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Landfill Analysis Overview

EPA Organics Workshop

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Objectives

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

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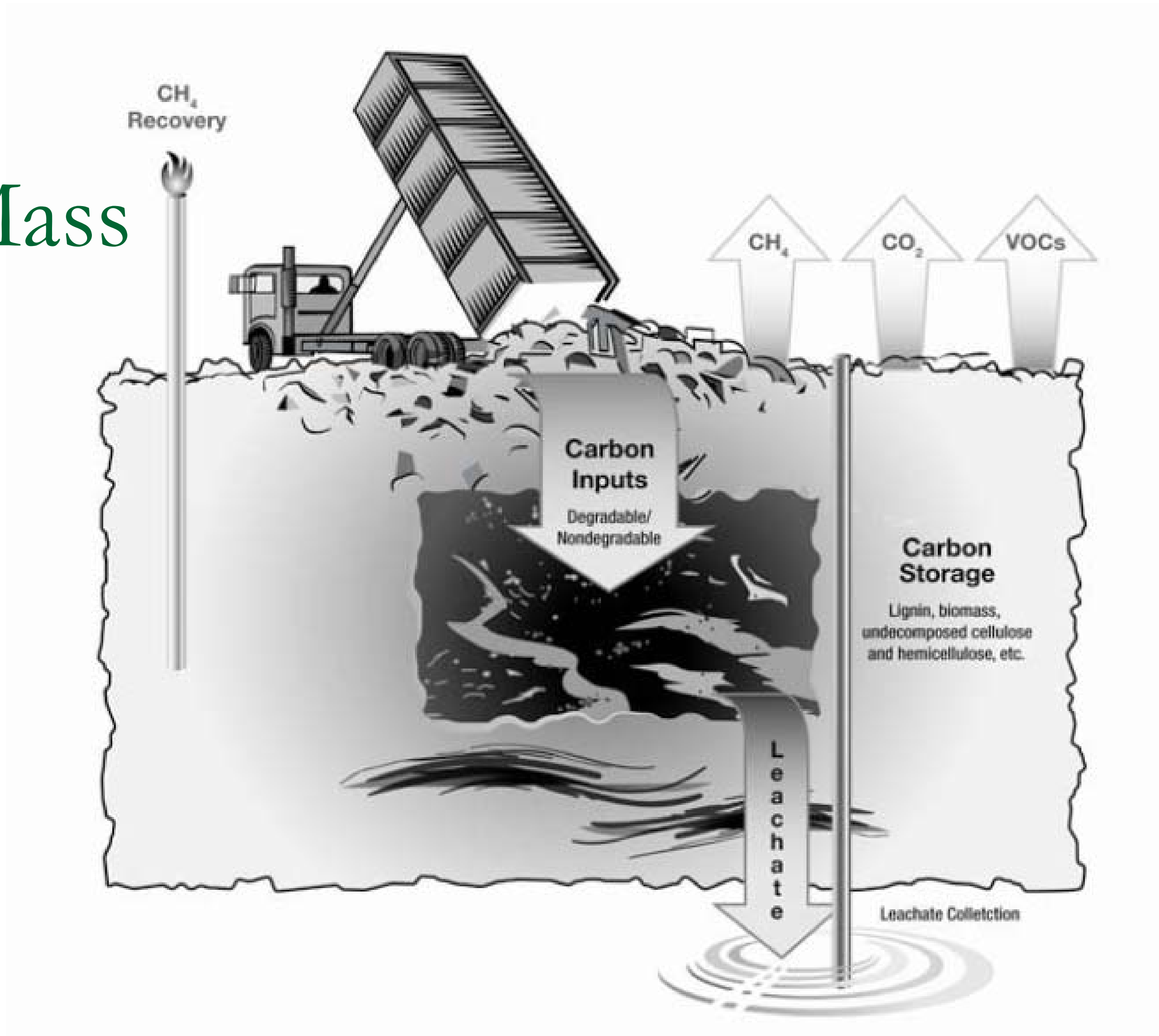
Landfill Carbon Mass Balance



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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

Potential GHG Emissions

- 0.01 MTCE/Ton — **CO_2 from transportation to landfill and equipment use**
- 0.08 to 0.60 MTCE/Ton — **Landfill CH_4**

Avoided Electricity Generation Emissions

- -0.04 to 0 MTCE/Ton — **Avoided CO_2 from energy recovery**

Potential Carbon Storage

- -0.02 to -0.36 MTCE/Ton — **Landfill carbon sequestration**

*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/wycd/waste/SWMGHGreport.html#sections

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Potential GHG Emissions

- CO_2 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 CO_2 emissions assuming diesel fuel combustion

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Potential GHG Emissions (cont.)

- CH_4 emissions from anaerobic decomposition
  - Applies only to food discards, yard trimmings, paper, and wood
  - Anaerobic degradation and CH_4 release would not have occurred if not for deposition in landfill environment
- Biogenic CO_2 (not included)
  - Applies only to food discards, yard trimmings, paper, and wood
  - In keeping with IPCC accounting principles for CO_2 from sustainably harvested biogenic sources, these emissions are omitted

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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

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CH_4 Generation and Carbon Storage Methodology

- CH_4 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

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CH_4 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 CH_4 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 CH_4 mass were accurate (i.e., decrease carbon storage)

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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

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CH_4 Emissions by Landfill Type

- Emission Factors for Landfilling:
  1. Landfills without gas recovery systems
  2. Landfills that recover and flare CH_4
  3. Landfills that combust CH_4 for energy recovery
  4. National average mix of above three categories ("national average" factor)

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Landfill CH_4 Emissions

- Key Assumptions:
  - Oxidation from CH_4 to CO_2: 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

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Utility CO_2 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 CH_4 is flared)
  - Approx. 1,000 Btu of energy contained in a cubic foot of landfill CH_4 generated

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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

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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 CH_4 oxidation rate and LFG collection system efficiency exhibit varying degrees of sensitivity
- CH_4 generation rates do not reflect influence of industry shifts in landfill cover, liner systems and controls

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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)

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- 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-sale 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.

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