IMPROVING LANDFILL GAS RECOVERY

Recent Evaluations, Results of Large Scale Tests in California, United States

Don Augenstein [A] (speaker)
Ramin Yazdani [B],
Jeff Kieffer [B]
Paul Imhoff [C]
Morton Barlaz [D]
Harold Bentley [E]
John Benemann [A]

A. Institute for Environmental Management, (IEM Inc), Palo Alto CA USA
B. Yolo County Public Works and Planning, Woodland CA, USA
C. University of Delaware, Newark, DE USA
D. North Carolina State University, Raleigh, NC USA
E. Hydro Geo Chem, Tucson, AZ

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ISSUES --

FREQUENT LIMITATIONS WITH LANDFILL GAS RECOVERY:

1. **Inefficiencies of collection, and problems with air entrainment, and maintaining constant methane content in extracted gas**

2. **Conventional landfills decompose very slowly over decades and may decompose incompletely (the infamous “dry tomb”)**

3. **Fugitive methane emissions and losses in early stages of filling when extraction is often inconvenient, inefficient (or absent)**

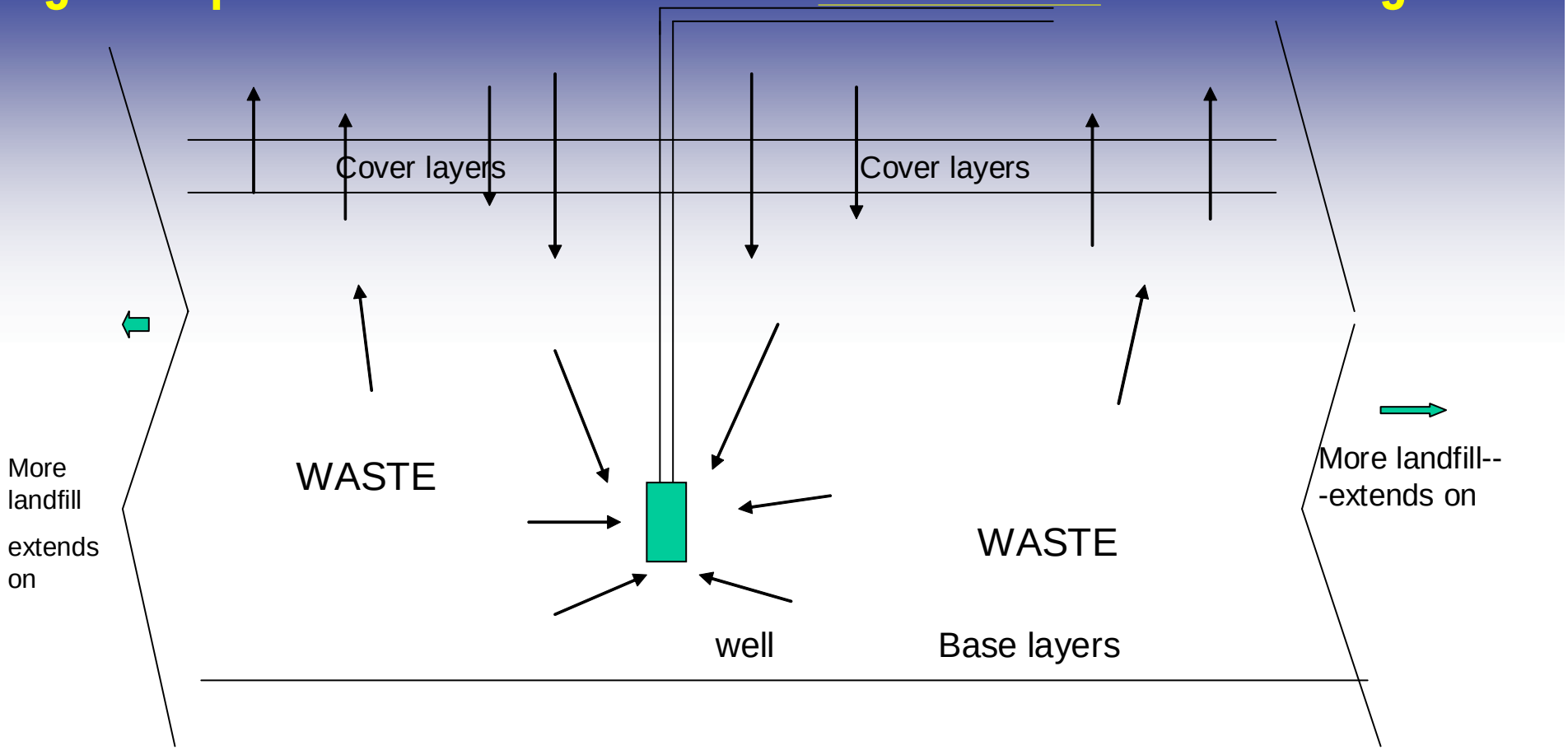
4. **Tedious and slow iterations of monitoring/adjustment/control when basing such control on "typical" indicators like wellhead gas composition**

5. **Predicting most effective designs for gas recovery**

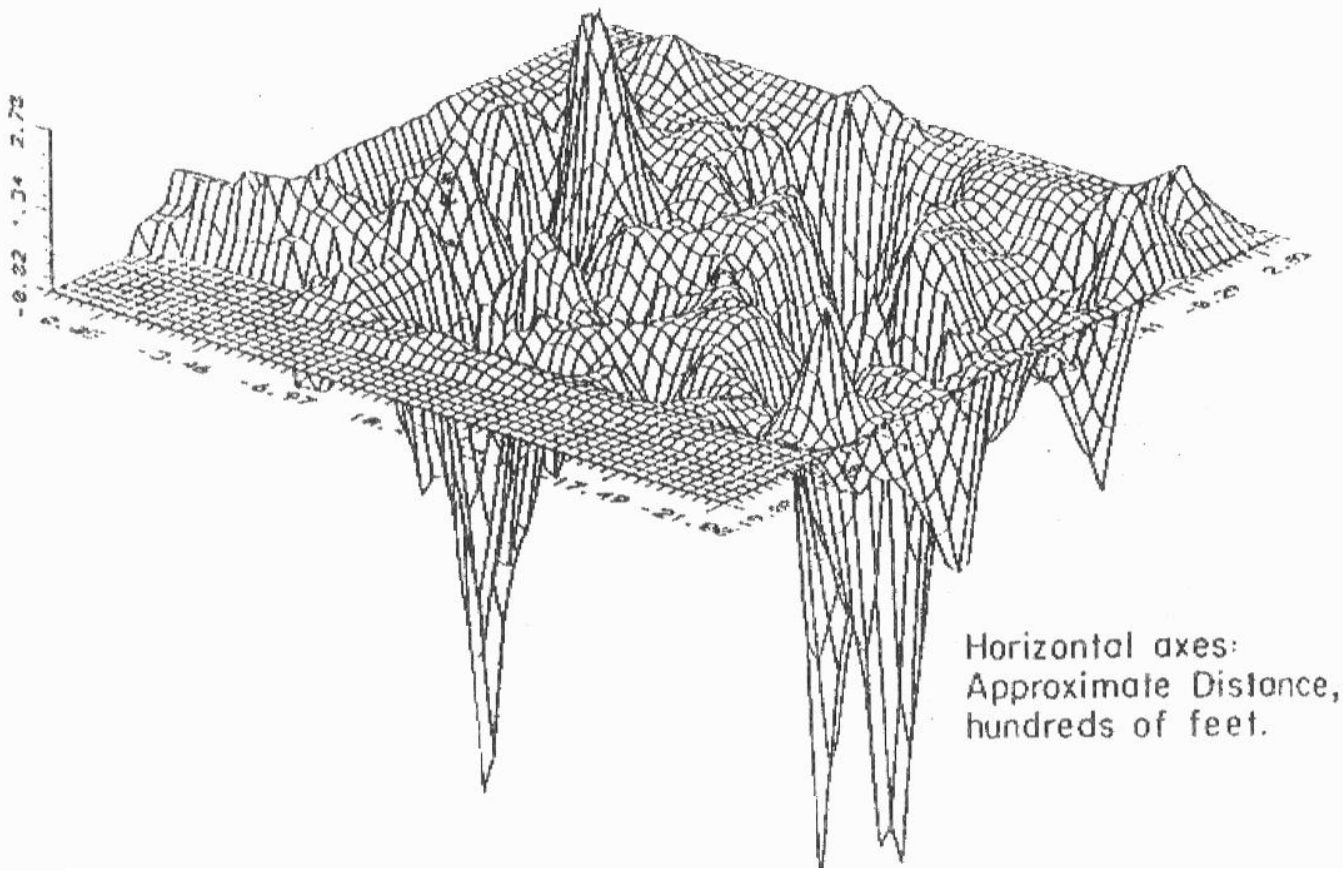
6. **Predicting and assessing methane recoverability at a given site, where misses in predictions lead to performance shortfalls relative to expectations**

THERE IS ROOM FOR IMPROVEMENT !!

