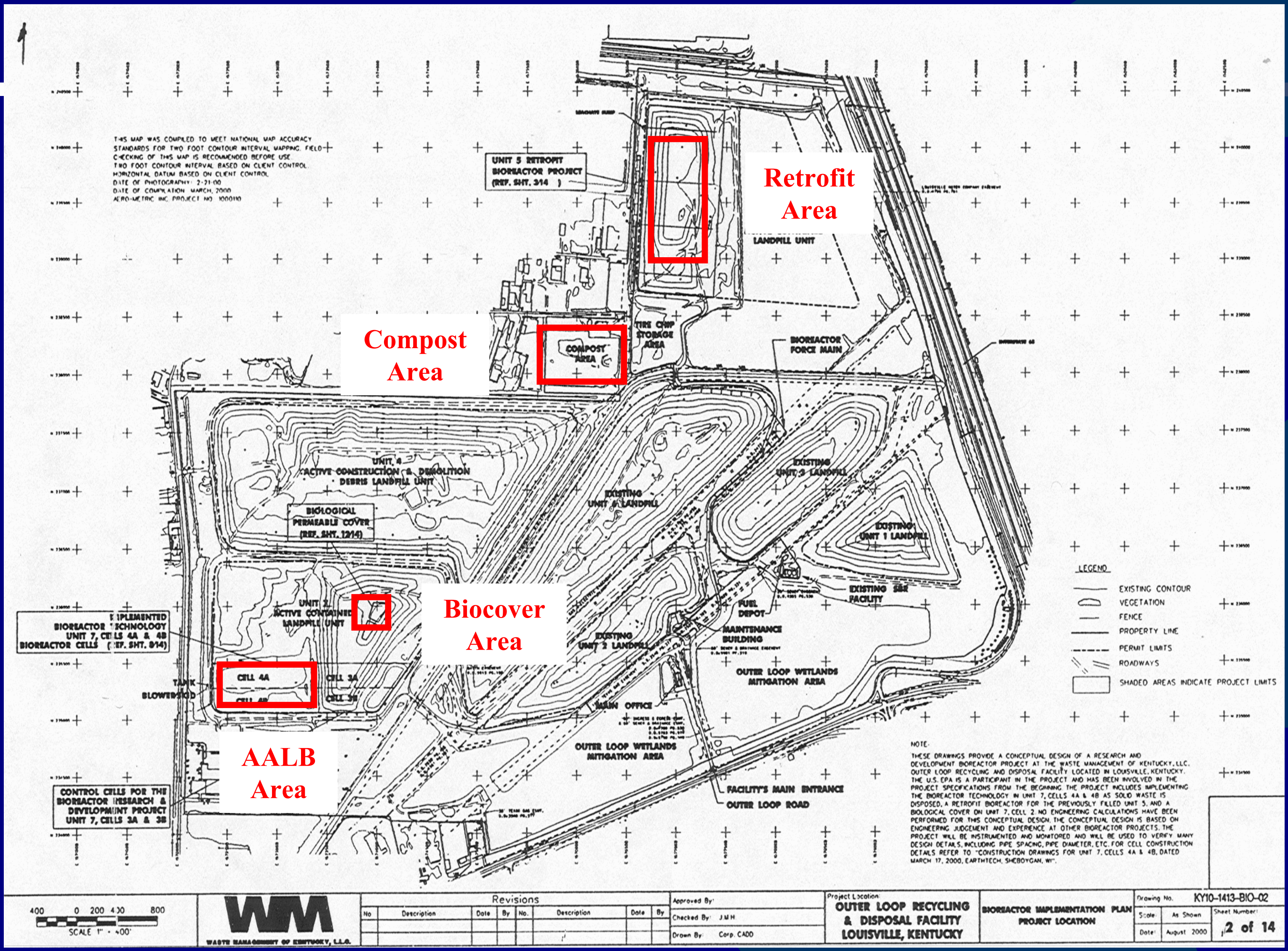
Organization Chart for CRADA Bioreactor Research



