Fifth Annual Conference on Carbon Capture & Sequestration

Steps Toward Deployment

CCS w/Biomass and Landfill Gas

Development of an Intelligent Bioreactor Management Information System for Mitigation of Greenhouse Gas Emissions from Landfills

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Project Partners & Funding

- **Project Partners**
  - National Energy Technology Laboratory (Heino Beckert, Karen Cohen)
  - California Energy Commission-PIER
  - Sacramento Municipal Utility District
  - California Integrated Waste Management Board
  - **Yolo County, CA (Ramin Yazdani)**
  - **Institute for Environmental Management, Inc. (Don Augenstein)**
  - **Hydro Geo Chem, Inc. (Harold Bentley)**
  - **University of Delaware (Paul Imhoff & Pei Chiu)**

Background

- **Landfill Methane Emissions**
  - **Methane's contribution to total climate forcing ~ 20% that of CO_2 in last 20 yrs.**
  - **Landfills are largest anthropogenic source of methane - 30% of emissions.**
  - **Bioreactor landfilling may reduce annual US greenhouse emissions by about 15-30 million tons of CO_2 carbon (equivalent) at costs between $3-13/ton carbon**
    - **Enhanced CH4 generation and efficient capture (anaerobic)**
    - **Reduced CH4 generation (aerobic)**

Background

- **Bioreactor Landfills**
  - **Controlled Landfilling – liquid added to increase rates of degradation, producing more methane over shorter time periods**
  - **1970's – first laboratory and field tests**
  - **1980's – 1990's – not accepted by regulators, because of concerns over design and operation**
  - **2000's – tremendous growth in interest, based on recent field successes**