Fig. 1 Simplified schematic section of conventional LFG well and gas flow



Arrows and lengths denote gas flows or fluxes.. Note variable surface fluxes and emissions distant from well, entrainment near well, inefficient collection



PENROSE SURFACE FLUX – ZISON, Getty Syntheic Fuels and Pacific Energy

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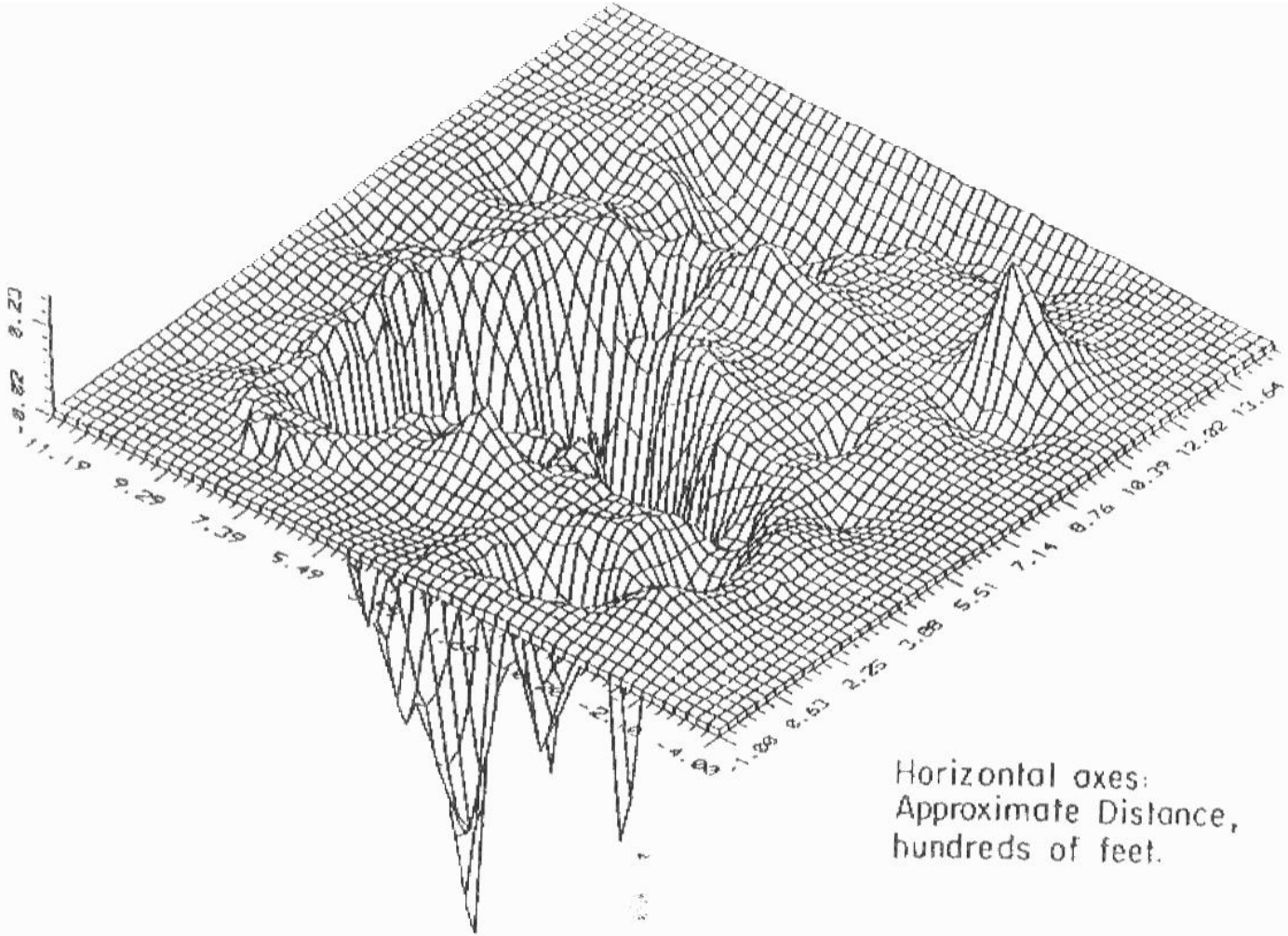


SHELDON –ARLETA LANDFILL RELATIVE SURFACE FLUX

REPORTED RECOVERY EFFICIENCIES

1. **SPOKAS et al. 2006—THREE LANDFILLS < 10% methane emitted (excellent)**
2. **BORJESSON et al 2007 –11 measurements summarized**

   Emissions generally 30-60% of CH4 generated

3. **USEPA Default – 75% (estimate)**

BUT MEASUREMENTS ARE DIFFICULT

AND:

"Point in time" measurements do not cover (a) early emissions of methane during filling, or (b) at long terms.

Long term generation can be significant – at k = 0.04 year^{-1}, over 30% of methane generated from waste 30 years or more after placement

Capture of methane at long terms can be difficult – inefficiencies increase due to diffusion and other factors.

WHEN METHANE GENERATION FROM BEGINNING TO END OF FILLING IS CONSIDERED, COLLECTION AT MOST SITES LIKELY 60-85%.

HOW MIGHT EFFICIENCY BE INCREASED?

IMPROVING CAPTURE WITH CONVENTIONAL APPROACHES:

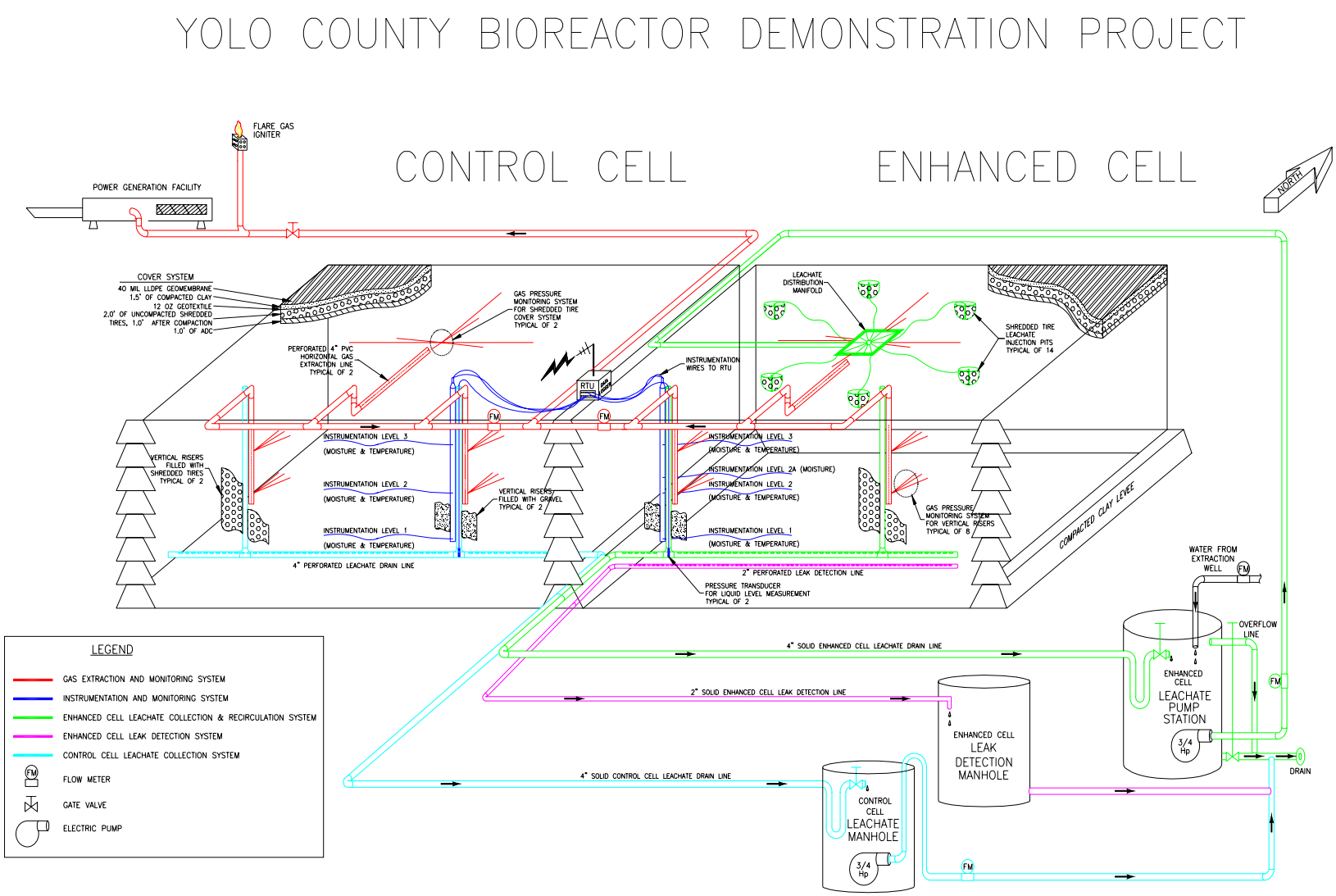
1. **THICKER COVER > 5ft clay (cost)**
2. **“OVERPULL” – EXTRACT AT 130-150+% GENERATION (air entrainment and energy use problems)**
3. **MORE AND CLOSER EXTRACTION WELLS**
4. **MORE INTENSIVE AND FREQUENT MONITORING**
5. **FIX COVER CRACKS**

