



Landfill Analysis Overview

EPA Organics Workshop

May 14, 2008

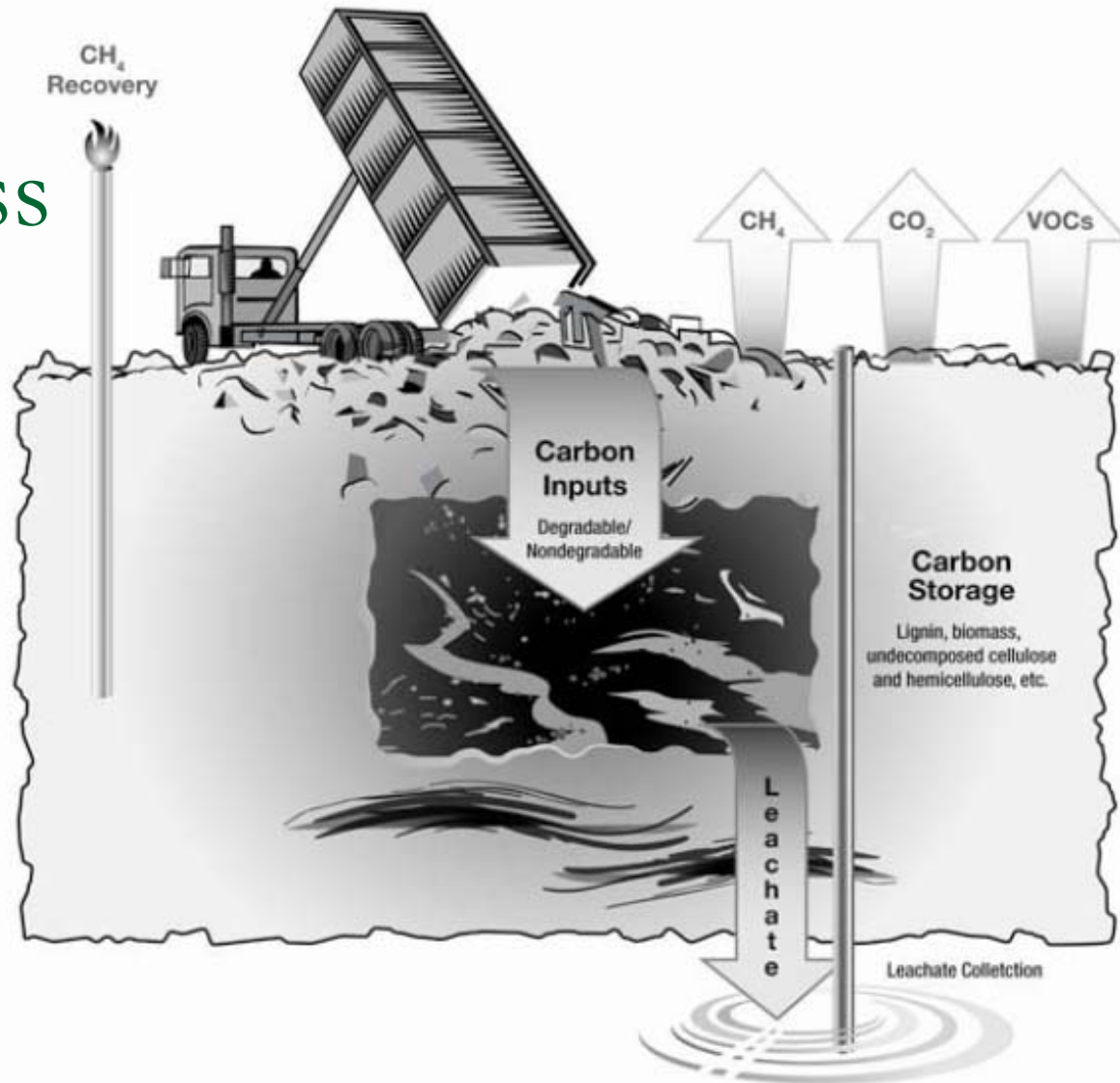
Anne Choate, ICF International



Objectives

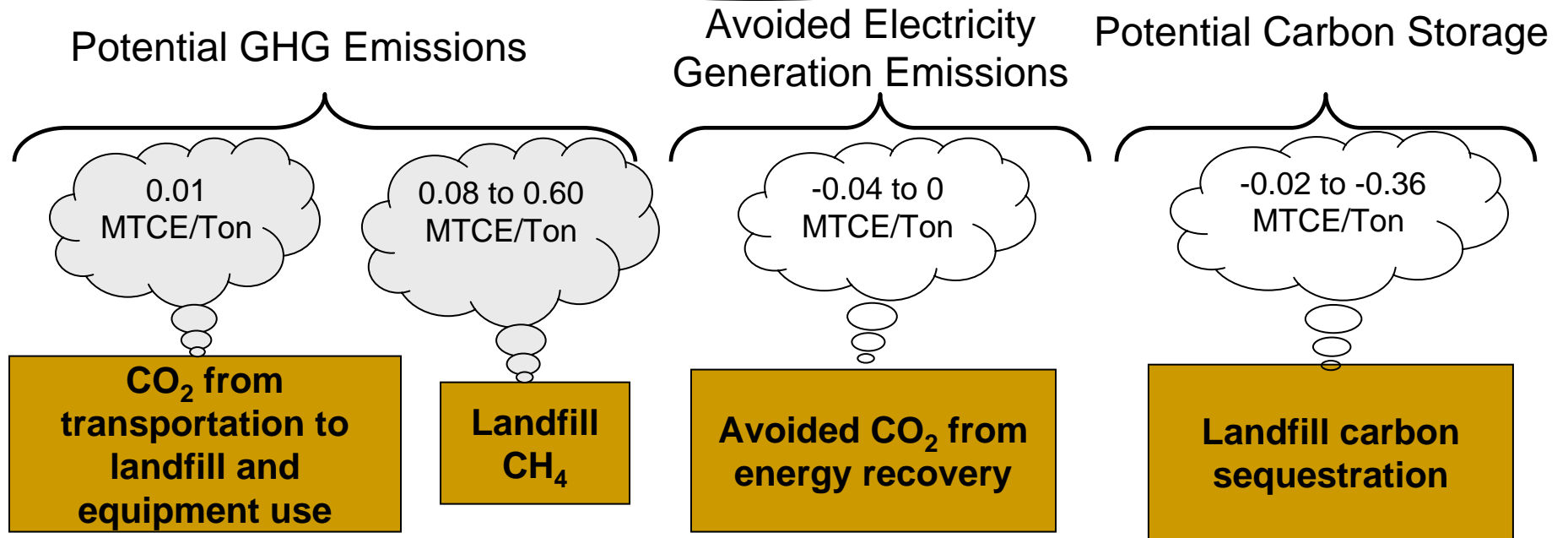
- Overview of existing emission factors
- Description of methodology and key assumptions
- Modeling limitations

Landfill Carbon Mass Balance



Landfilling Emission Factor Framework

Net Emissions* =
-0.24 for newspaper and phonebooks;
-0.13 to -0.08 for dimensional lumber, fiberboard, and magazines;
-0.06 to 0 for yard trimmings, leaves, and grass;
0.11 to 0.53 for cardboard, food discards, office paper,
and textbooks



*The totals do not sum due to rounding.

Source: EPA, 2006. *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*.
Developed by ICF International for EPA. Available at

<http://epa.gov/climatechange/wyacd/waste/SWMGHGreport.html#sections>

Potential GHG Emissions

- CO₂ from transportation to facility and equipment use
 - Estimated from MSW collection, transport, and operation of landfill equipment on-site
 - Used energy data per ton of MSW collected, estimated by Franklin Associates in the early 1990s
 - Converted these energy estimates to CO₂ emissions assuming diesel fuel combustion

Potential GHG Emissions (cont.)

- CH₄ emissions from anaerobic decomposition
 - Applies only to food discards, yard trimmings, paper, and wood
 - Anaerobic degradation and CH₄ release would not have occurred if not for deposition in landfill environment
- Biogenic CO₂ (not included)
 - Applies only to food discards, yard trimmings, paper, and wood
 - In keeping with IPCC accounting principles for CO₂ from sustainably harvested biogenic sources, these emissions are omitted

Potential Carbon Storage

- Landfill carbon sequestration
 - Food discards, yard trimmings, and paper are not completely decomposed by anaerobic bacteria, so some of the carbon in these materials is stored in the landfill
 - Counted as an anthropogenic sink since this carbon storage would not normally occur under natural conditions

CH₄ Generation and Carbon Storage

Methodology

- CH₄ generation potential and carbon storage factors (CSFs)
 - Developed for corrugated cardboard, newsprint, office paper, coated paper, food discards, grass, leaves, and branches measured by Barlaz et al. (1998)
 - Updated CSF for leaves in 2005
 - Additional updates (2008) available
 - CSF for some materials will change
 - Not yet reflected in WARM

CH₄ Generation and Carbon Storage (cont.)