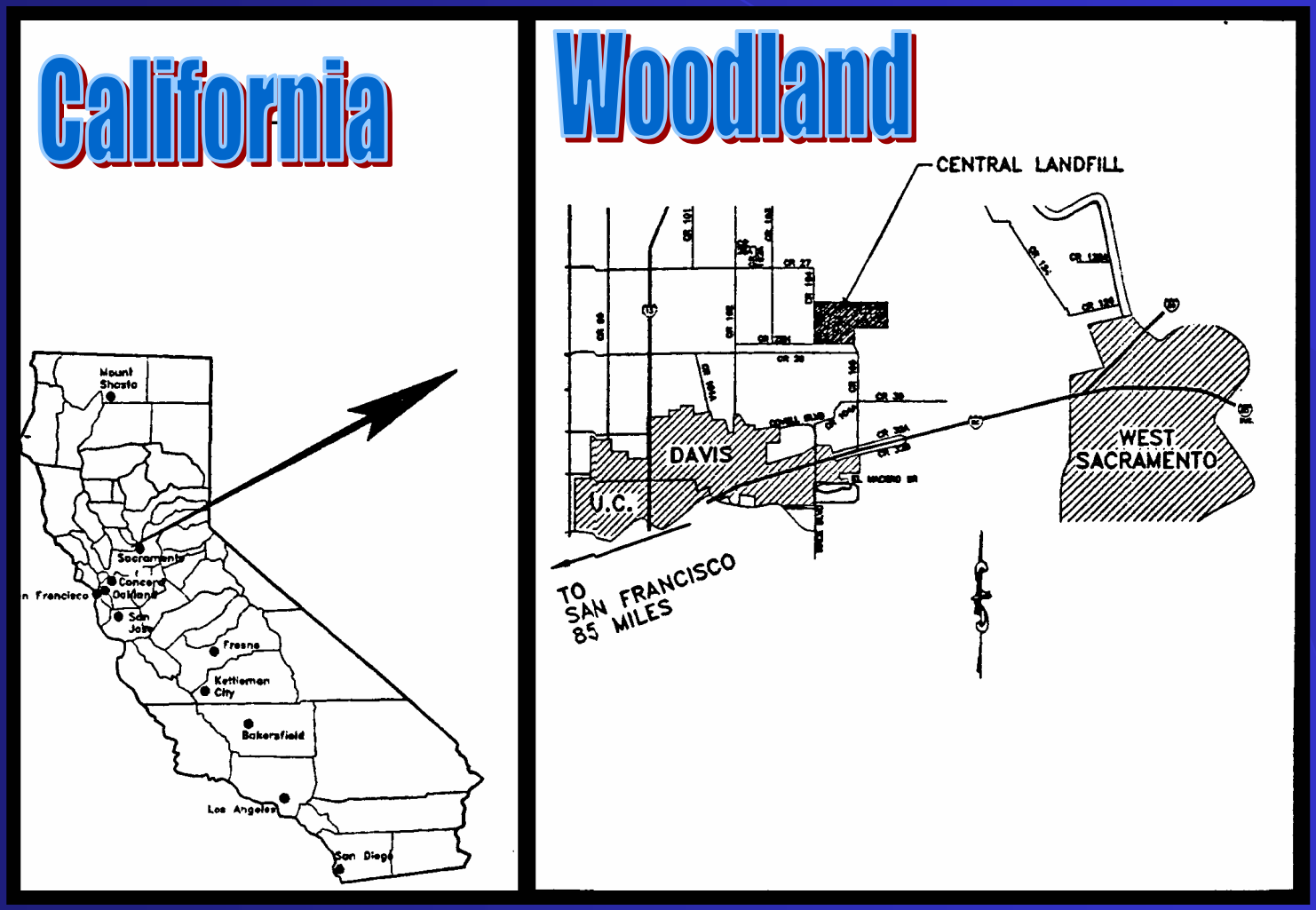
Future of Bioreactor Landfills

- Technology advancing rapidly, but
  - Concerns over excess liquid pressures (side seeps, landfill failures)
  - Concerns over fires (aerobic bioreactors)
  - Concerns over methane emissions, when earthen cover used
- Inadequate models for designing and operating bioreactors
  - Inadequate understanding of how fluids move in refuse
  - Ad hoc designs