Conventional approaches can give diminishing returns

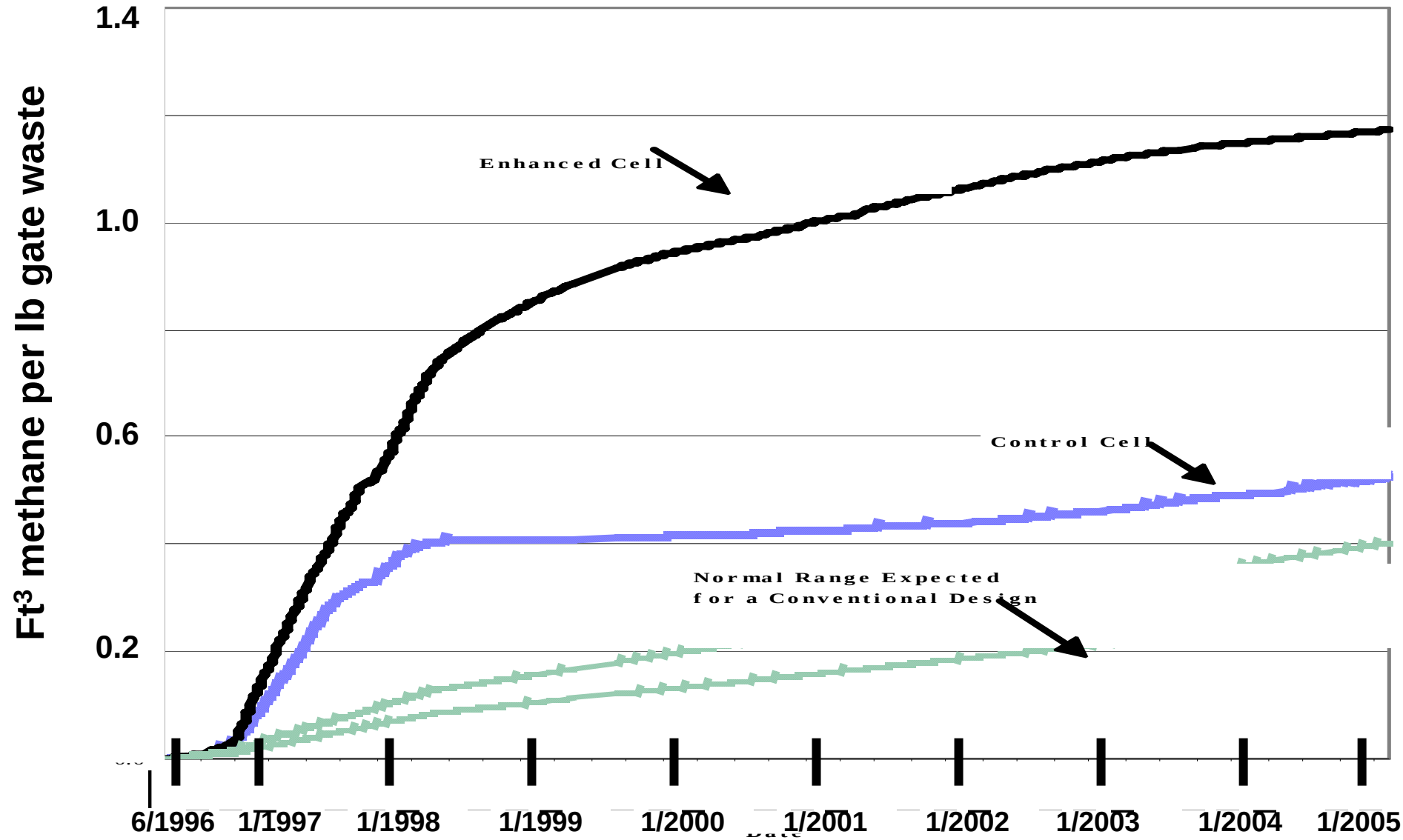
Controlled Landfill-- minimize greenhouse emissions, maximize lfg energy

- **FILL QUICKLY, MINIMIZE LFG LOSSES**
- **COVER WITH CONDUCTIVE GAS RECOVERY LAYER --- THEN POLYMER COVER (GEOMEMBRANE). LOW PERMEABILITY CLAY CAN ALSO BE USED.**
- **<u>ONLY THEN</u> ENHANCE METHANE GENERATION BY LIQUID:**
  - **--COMPLETE LFG GENERATION SOONER**
  - **--AVOID LONG TERM COLLECTION DIFFICULTIES, DIFFUSIONAL LOSSES, WITH LONG-TERM LOW- RATE LFG GENERATION.**
- **CONTROL AIR INTRUSION -- ALSO HELPS MAXIMIZE GENERATION AND RECOVERY**

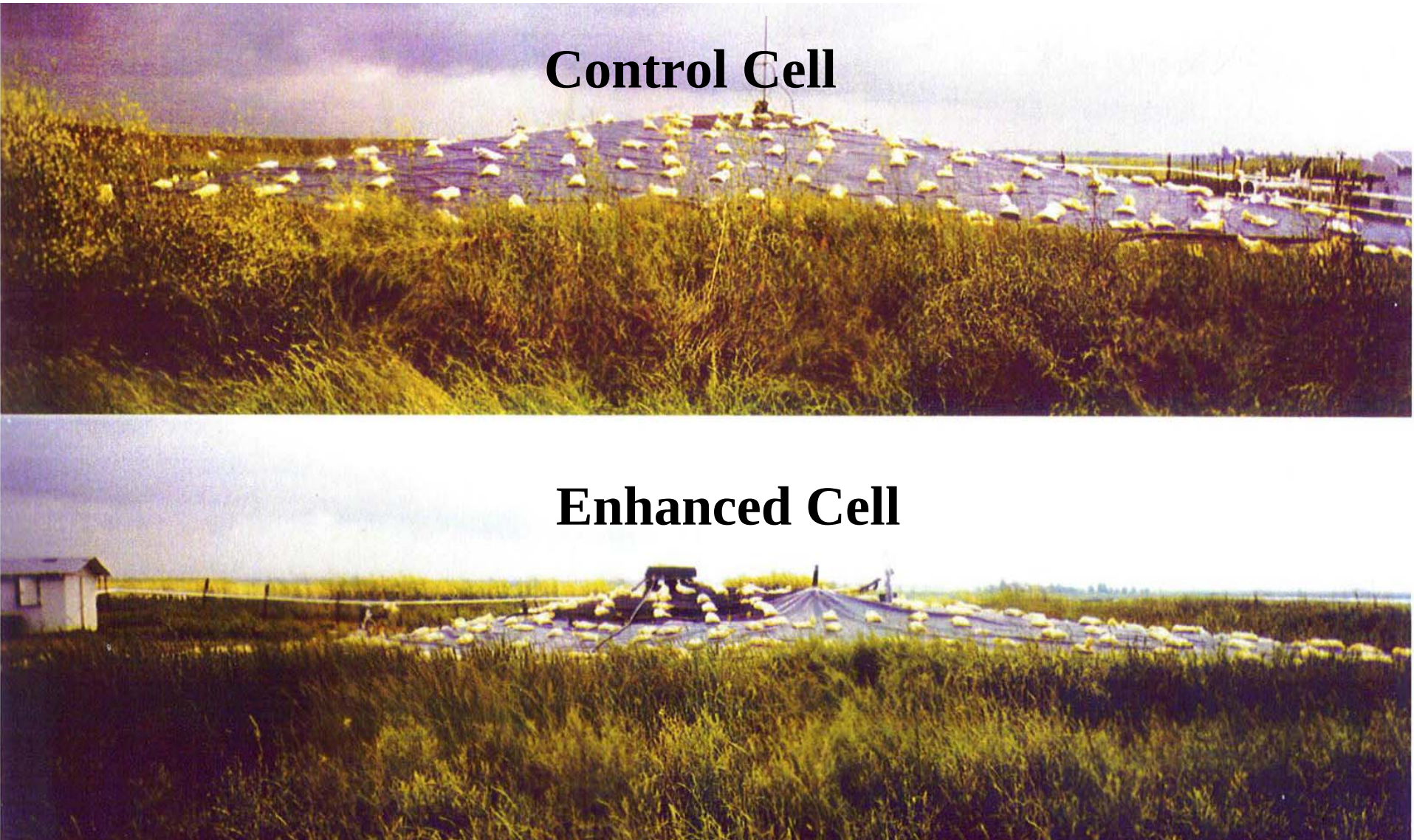
Test cell oblique view



Cumulated methane generation, Yolo 9000 Ton demonstration cells, 1996-2005



Comparing profiles--enhanced vs. control cell --Enhanced decomposition reduces volume quickly,can extend landfill life.



Scaleup: Completed 3.5 Acre (Northeast) cell, 2001

CONTROLLED LANDFILL

--OFFERS A NUMBER OF ADVANTAGES OVER CONVENTIONAL LANDFILL GAS RECOVERY.

