



Bioreactor Landfill Technology: Owner's Perspective

Roger B. Green

CTI and Associates Waste Technology Symposium

Novi, MI

December 4, 2006



outline

- Introduction and background to the WM bioreactor landfill program
- Current projects
- Outer Loop study results





WM profile

- 283 active landfill disposal sites
- 413 collection operations
- 370 transfer stations
- 131 recycling plants
- 17 waste to energy plants
- 95 beneficial-use landfill gas projects
- 6 independent power production plants
- 21 million customers
- 50,000 employees



WM facts

- Generate more than 250 megawatts of energy from landfill gas, enough to power about 225,000 homes or replace about 2 million barrels of oil per year.
- We operate one of the nation's largest fleets of heavy-duty trucks powered exclusively by natural gas with 495 vehicles.
- North America's largest recycler. We process 5.8 million tons of commodities each year, saving approximately 41 million trees through paper recycling alone.
- Our landfills provide more than 17,000 acres of protected land for wildlife; 15 landfills are certified by the Wildlife Habitat Council.
- WM helped found the Chicago Climate Exchange, an organization established to provide a voluntary marketplace for reducing and trading greenhouse gas emissions.





WM's bioreactor program

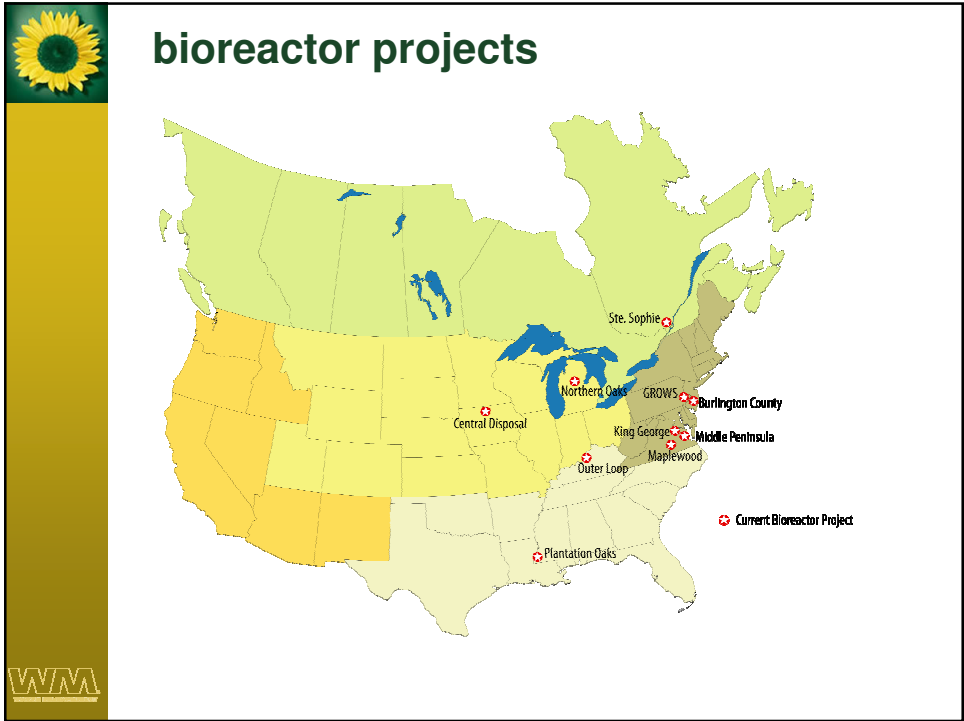
- The purpose of Waste Management's Bioreactor Program is to confirm the economic and environmental benefits of bioreactor landfill technology and to promote changes to federal and state solid waste regulations that will allow development of controlled bioreactor landfills throughout North America.
- Bioreactor landfills will have greater capacity, accept a broader waste stream, and have less environmental liability than current MSW landfills. This program will advance Waste Management's position as a leader in environmental protection and efficient waste stream management.




current bioreactor R&D efforts

- 10 field-scale demonstration projects in the US and Canada
- Directed and sponsored bioreactor related research (1998-2006)
 - Waste solids decomposition
 - Nitrogen cycling and management
 - Liquid distribution
 - Landfill gas production modelling
 - Liquid waste bioassay development
 - Methane oxidation and emissions measurement
 - North Carolina State, Virginia Tech, Florida, Florida State, Central Florida, Michigan State, Cincinnati.
 - 12 Masters and 4 PhD students
- 8 patents issued 6 applications pending.