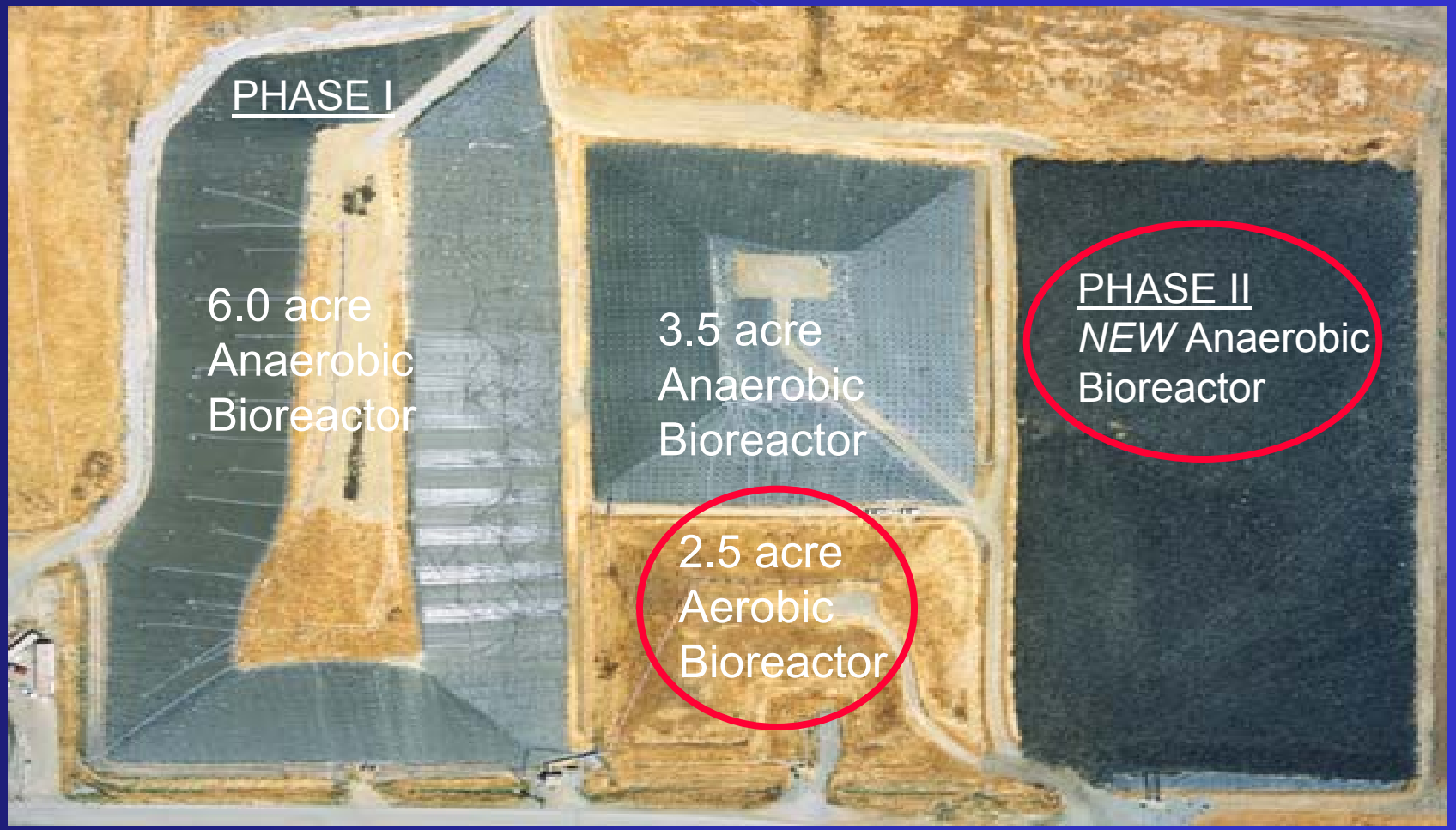
Project Objectives

- Develop Intelligent Bioreactor Management Information System (IBM-IS) for controlling air injection (aerobic) or gas collection (anaerobic)
  - Models to guide air injection and gas collection linked to distributed sensors
- Develop IBM-IS for liquid addition
- Demonstrate the utility of the IBM-IS for reducing GHG emissions
- Develop cost/benefit ratio for IBM-IS