Plot Plan of Bioreactor Field Test



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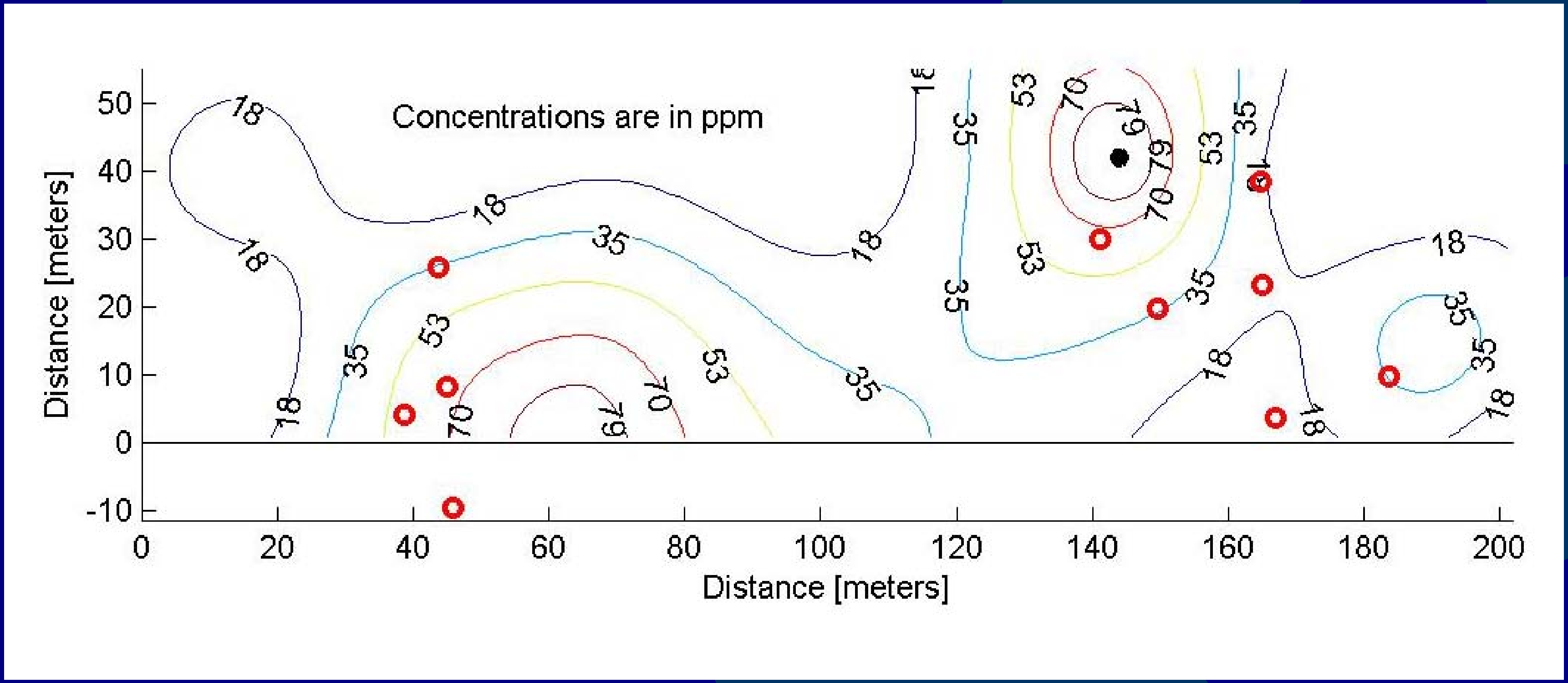