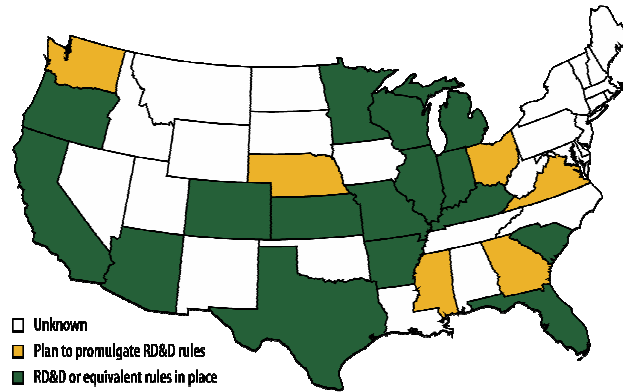




- 
- ## performance and evaluation
- Verified up to 28% increase in airspace utilization versus normal MSW landfills
 - Verified up to 5 times greater landfill gas generation rate
 - Demonstrated enhanced solid degradation
 - 123 bioreactor candidates selected from MSW landfill inventory
 - climate and water balance
 - regulatory status
 - operational status
- WWM



RD&D rule



outer loop project background

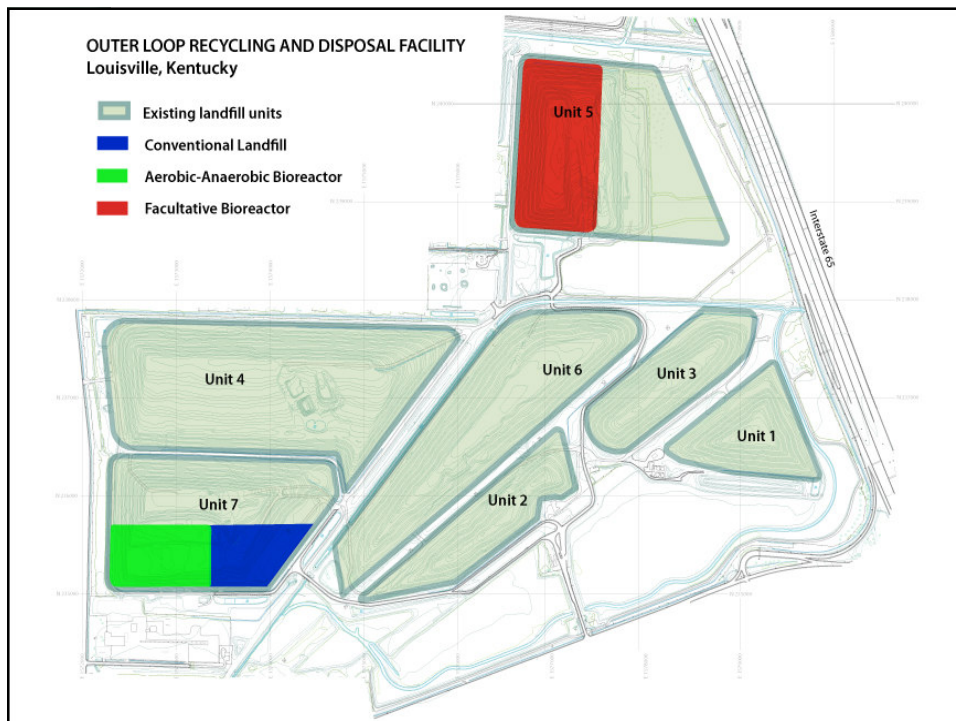
- Central project of a cooperative research and demonstration agreement (CRADA) project between Waste Management and EPA's ORD and OSW.
- Objective to evaluate the application of two bioreactor landfill processes; one to a newly constructed cell and the other to an existing landfill.
- Performance characterized by liquids, landfill gas and waste solids parameters in replicate bioreactor treatment cells and traditional or control landfill cells.
- Project timeline 2000-2005.