HOWEVER

CAN BE DEMANDING OF TECHNICAL EXPERTISE, OPERATIONAL CARE, AND INFRASTRUCTURE.

ON TOP OF THAT, GEOMEMBRANE COVER IS EXPENSIVE.

IMPROVING LFG RECOVERY VIA PERMEABLE LAYERS

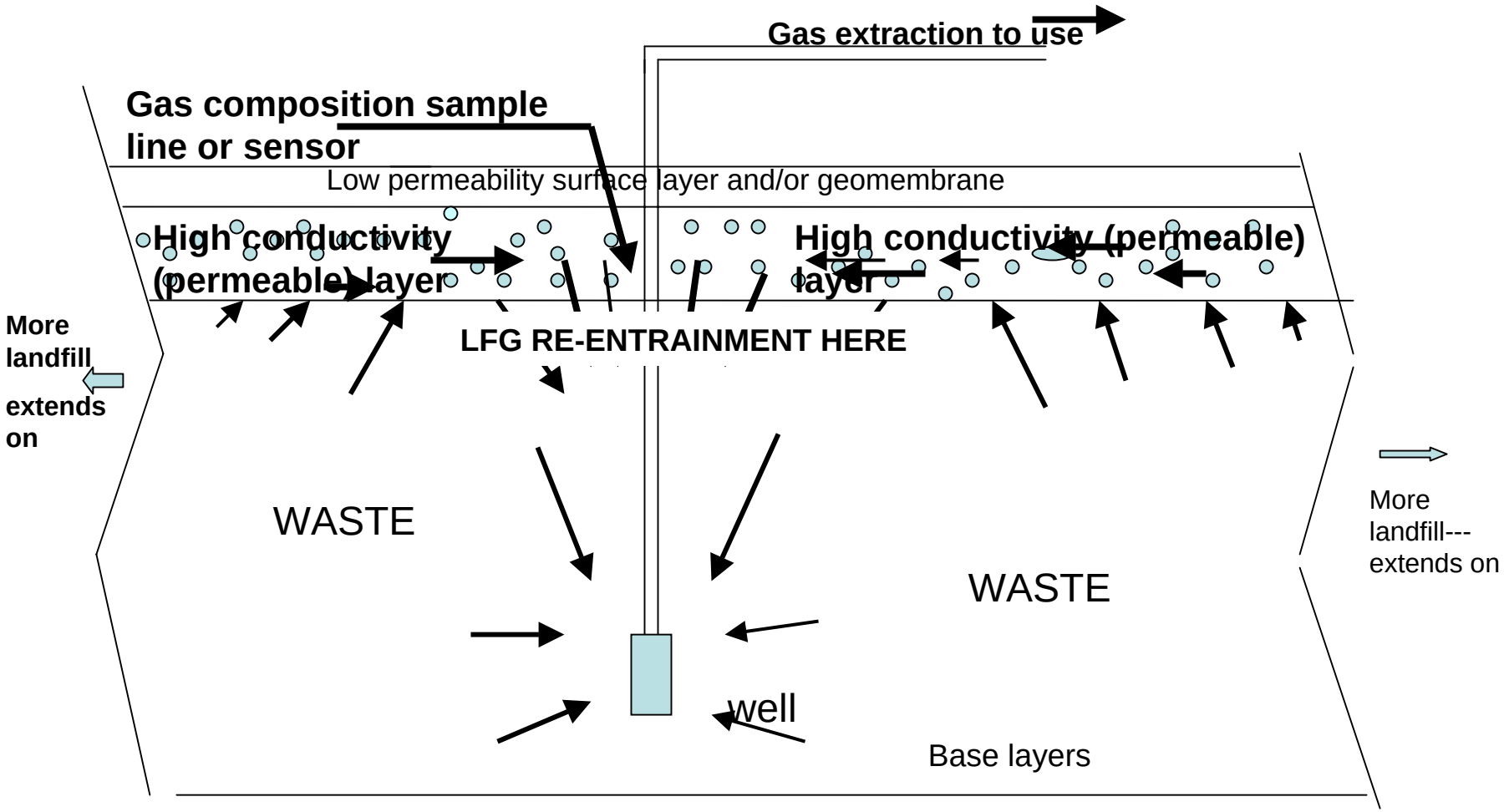
SHRED TIRES AND/OR RUBBLE OR WOOD CHIPS

CONDUCTIVITIES FOR LFG FROM 10^3 TO 10^6 (I.E. THOUSAND TO MILLION FOLD) GREATER THAN SURROUNDING WASTE OR SOIL . THESE WIDELY AND ECONOMICALLY AVAILABLE FOR INCORPORATION INTO LANDFILLS.

PERMEABLE (HIGHLY GAS CONDUCTIVE) LAYERS OF SUCH MATERIAL CAN BE EMPLACED DURING FILLING SLIGHTLY BELOW THE LANDFILL SURFACE

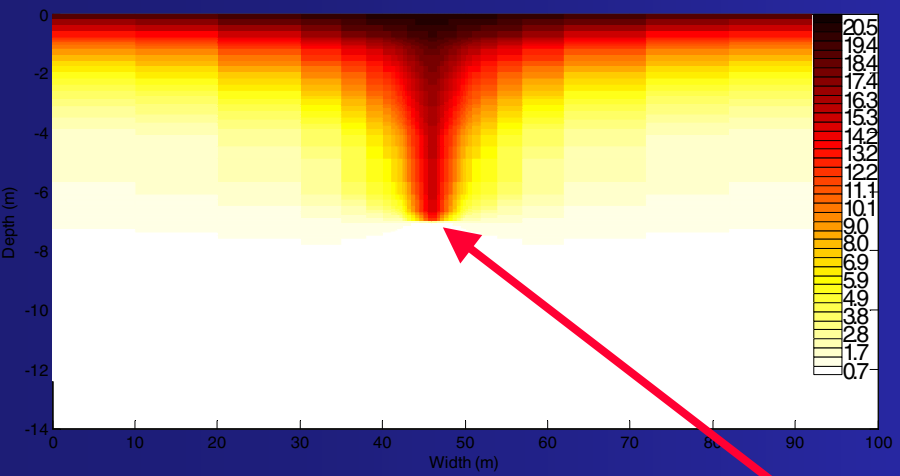
LFG CAN BE CAPTURED EFFICIENTLY AND “GO WHERE WE (LFGTE OPERATORS) WANT”

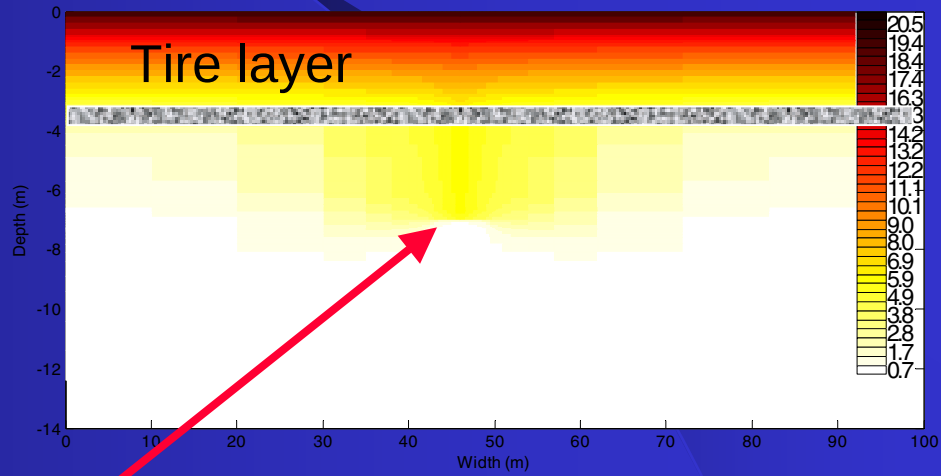
SIMPLIFIED SCHEMATIC OF PERMEABLE LAYER USE_ ARROWS AND LENGTHS DENOTE GAS FLOWS OR FLUXES. NOTE EFFICIENT CAPTURE AND RE-ENTRAINMENT OF LFG ENTERING PERMEABLE LAYER WITH CONSEQUENT RECOVERY EFFICIENCY INCREASE.