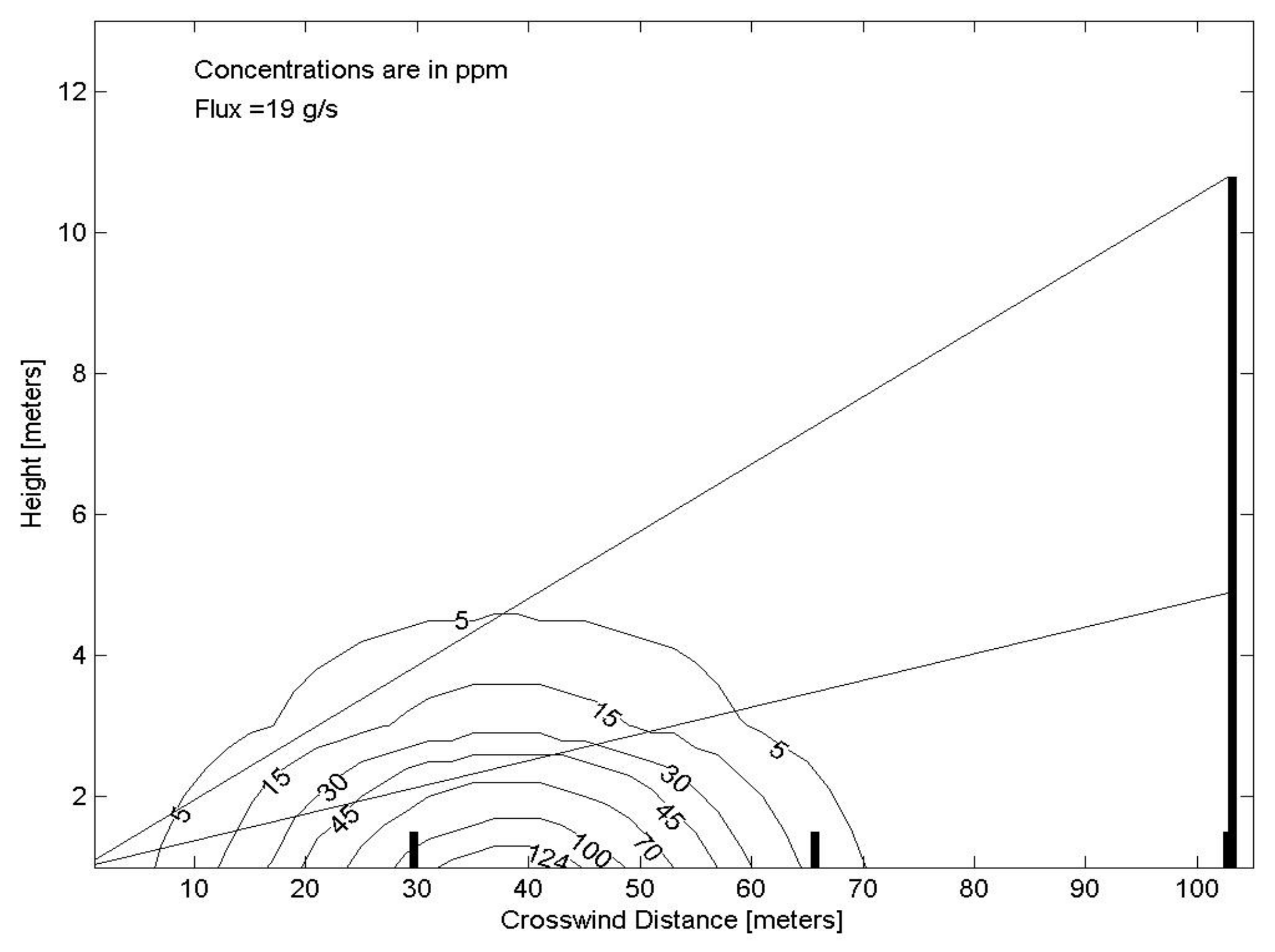
Preliminary Results for Radial Scanning – Methane Concentrations for Unit 5