Project Location Map



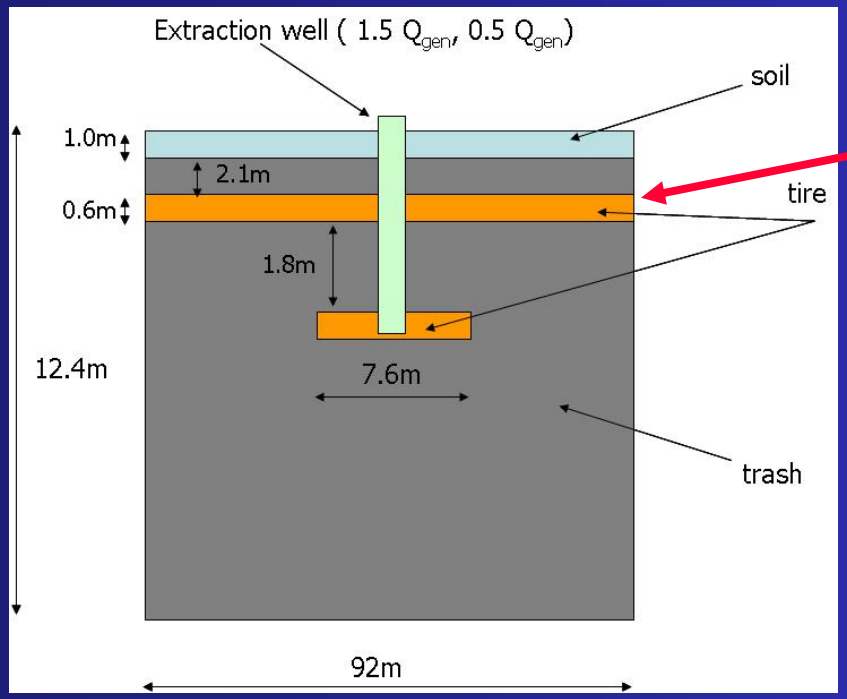
Bioreactor Landfill Cells at Site



Unique Design – highly instrumented

Anaerobic Bioreactor – First Year

- **Design of innovative permeable layer for enhanced methane collection**

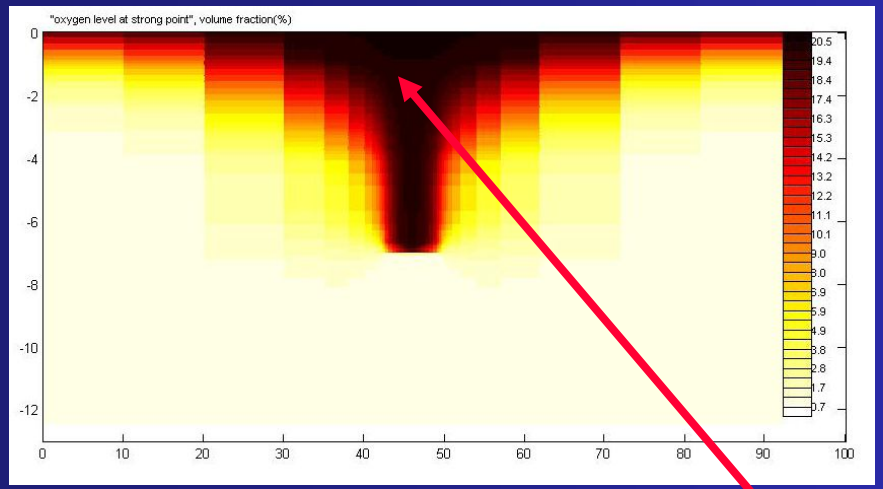


Shredded tires act as high-permeability layer for gas collection

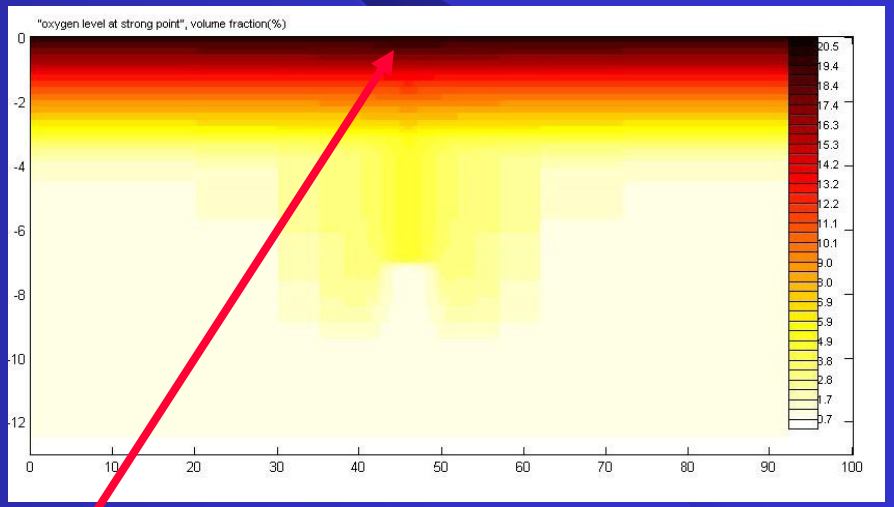
Anaerobic Bioreactor – First Year

- **Simulated intrusion of oxygen**

Without permeable layer



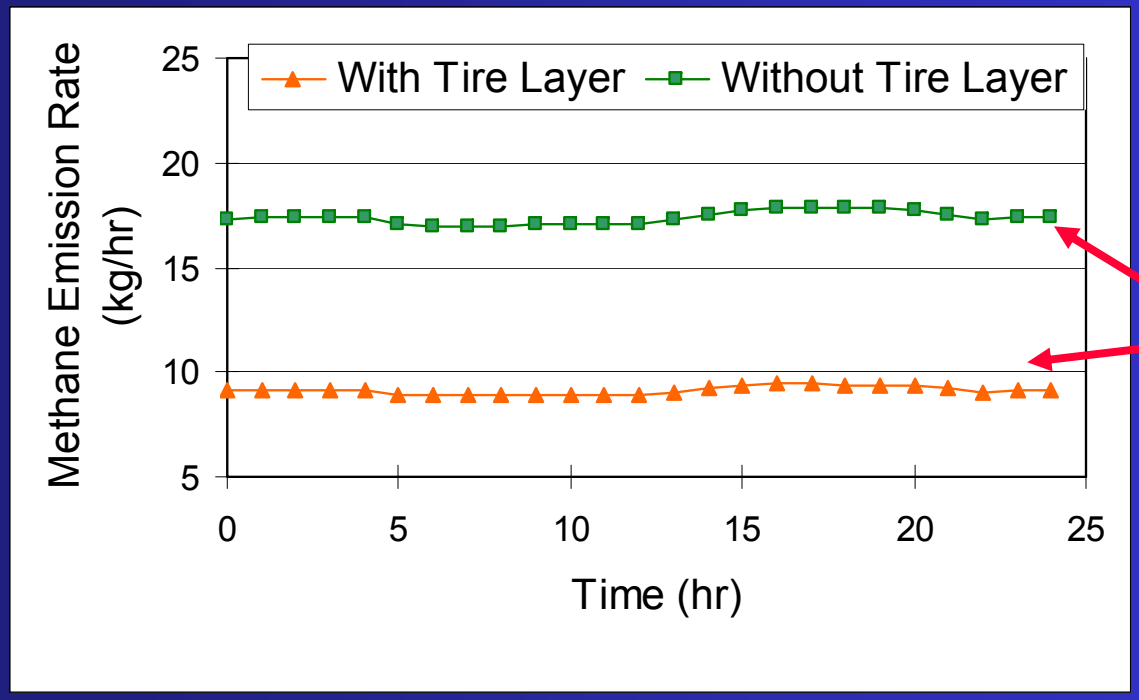
