

MECHANICAL PULP SLUDGE UTILIZATION



Quantification of GHGs From Utilizing Mechanical Pulp Sludge for Agricultural Application

Best Practices

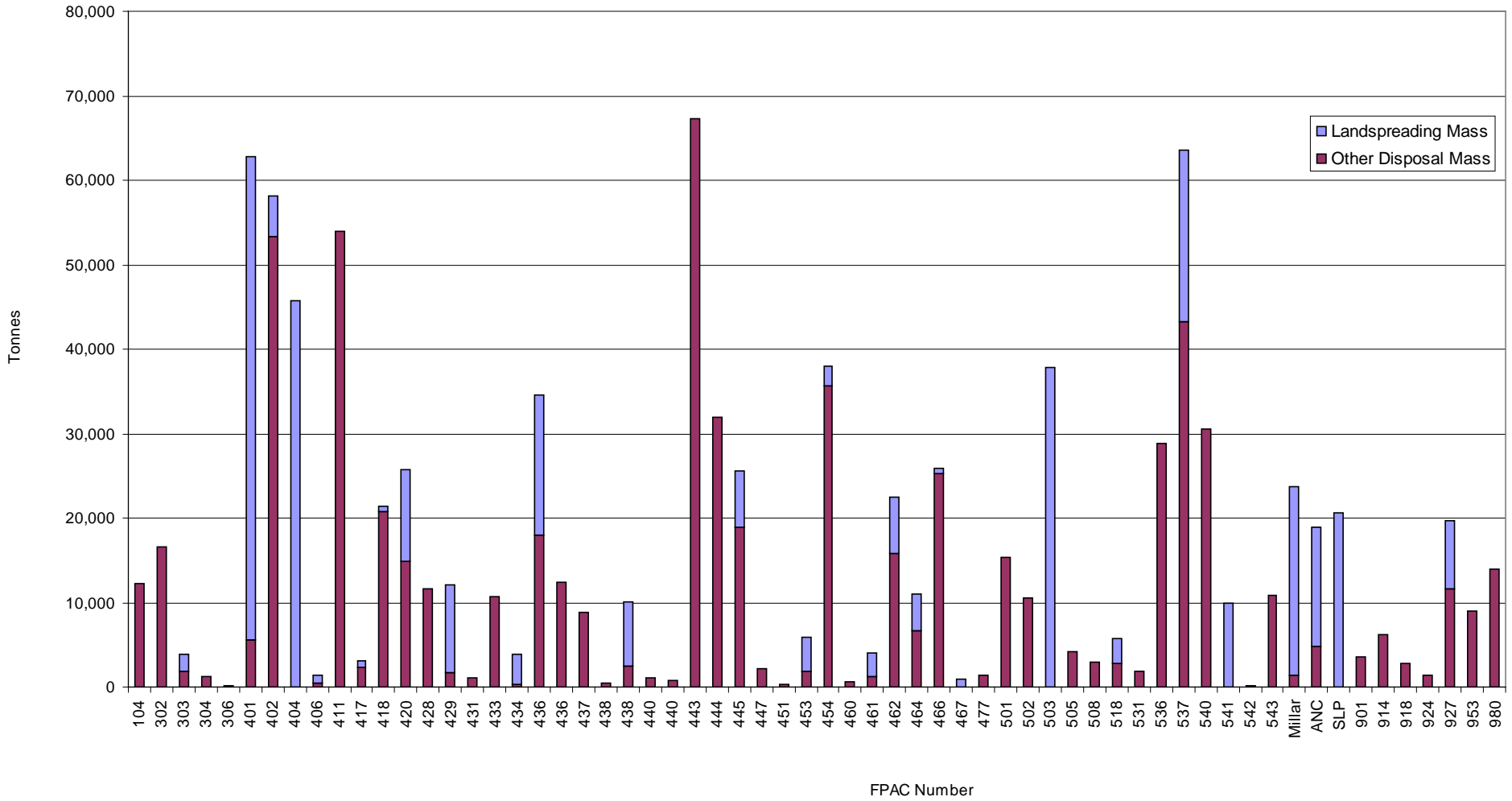
Guidance

- National Inventory Report (1990-2004) GHG Sources and Sinks
 - Described methods used to quantify emissions from landfills and incineration
- American National Standard: GHG - Part 2 (ISO 14064)
 - Guidance at project level for quantification, monitoring and reporting GHG emissions
- Canada's National Inventory
 - Description of IPCC tier 2 and 3 applications for quantifying GHGs
- Standards and Guidelines for the Land Application of Mechanical Pulp Mill Sludge to Agricultural Land
- Agriculture and Agri-Food Canada, 2006 – Draft Document – Tillage System Default Coefficient Protocol – Technical Background Document