University of Delaware Modeling of Air intrusion without and then with permeable layer (Tire Layer)

- **Oxygen intrusion**





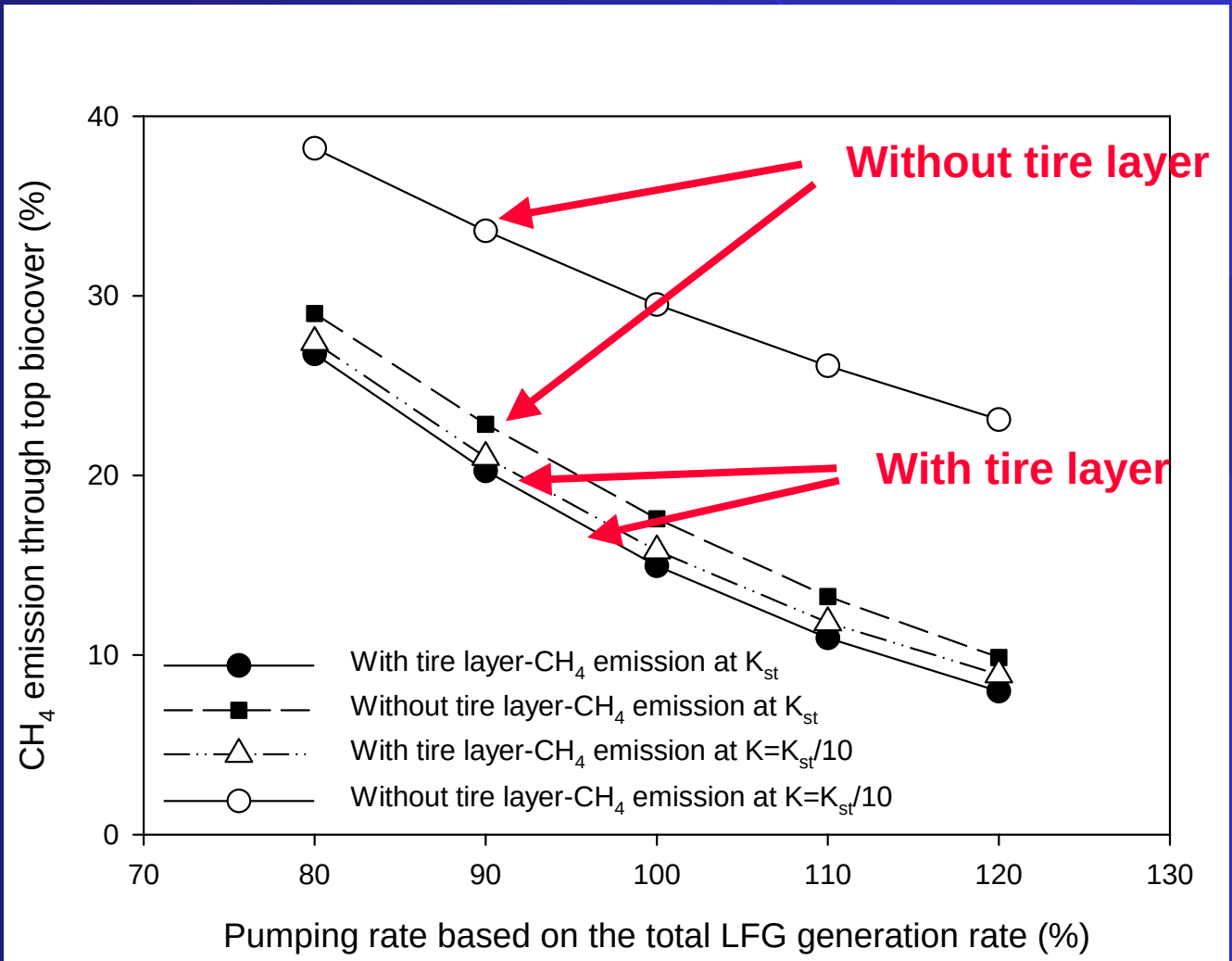
Pumping well

Without permeable (tire) layer

With permeable (shred tire) layer

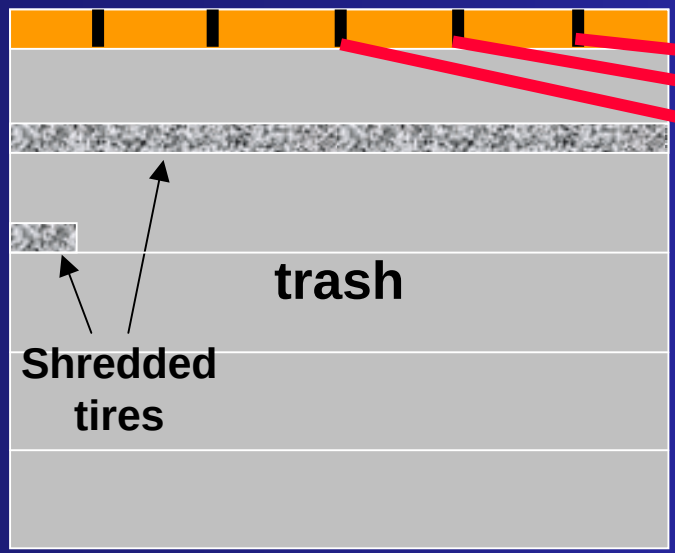
Results

- **Pumping rate**



Anaerobic Bioreactor – CH_4 Capture

- Simulated effect of cracks in biocover
  - Permeable layer ***increases*** the efficiency of CH_4 capture