site description

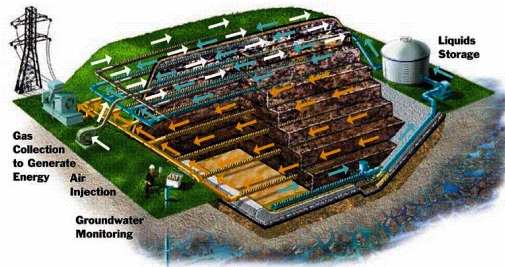
- Outer Loop landfill located in Louisville, Kentucky
- Precipitation = 109 cm yr⁻¹, (42 in yr⁻¹)
- Annual temperature = 14 °C [-19 to 37 °C], (57 °F [-2 to 98 °F])
- Property area = 3.2 km², (780 acres)
- 5 inactive and 3 active permitted landfill units
- Waste acceptance rate = 2,500 metric tons per day, (2,750 tpd)





aerobic-anaerobic bioreactor

- The objective of the **aerobic-anaerobic bioreactor** is to cause the rapid biological decomposition of easily degradable waste in an aerobic stage. This causes a reduction in acid production and an increase in waste temperature which in turn results in an earlier and higher rate of methane generation.

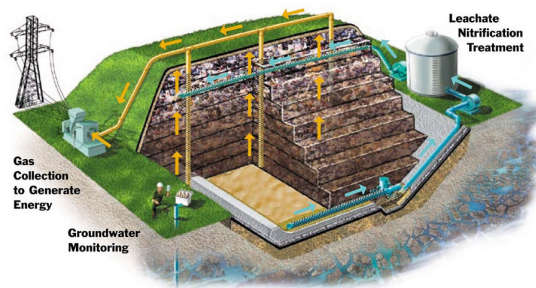


WM



facultative bioreactor

- The objective of the **facultative bioreactor** is to control the cycling of nitrogen in landfills. Ammonia-containing leachate is treated by nitrification in a SBR. The treated leachate is introduced to the landfill where nitrate is used by facultative bacteria resulting in denitrification and nitrogen loss.



WM



experimental design

FLB 51A	FLB 52B	AALB 74A	AALB 74B	CTL 73A	CTL 73B
--------------------	--------------------	---------------------	---------------------	--------------------	--------------------

5-10 years old

1-4 years old

1-7 years old

- FLB: facultative landfill bioreactor
- AALB: aerobic- anaerobic landfill bioreactor treatments
- CTL: control or conventional landfill
- Units composed of independent, paired cells



landfill operational summary

landfill type	waste acceptance		liquid addition*		landfill gas collection system	comment
	Dates	Mass (1,000 Mg)	Dates	Volume (m ³)		
conventional	1998-2005	511 (0.563 Mton)	—	—	Vertical Wells	—
aerobic-anaerobic bioreactor	2001-2005	1,233 (1.359 Mton)	2001-2005	104,491 (27.6 Mgal)	Horizontal wells and layers of permeable media	Leachate and other liquids + aeration of waste.
facultative bioreactor	1995-1998, 2000	1,892 (2.085 Mton)	2001-2005	65,631 (17.3 Mgal)	Vertical and horizontal wells	Recirculation of nitrified leachate.





project data collection plan

- QAPP governing all aspects of data collection and analysis
 - Gas
 - Leachate
 - Solids
- Multiple audits of site and laboratories by EPA and their contractors



results

- Solids
- Gas





solids sampling

- Sampling campaigns in 2000, 2002, 2003 and 2005.
- Stratified random sampling approach.
- Vertical borings made with 36" diameter bucket auger.
- Samples composited every 10 feet of depth.
- 5 gallon bucket (30-70 lbs) of sample to lab.