Process Overview

- 1st Round of Technical Review
 - October 2, 2008
- TPP was not required at this time and was submitted along with revisions from the Technical Review
- Several Technical Meetings with Professionals, Industry and Government
 - Supplemental Information and Technical Background Information Document

Mass of Sludge Landspread vs Other Disposal Methods for Canadian Pulp Mills in 2003



Protocol

Applicability

The following must be demonstrated to gain carbon offsets:

- Sludge was handled with approved methods
- Project meets sludge land application guidelines
- Number of samples required for quantification increases with increased variability
- Project meets requirements for offset eligibility

Quantification Development

Baseline Emissions

- Business as usual practices – incineration and landfilling

Project Emissions

- Sludge application on agricultural land – increased soil carbon storage

Project Condition

Upstream SS's During Project

P1 Sludge Loading

P3 Pesticide
Production

P5 Seed Production

P24 Fuel Extraction /
Processing

P2 Sludge
Transportation

P4 Pesticide
Transportation

P6 Seed Transportation

P27 Fuel Delivery

Upstream SS's Before Project

P25 Building
Equipment

P26 Equipment Testing

P28 Equipment
Transportation

On Site SS's During Project

P21 Sludge
Application

P22 Sludge
Incorporation

P14 Pesticide
Application

P15 Crop Seeding

P16 Above Ground
Carbon Reservoir

P17 Soil Organic
Carbon Reservoir

P18 Crop Harvest

P23 Sludge N₂O
Emissions

Downstream SS's After Project

Downstream SS's During Project

P19 Crop Transportation

P20 Crop Processing

Identification of Baseline

Comparison Based

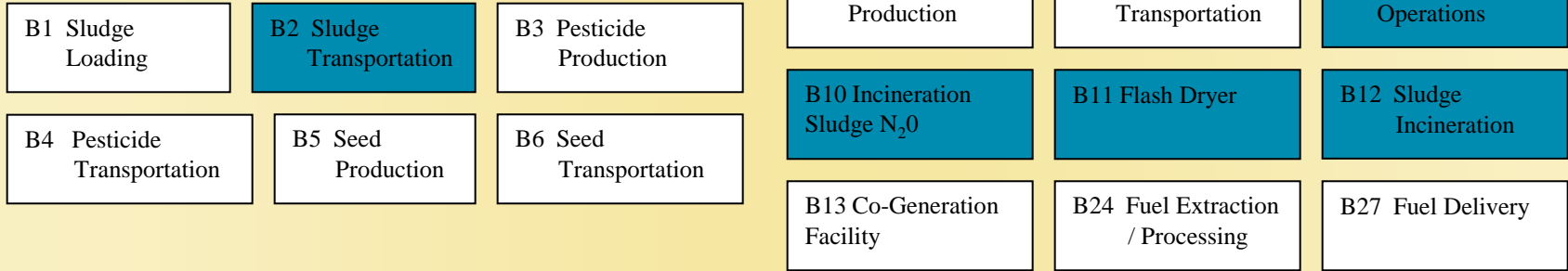
- Actual measurements produce the most accurate and reliable results and can not be discounted by variability

Adjusted Baseline

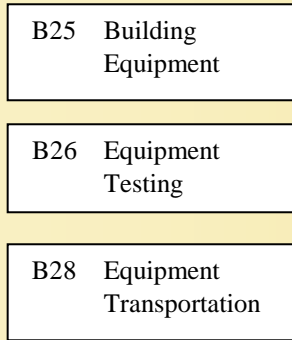
- Must account for the industry based adoption level of land application for 5 years prior to the start of the credit period to ensure the project is NOT a business as usual practice