Preliminary Results of Vertical Scan of North Side of Unit 5 – Methane Flux



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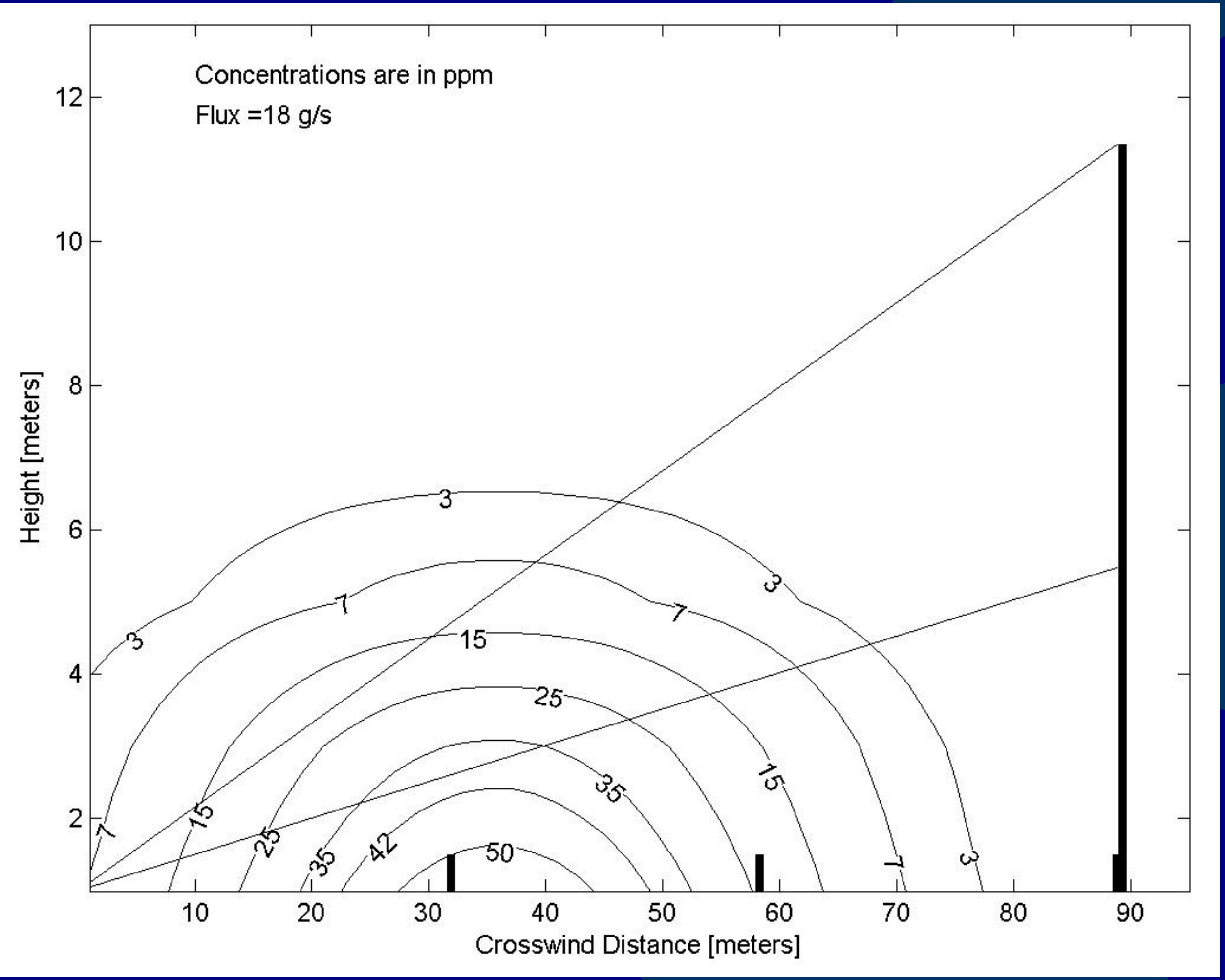
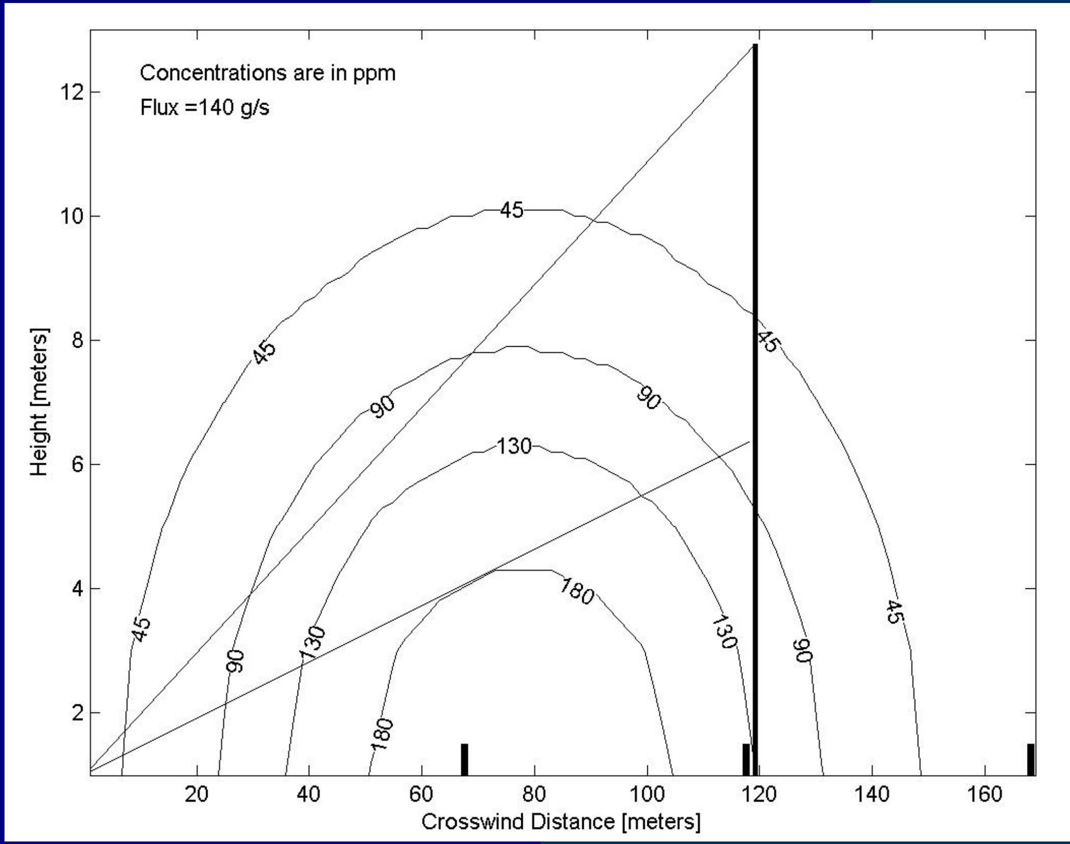
Preliminary Results of Vertical Scan of South Side of Unit 5 – Methane Flux