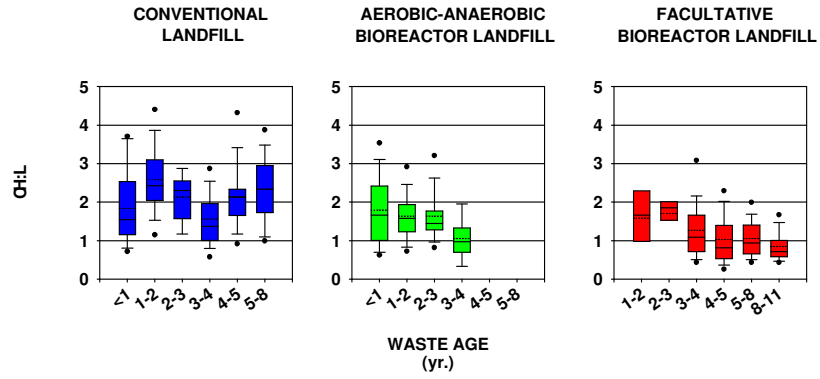
sample analyses

- Cellulose
- Hemicellulose
- Lignin
- Biochemical Methane Potential
- Organic solids (550 C)
- Gravimetric moisture
- Samples dated by survey records for waste placement

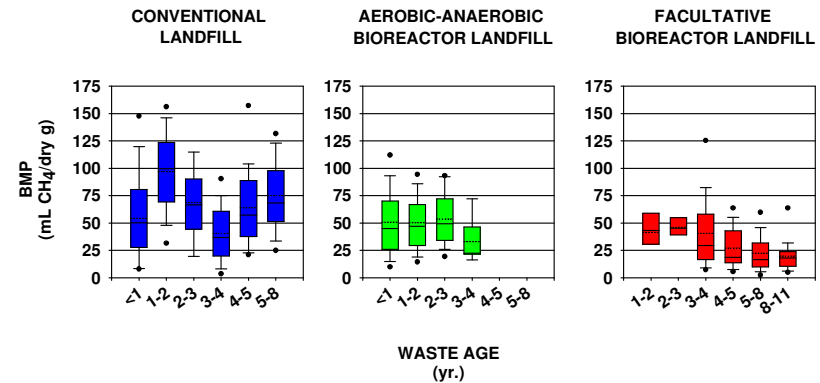




c+h:l ratio vs. waste age range

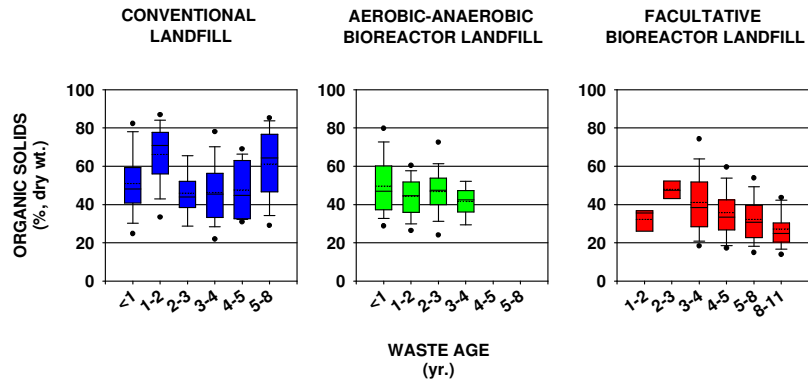


bmp vs. waste age range

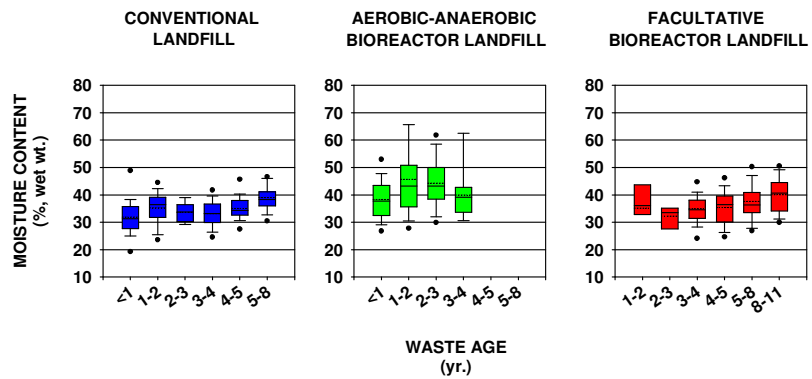




organic solids vs. waste age range