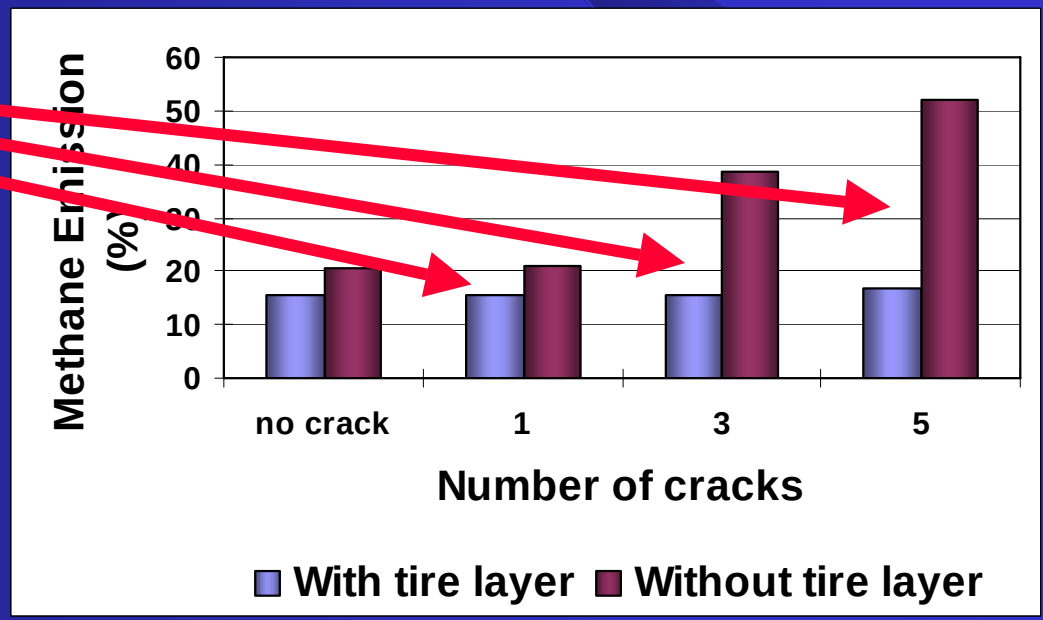
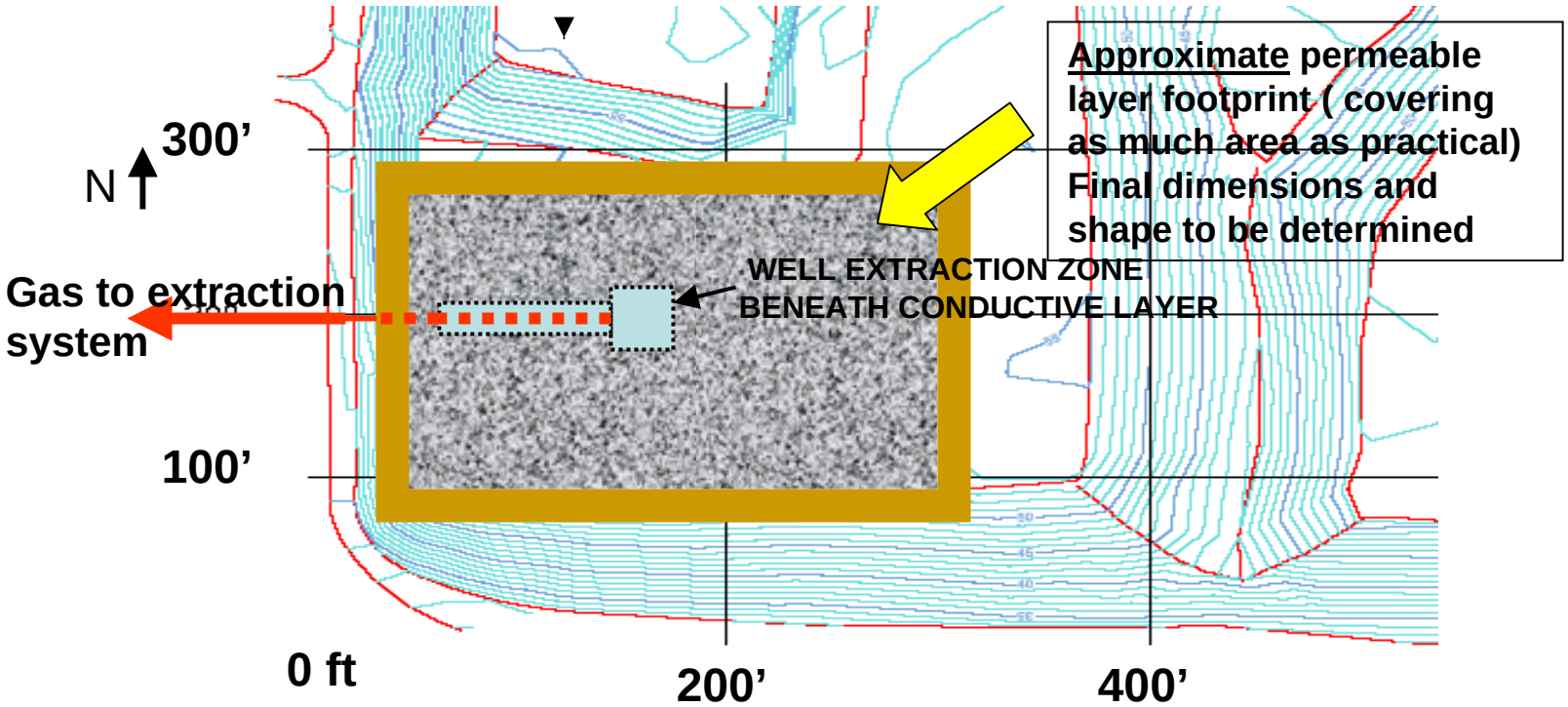
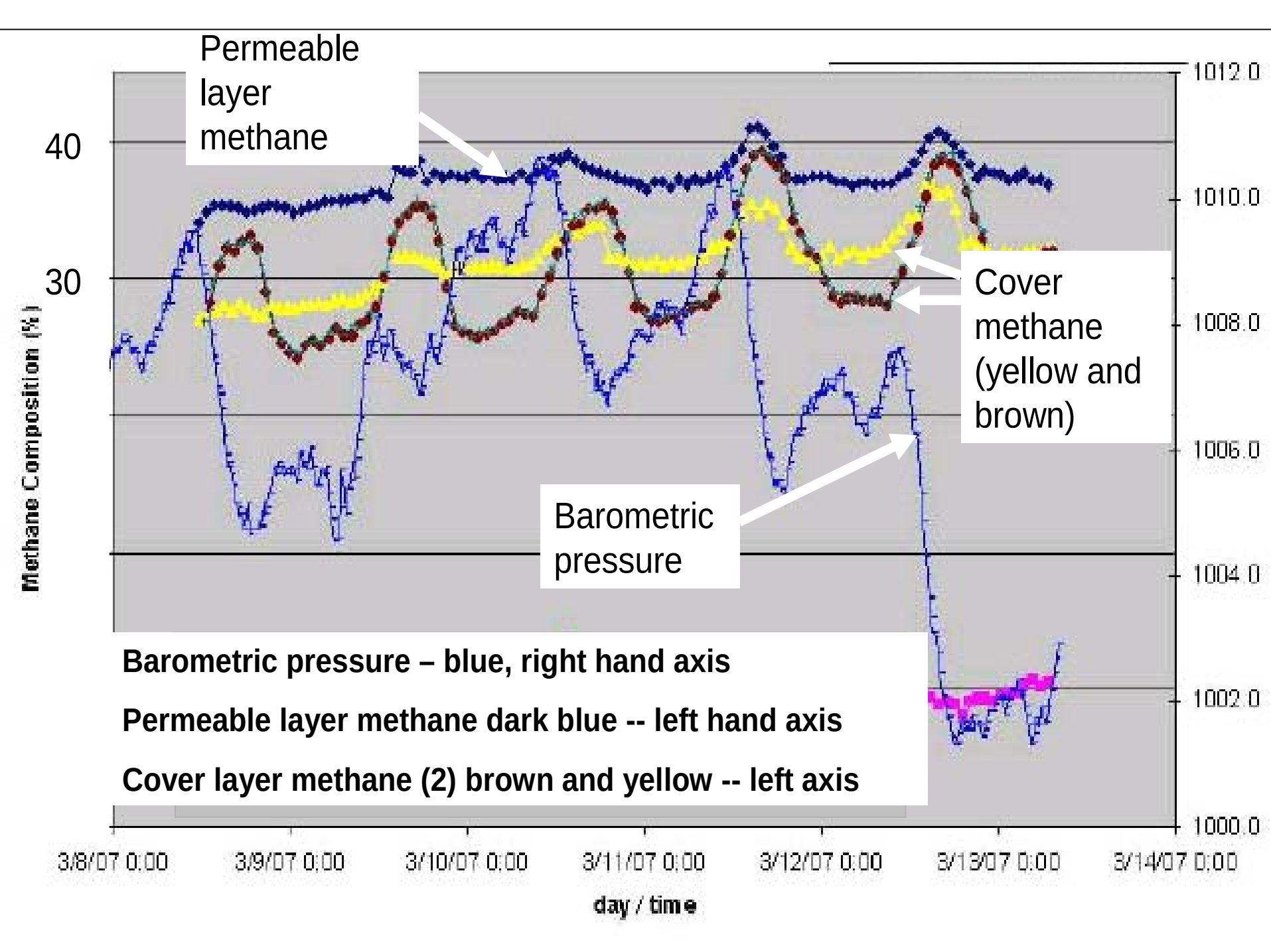


Figure : Top view of plan permeable layer test area, showing (at lower left) conductive layer textured) footprint and well.



VIEW OF MULTI- ACRE SHRED TIRE LAYER

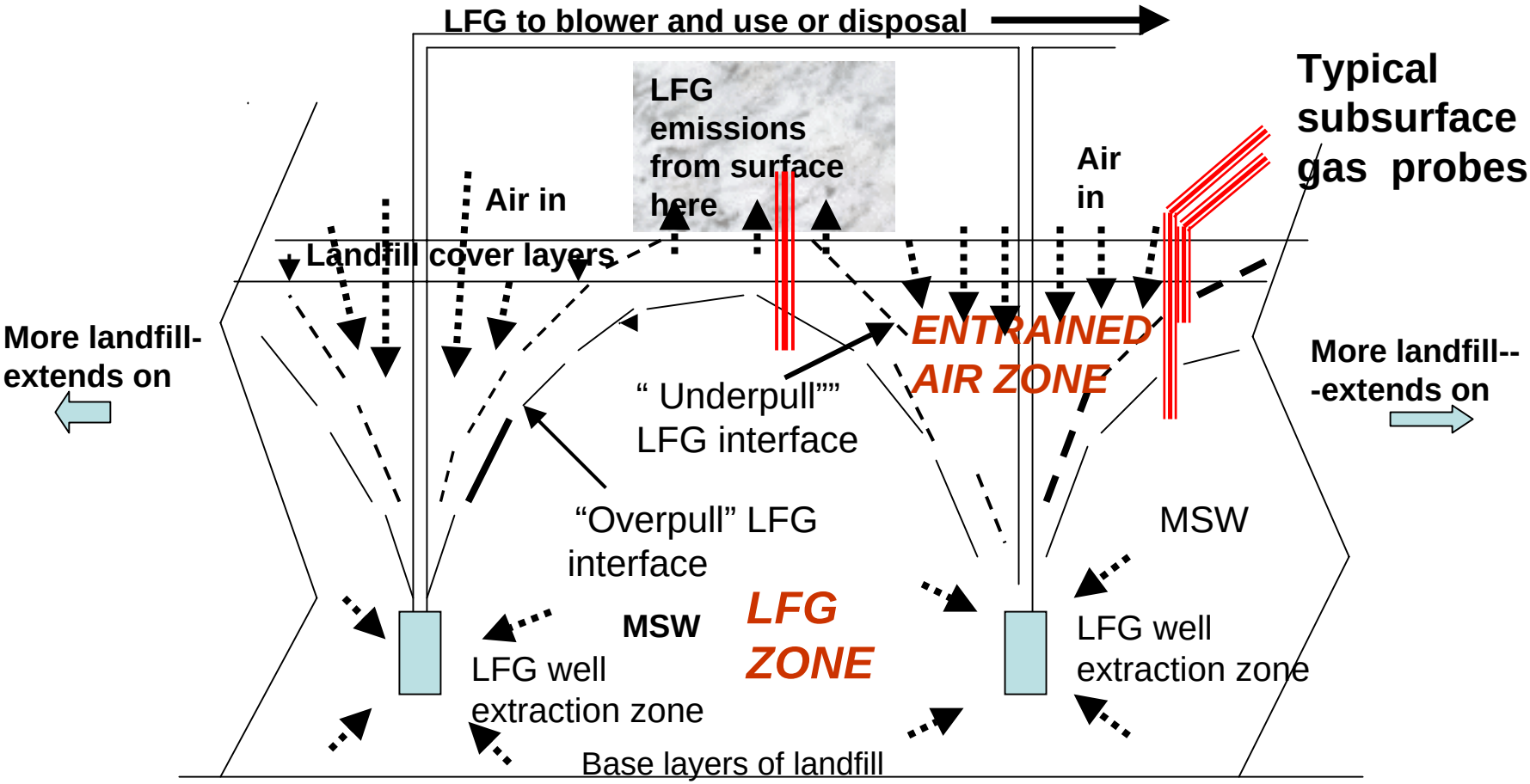

SHRED TIRE PERMEABLE LAYER BEING PLACED
WASTE LAYERS
SEP 28 2005


Permeable layer methane
Cover methane (yellow and brown)
Barometric pressure
Barometric pressure – blue, right hand axis
Permeable layer methane dark blue -- left hand axis
Cover layer methane (2) brown and yellow -- left axis
40
30
Methane Composition (%)
1012.0
1010.0
1008.0
1006.0
1004.0
1002.0
1000.0
3/8/07 0:00
3/9/07 0:00
3/10/07 0:00
3/11/07 0:00
3/12/07 0:00
3/13/07 0:00
3/14/07 0:00
day / time