Baseline Condition

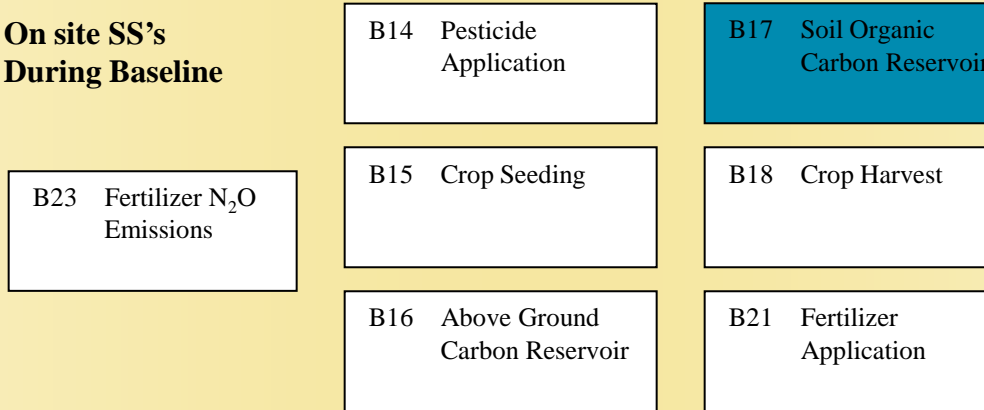
Upstream SS's During Baseline



Upstream SS's Before Baseline



On site SS's During Baseline



Downstream SS's After Baseline

Downstream SS's During Baseline



Protocol Flexibility

Two Approaches for Quantification

1) Advanced Approach

- comparison based sampling/monitoring approach (incorporates a REVERSAL COEFFICIENT)

2) Simple Approach

- If no control strip was established before sludge application, baseline soil carbon contents and bulk densities can be determined from soil maps and benchmarks and a DISCOUNT FACTOR will be applied to quantifications

Development of a Discount Factor

Soil Group	Horizon	Organic Carbon %	Bulk Density (Mg/m ³)
Dark Grey and Dark Grey Wooded	Ap	3.5 to 12.0	0.60 to 1.0
	B	0.5 to 2.0	0.90 to 1.4
Gray Wooded	Ap	1.5 to 6.0	0.60 to 1.0
	B	0.2 to 1.2	0.90 to 1.4

Max Variability =
70%

Max Variability =
40%

Quantification Approaches

$$\text{Emission Reduction} = (\text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}})$$

$$\text{Emissions}_{\text{Baseline}} = \text{Adjusted Baseline} * [\text{Emissions}_{\text{Landfill Operations}} + \text{Emissions}_{\text{Dryer}} + \text{Emissions}_{\text{Incineration}} + \text{Emissions}_{\text{Incineration N2O}} + \text{Emissions}_{\text{Sludge Transportation}} + (- \text{Emissions}_{\text{Soil Carbon}})]$$

$$\text{Emissions}_{\text{Project}} = \text{Emissions}_{\text{Sludge Transportation}} + (- \text{Emissions}_{\text{Soil Carbon}})$$

Quantification

Procedures

Landfill Operations (Scholl Canyon Method)

$$G_i = M_i * k * L_o * \exp(-k * t_i)$$

$$L_o = MCF * DOC * DOC_F * f(16/12) * (1000 \text{ kg CH}_4 / \text{t CH}_4)$$

Incineration (assuming complete combustion)

$$\text{CO}_2 \text{ equiv} = \text{BDT sludge} * \% \text{ carbon} * \text{MW CO}_2 / \text{MW Carbon}$$

$$\text{N}_2\text{O} = \text{t sludge} * (\text{t N} / \text{t sludge}) * (44 \text{ t} \cdot \text{mol N}_2\text{O} / 28 \text{ t} \cdot \text{mol N}_2)$$

Dryer Natural Gas Usage

$$\text{t CO}_2 \text{ equiv} = \text{Mg wet sludge} * \text{Gj/Mg wet sludge} * \text{m}^3 / 0.03723 \text{ Gj} * 1.902 \text{ kg CO}_2 \text{equiv} * \\ \text{Mg CO}_2 \text{ equiv} / 1000 \text{ kg CO}_2 \text{equiv}$$

Transportation

Based on liters of fuel *or* kilometers travelled

Quantification Approaches

Advanced Approach

$$\text{Emission Reduction} = (\text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}}) - \text{Total Reversal Coefficient}$$

Simple Approach

$$\text{Emissions Reduction} = (\text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}}) * 0.55 \text{ Discount Factor}$$

Quantification

Approaches

Advanced Approach (Soil Carbon)