With permeable layer



Intruding oxygen

Anaerobic Bioreactor – First Year

- **Simulated fugitive methane emissions**
  - **Permeable layer *increases* the efficiency of CH4 capture**



Two-fold decrease

Anaerobic Bioreactor – First Year

- Construction of anaerobic bioreactor with biocover (soil + compost)

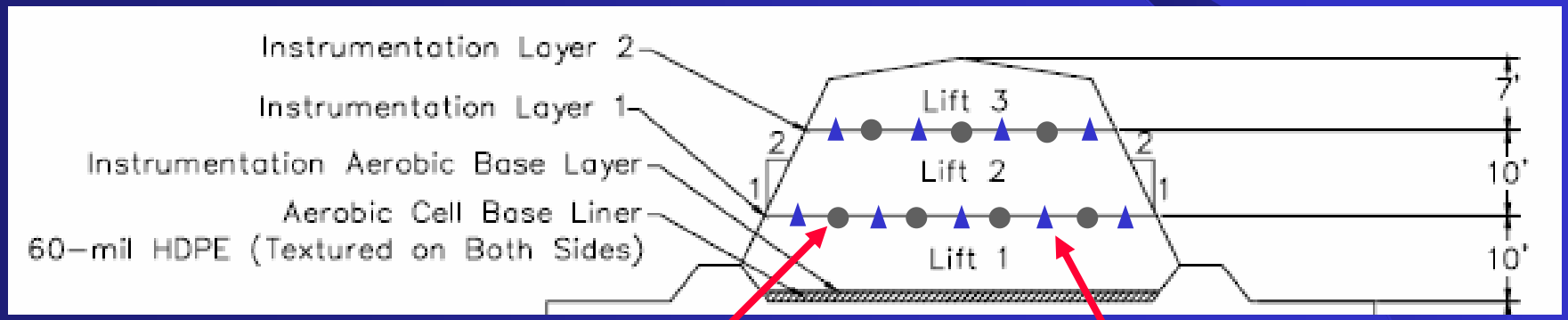
Liner system

Permeable Tire Layer

Biocover + CH4 Emission Sampling

Aerobic Bioreactor – First Year

- Installation of automatic gas pressure measurement system, pump tests, gas flow model