SUBSURFACE COMPOSITION PROBES CAN ALLOW CONTROL, INDICATE (a) TOO LOW EXTRACTION (b) TOO HIGH EXTRACTION RATE

Example landfill cross section showing approximate interface location between entrained air and LFG. Sensors/tubes detect subsurface gas composition Arrows (·····▶) denote LFG or gas flow

interfacial location: (- - - - Extraction too slow) (——— ext. too fast)



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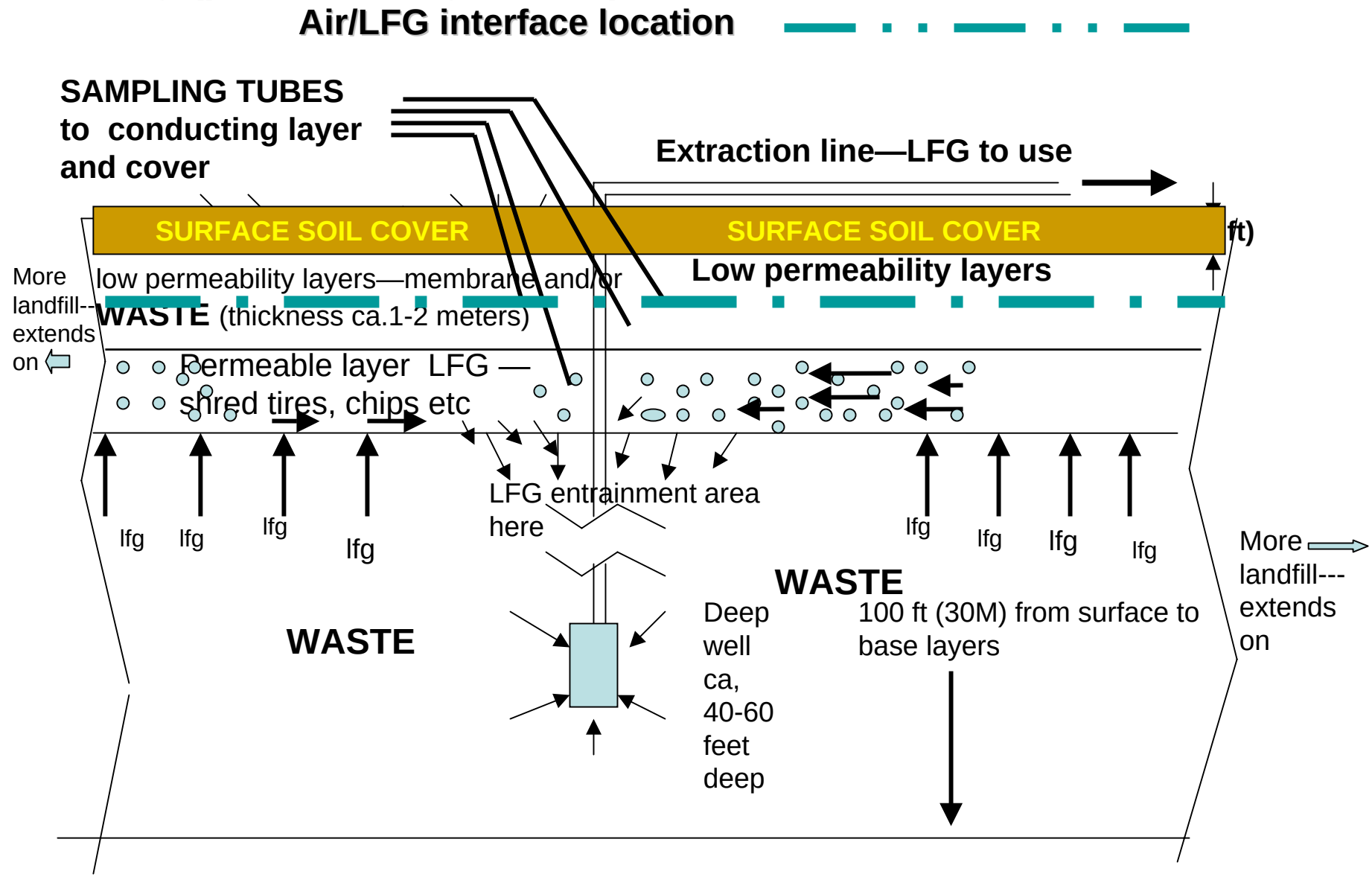
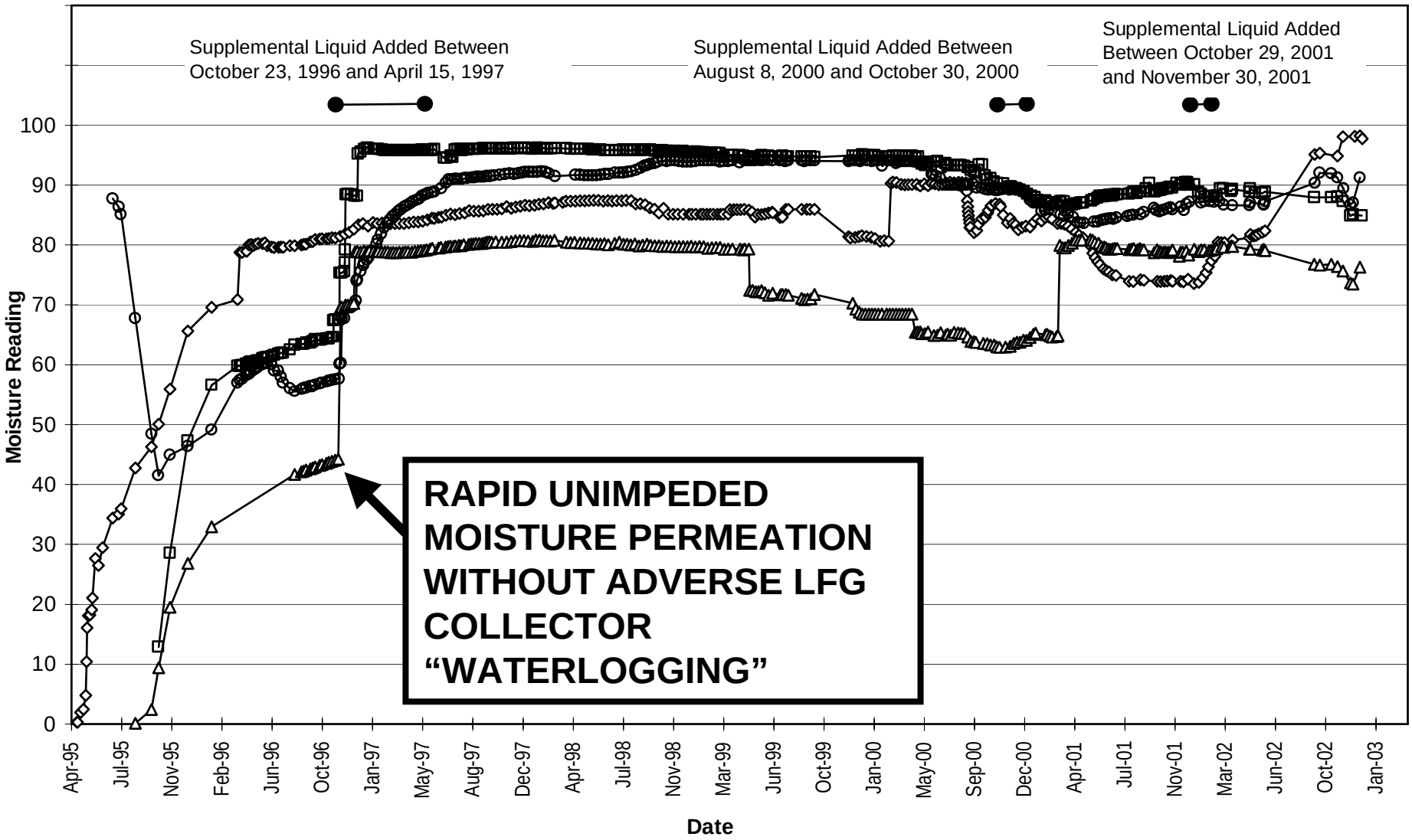
Simplified illustration: Subsurface probes to track and control LFG recovery (permeable layer used).