moisture content vs. waste age range





gas sample collection & analysis

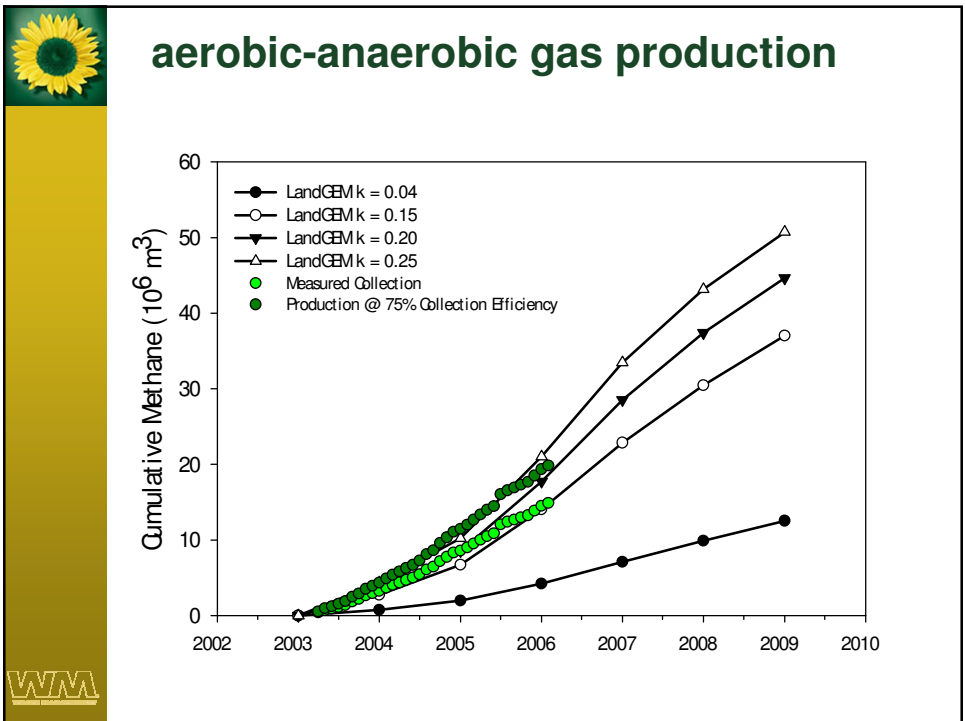
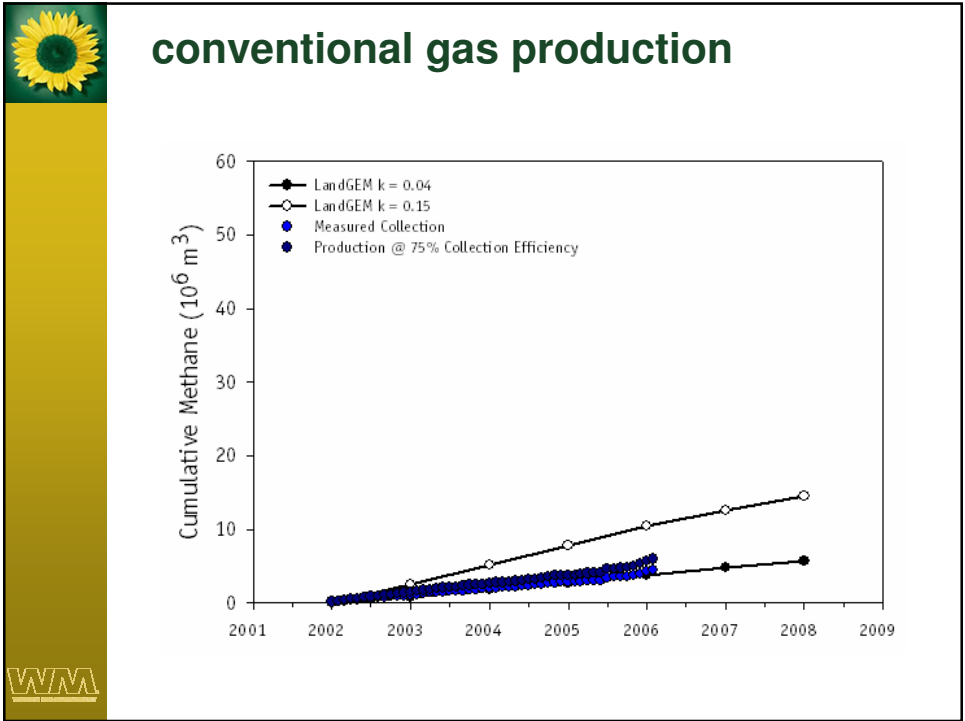
- Weekly field measurements to determine landfill gas composition and flow rate were made using a GEM-2000 portable landfill gas analyzer.
- Analysis of methane, carbon dioxide, and oxygen by US EPA Method 3
- (NMOC) by US EPA Method 25C. Samples were collected on quarterly basis in 6-liter SUMMA® passivated stainless steel canisters.