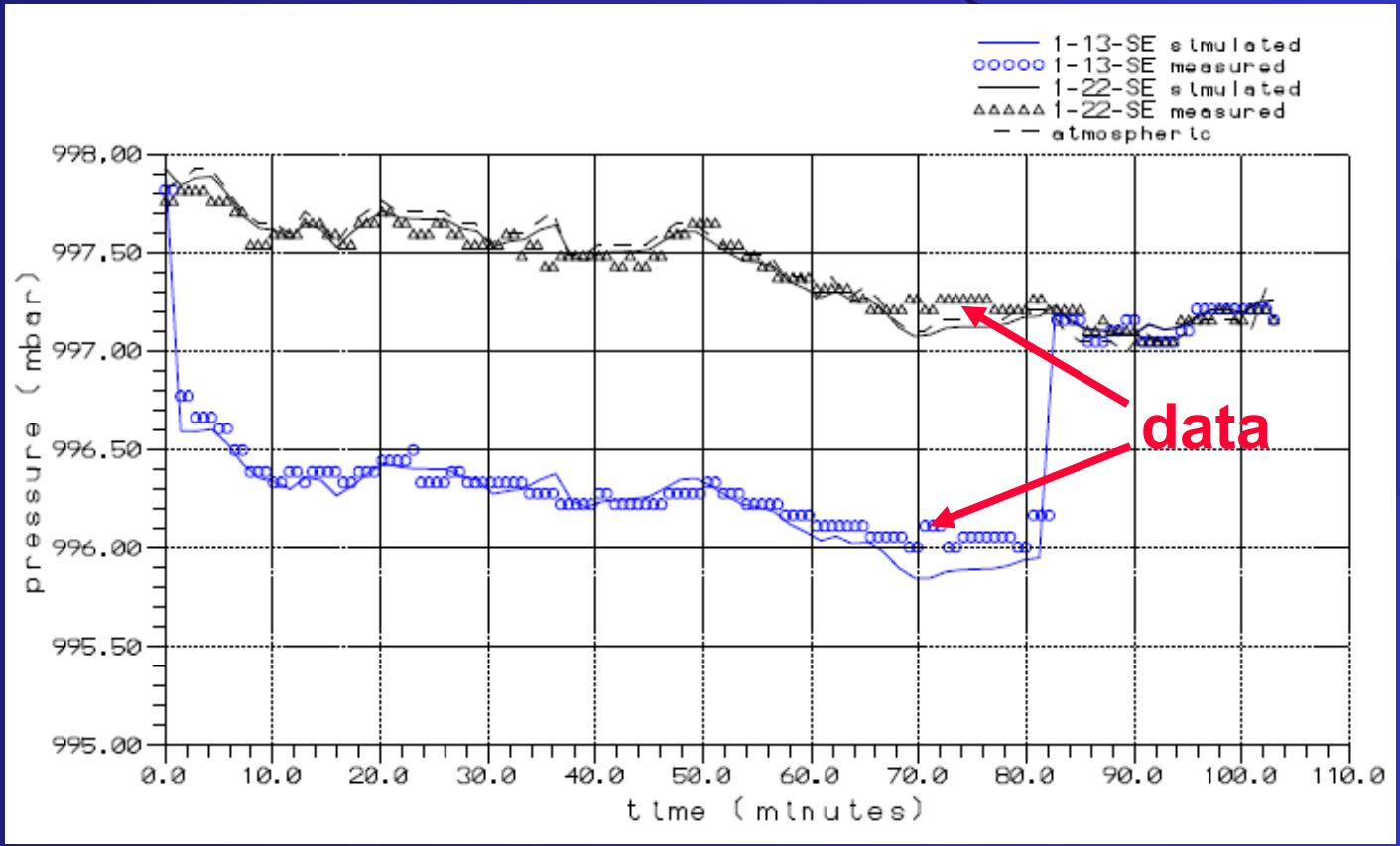


Horizontal gas collection wells and liquid addition lines

Instrumentation – gas pressure, temperature, moisture

Aerobic Bioreactor – First Year

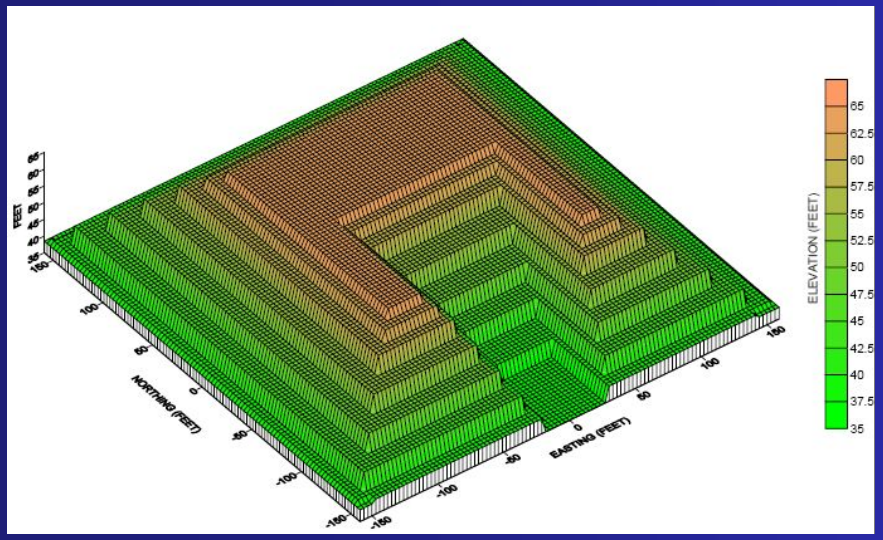
- Pump tests – determine gas permeability field