RAPID MOISTURE PERMEATION –NO LIQUID BUILDUP
(1-3 cm/day with greenwaste/compost daily cover)
ENHANCED CELL MOISTURE SENSOR READINGS-1995 TO 2003 -



COVER SOIL (REMNANT) CREATES LIQUID MANAGEMENT PROBLEMS

GAS WELL WATERLOGGING, SLOWER MOISTURE INFILTRATION SIDE SEEPS, PERCHED LIQUIDS AND BLOCKED GAS WELLS

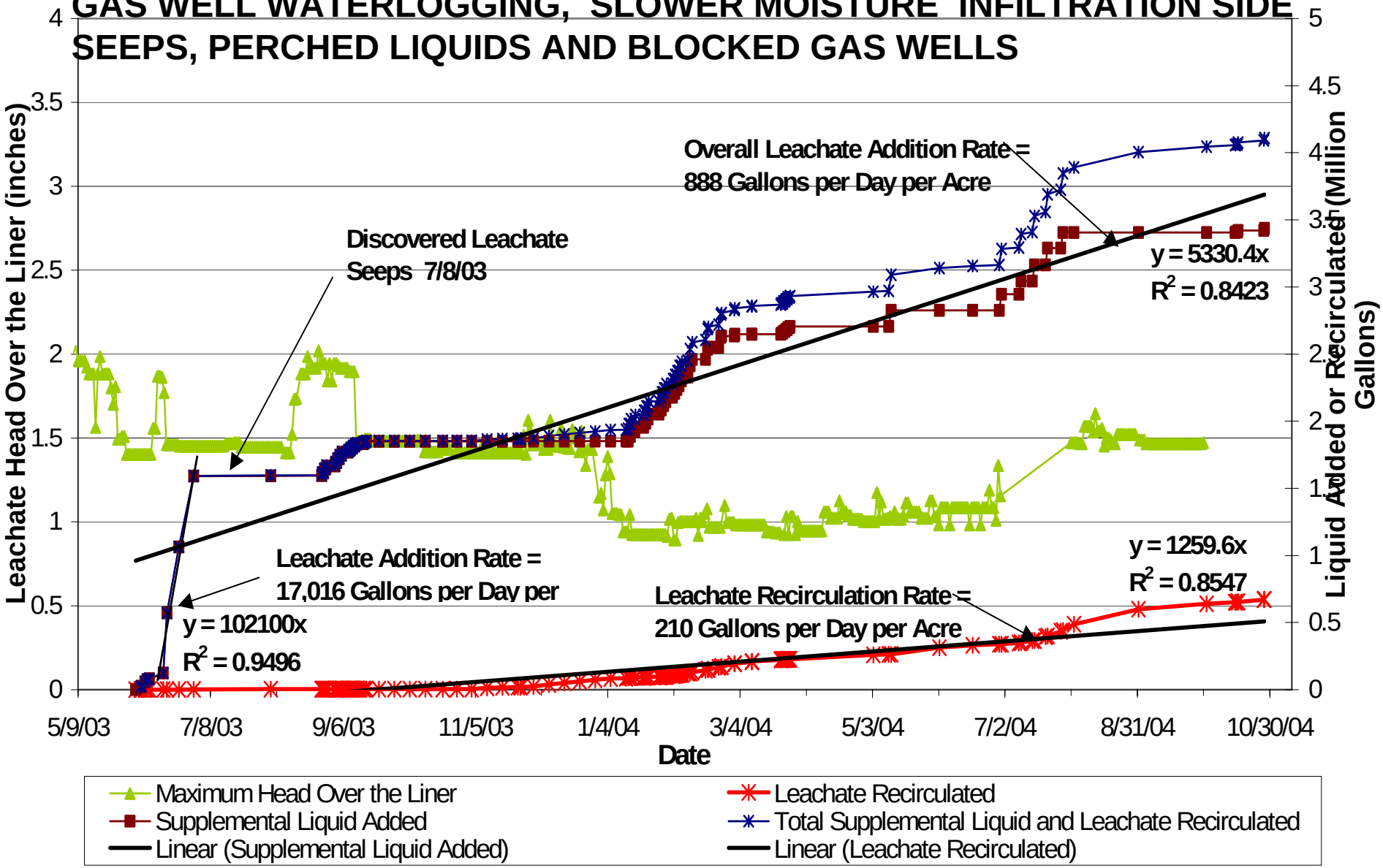
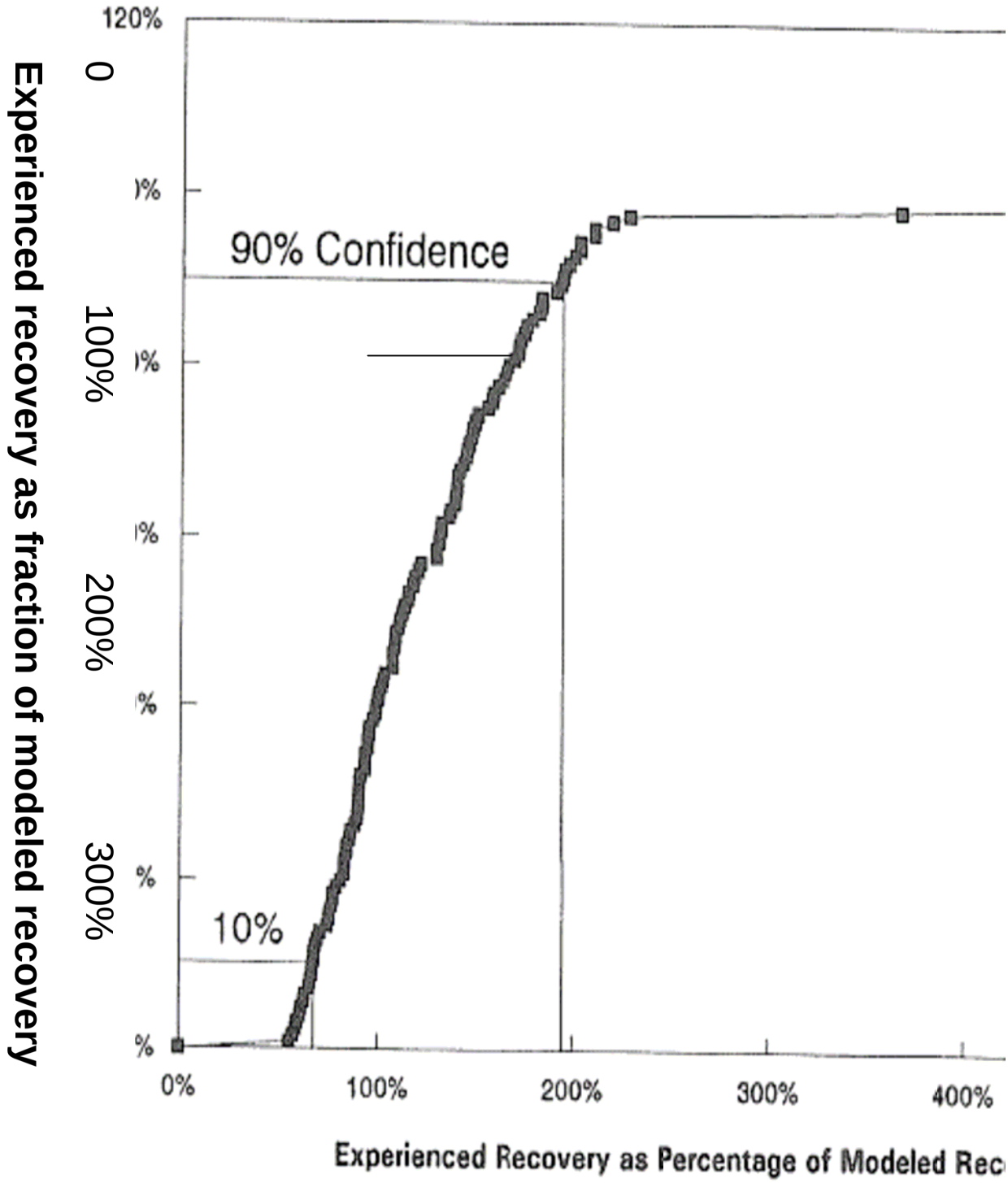


FIGURE 29
SIMPLE FIRST ORDER MODEL: ARITHMETIC
DISPERSIONS AND CONFIDENCE LIMITS



OTHER AVENUES TO IMPROVE LFG RECOVERY

EARLY STAGE MEASURES

PROJECTING GAS AVAILABILITY

- **MODELING GENERATION**
- **PNEUMATIC GENERATION ASSESSMENT**

PEAKING ELECTRICITY

IN-LANDFILL POLLUTANT BIOFILTRATION

ADVANCED FINITE ELEMENT FLOW MODELING

SUMMARY

PROMISING NEWER AVENUES AND APPROACHES AVAILABLE TO IMPROVE LFG CAPTURE.

APPROACHES GIVING VERY ENCOURAGING RESULTS AT YOLO COUNTY

IEM, INC., WITH PROJECT MEMBERS WOULD LIKE TO APPLY WIDELY, INCLUDING PARTICIPATING IN CHINA PROJECTS