- Laboratory experiments designed to measure biodegradation in a simulated landfill environment designed to promote decomposition
- Key outputs for each material
 - initial carbon content (carbon in the cellulose, hemicellulose, lignin, and protein components)
 - cumulative CH₄ emissions
 - carbon stored
- Adjustments made to measured values to account for exactly 100 percent of the initial C
 - where C outputs < initial C, “missing” C assumed to be emitted.
 - where C outputs > initial C, assumed initial C and CH₄ mass were accurate (i.e., decrease carbon storage)

Carbon Storage Factor (CSF) Proxies

- WARM includes paper grades not tested by Barlaz, so proxies were assigned
 - Magazines and third-class mail CSF = coated paper CSF
 - Phonebooks CSF = newspaper CSF
 - Textbooks CSF = office paper CSF
 - Lumber and fiberboard CSF = branches CSF
- CSF for “mixed paper” types calculated based on compositions established by Franklin Associates

CH₄ Emissions by Landfill Type

- Emission Factors for Landfilling:
 1. Landfills without gas recovery systems
 2. Landfills that recover and flare CH₄
 3. Landfills that combust CH₄ for energy recovery
 4. National average mix of above three categories (“national average” factor)

Landfill CH₄ Emissions

- Key Assumptions:
 - Oxidation from CH₄ to CO₂: Assumed to be 10 percent
 - Landfill gas collection system efficiency, where applicable: 75 percent
 - Breakdown of landfill types used to develop “national average” factor based on 2003 U.S. GHG Inventory data

41%	from landfills without LFG recovery
28%	from landfills with LFG recovery and flaring
31%	from landfills with LFG to energy

Utility CO₂ Emissions Avoided

- Key Assumptions:

- Landfill-based energy recovered for energy offsets the national average fossil fuel mix used to generate electricity
- 15% efficiency loss (in which CH₄ is flared)
- Approx. 1,000 Btu of energy contained in a cubic foot of landfill CH₄ generated

Post-Consumer Results

- Substantial negative net emissions: newspaper, phonebooks, and yard trimmings
- Substantial positive net emissions: office paper, textbooks, corrugated cardboard, and food discards



www.norcalblogs.com/watts/2007/05/



www.emporia.edu/lifelong/geninfo/textbooks.htm



<http://www.mygreenstart.net/?cat=7>

Modeling Limitations

- Analysis results based on a single set of laboratory experiments
- “National Average” results are sensitive to % of U.S. landfills assumed to have LFG recovery systems in place
- Upper and lower bounds for CH₄ oxidation rate and LFG collection system efficiency exhibit varying degrees of sensitivity
- CH₄ generation rates do not reflect influence of industry shifts in landfill cover, liner systems and controls

Modeling Limitations (cont.)

- National average estimate of emissions does not take into account:
 - Timing delays
 - Shifts in LFG recovery rates
 - Removal of LFG recovery equipment
- Assume no “waste mining”
- Assume all gas-to-energy projects produce electricity and displace fossil fuel generated electricity (i.e., coal, petroleum, and natural gas)
- Assume incremental storage for organics such as yard trimmings as compared to non-landfill environment (i.e., no long term storage for non-landfilled organics)

References

- EPA, 2006. *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*. Developed by ICF International for EPA.
- Barlaz, Morton. "Carbon storage during biodegradation of municipal solid waste components in laboratory-scale landfills." *Global Biogeochemical Cycles*. 1998; 12,2 : 373-380.
- Eleazer, W., Odle III, W., Wang, Y., Barlaz, M., 1997. Biodegradability of Municipal Solid Waste Components in Laboratory-Scale Landfills, *Environmental Science and Technology*, 31, 911-917.