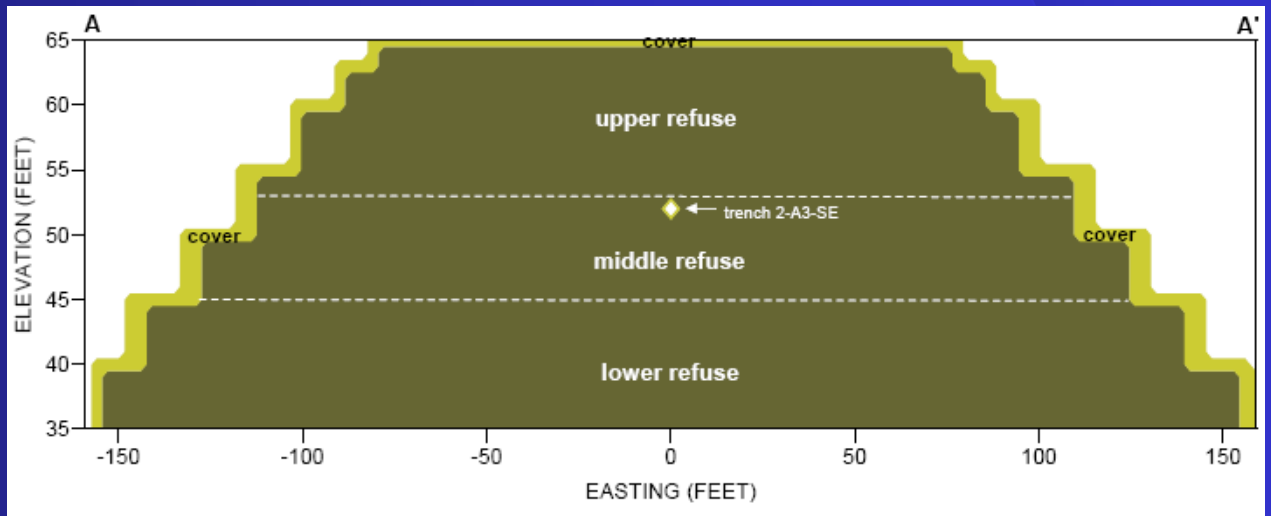
Reasonable fit to measured pressures

Aerobic Bioreactor – First Year

- **Gas flow model developed for landfill**

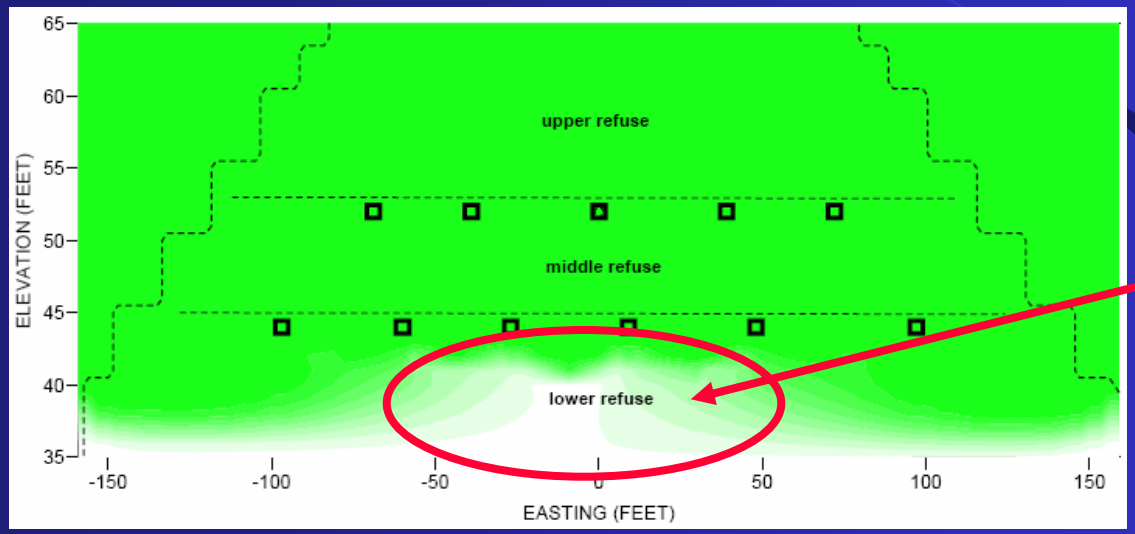


3 layers with homogeneous properties for each layer (K_H,K_V)