Preliminary Results from OP-FTIR Measurements on South Side of Active Site - Methane Flux



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Update to EPA's Landfill Gas Emission Factors (AP 42)

- Plans to have update by Spring 2004; will include emission factors for bioreactor operations in addition to updated data for conventional landfilling operations for
  - » Use in State emission inventories and obtaining air permits
  - » Use in MSW Decision Support Tool (includes conventional and bioreactor landfills)
- Results will also be used in evaluating residual risk for landfills as specified in CAA Section 112 (f)

Update to EPA's Municipal Solid Waste Decision Support Tool

- Municipal Solid Waste Decision Support Tool (MSW DST) provides holistic approach to evaluation of solid waste management
  - » Evaluates life-cycle environmental tradeoffs (multi-media, multi-pollutant) including potential benefits of recycling and energy recovery
  - » Includes analysis for all waste management processes – collection, transportation, recycling, composting, combustion, landfilling
  - » Includes capability for evaluating full costs of existing program and options to minimize costs and/or environmental burdens
  - » Helps communities to evaluate new technologies and have basis of comparing them to existing technologies in use
- Software is set up to enable states/communities/others to evaluate existing infrastructure and options for environmental and economic improvements
- Used in over 30 studies in various states, communities, and regions

Types of Questions Answered Using the MSW-DST

- What are the cost and environmental benefits of a municipality's recycling programs?
- Which strategy best minimizes GHG emissions for a given budget?
- What is the difference in cost and environmental tradeoffs using a landfill bioreactor (or other technology) versus what is currently used?
- What are the cost and environmental aspects of recycling versus composting corrugated containers?

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Complex Solid Waste Decisions Being Evaluated

How do we ensure

- Cost efficient waste management?
- Meeting state mandated recycling goals?
- Continued improvement of the environment?
- Fast, objective analysis of options?
- Best privatization bids?

Environmental Aspects

- Local air quality impacts
- Energy consumption and offsets
- Greenhouse gas emissions
- Benefits from materials recycling

Economic/Social Aspects

- Municipal budgets
- Need for new facilities
- Household convenience

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Case Studies Using MSW DST*

- Anderson County, South Carolina
- Atlanta, Georgia
- Great River Regional Waste Authority, Iowa
- Lucas County, Ohio
- Madison, Wisconsin
- Minneapolis, Minnesota
- Portland, Oregon
- Seattle, Washington
- Spokane, Washington
- State of California
- State of Georgia
- State of Washington
- State of Wisconsin
- Subbor – ETV GHG Center
- U.S. Conference of Mayors – U.S. GHG Study
- U.S. Navy Region Northwest
- Vancouver, Canada

*Many other case studies are under consideration and are being funded through participating organizations……

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Conclusions

- Ongoing research to evaluate bioreactors to document potential environmental benefits and/or burdens
- Will result in credible, objective, and peer-reviewed data and information
- Will use results to update –
  - » AP42 LFG emission factors for use in State emission inventories and obtaining air permits
  - » Defaults in MSW DST for conventional landfilling and bioreactor operations
- Results will also be used in evaluating residual risk for landfills as specified in CAA Section 112 (f)

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