gas production modeling

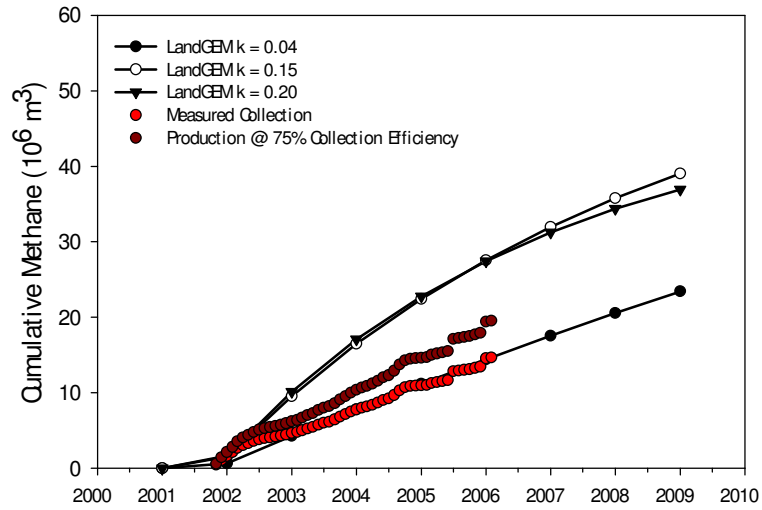
- The first-order decay equation specified in US EPA's LandGEM 3.02 model was used to predict methane generation for each of the landfill types.
- A site specific methane generation potential value, (L_0), of 59 m^3/Mg was used based on results of biochemical methane potential analyses performed on waste samples from the site.
- Model runs varied the rate constant value, (k), from the default of 0.04 year⁻¹ to a value of 0.25 year⁻¹, considered to represent the rate at a wet or bioreactor landfill.



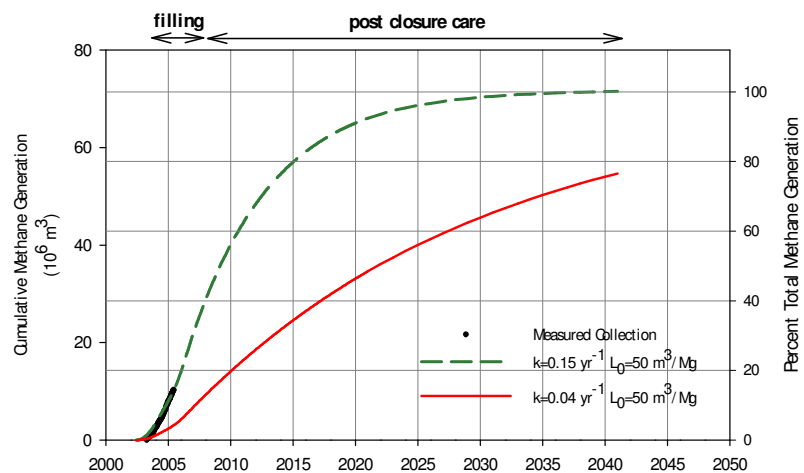




facultative gas production



implication of gas results





conclusions

Results from demonstration projects are in large measure confirming expectations regarding performance.

- ▣ Increased gas production
- ▣ Increased waste degradation
- ▣ Increased settlement
- Bioreactor landfills are an integral part of our development plan.
 - ▣ CRADA renewed through 2010
 - ▣ 6 new projects in process
 - ▣ New research into emissions processes
- RD&D process has been slower than hoped but is picking up steam.