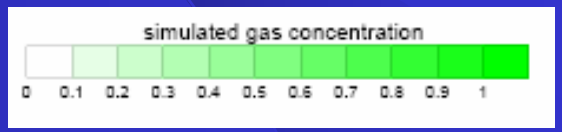
Aerobic Bioreactor – First Year

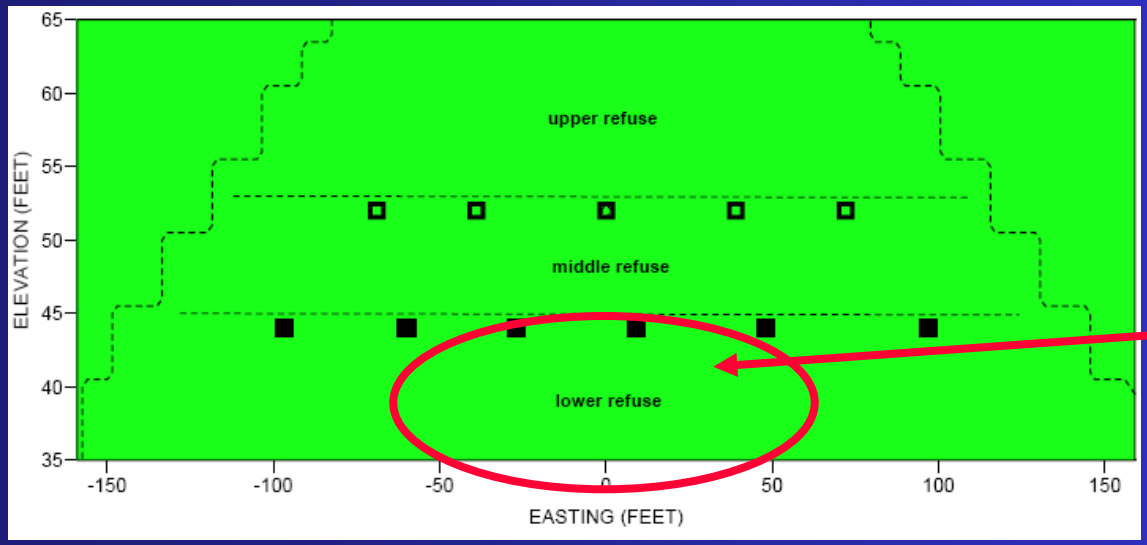
- **Development of IBM-IS for air injection**



Gas extraction all wells

Dead zone – fire potential!





Alternating gas extraction / injection wells

More uniform air air distribution

Summary

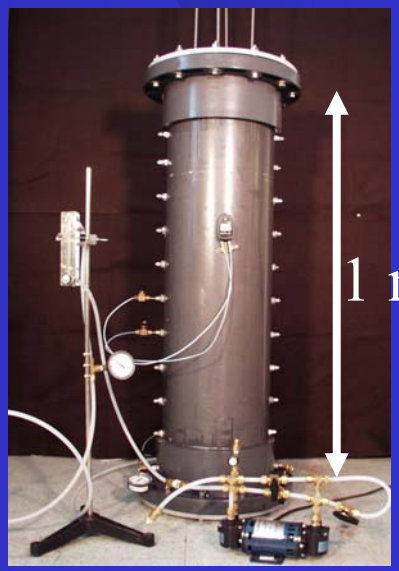
- **Bioreactor landfill promising**
  - **Enhanced CH4 generation and capture – energy production (anaerobic)**
  - **Reduced CH4 generation (aerobic)**
- **Anaerobic tests**
  - **Permeable layers for enhanced CH4 capture promising**
  - **Landfill test cell constructed and tests ongoing**

- **Aerobic tests**
  - Automated data collection system installed
  - Development of IBM-IS for gas flow – suggests new operating procedures

- **Ongoing work**
  - Model development
    - TRACRN to include energy balance and biodegradation
  - Testing of IBM-IS for gas flow in aerobic and anaerobic cells
  - Laboratory tests of waste properties for improved constitutive modeling

Compaction cell

Flow cell



  - Development of IBM-IS for liquid addition

Questions ?

University of Delaware