Emissions_{Soil Carbon} =

$$\text{t C/ha} = \text{SOC\%/100} \times \text{Db (kg/m}^3\text{)} \times \text{sample depth (m)} \times 10000 \text{ m}^2\text{/ha} \times 1 \text{ t/1000kg}$$

$$\text{t CO}_2\text{e} = \text{t C/ha} \times \text{Area (ha)} \times 44\text{t}\cdot\text{mol CO}_2\text{/12 t}\cdot\text{mol C}$$

Simple Approach (Soil Carbon)

$$\text{Baseline Emissions}_{\text{Soil Carbon}} = \text{t C/ha} = \text{Db (kg/m}^3\text{)} \times (\text{\%Carbon}/100)$$

$$\text{Project Emissions} = \text{Mix (t)} = \text{Organic soil (t/ha)} + \text{Mineral soil (t/ha)} + \text{Sludge (t/ha)}$$

$$\text{Where: Soil (t/ha)} = \text{soil depth (cm)} \times \text{bulk density (g/cm}^3\text{)} \times \text{area}$$

$$\text{Soil depth} = \text{incorporation depth (cm)} - \text{sludge depth (cm)}$$

$$\text{Sludge (t/ha)} = \text{application rate (t dry sludge/ha)}$$

$$\text{Carbon content of final mix (t C / Mix (t))} = ((\text{Sludge} \times \text{Sludge \% carbon}) / \text{Mix (t)}) + ((\text{Soil} \times \text{Soil \% carbon}) / \text{Mix (t)})$$

$$\text{t C/ha} = (\text{t Carbon/ Mix (t)}) \times \text{Mix (t)}$$

Example Quantification Assumptions

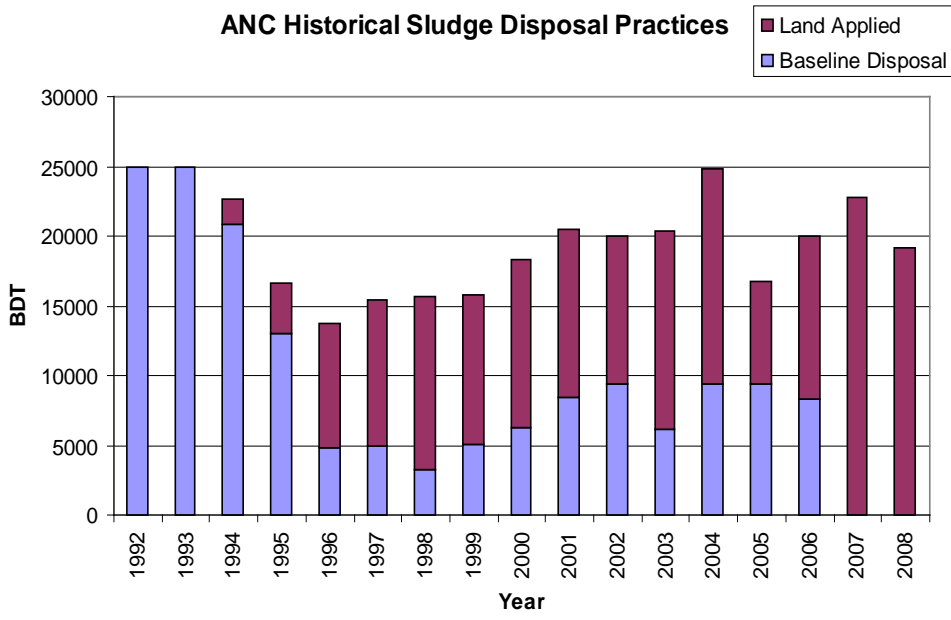
Sludge Parameters	Trucking	Receiving Soil Properties		
		<u>Depth</u>	<u>Db</u> (kg/m ³)	<u>% Carbon</u>
Carbon Content = 45% Nitrogen Content = 2%	Haul Distance = 100 km			
Application Rate = 50 t/ha	35 t Truck Capacity	0-15 cm	0.9	3.29
	33.6 L/100km	15-30 cm	1.35	1.06

		t CO _{2e} / 50 t/ha application	
		Landfill	Incineration
Baseline	B9 Landfill Operations	78.0	-
	B11 Flash dryer	-	71.9
	Incineration N ₂ O		34.9
	B12 Incineration	-	82.5
	B2 Sludge Transportation	0.044	-
	B17 SOC Reservoir	- 201	- 201
	Σ Emissions Baseline	-122.96	-11.66
Project	P17 SOC Reservoir	- 279	- 279
	P2 Sludge Transportation	0.44	0.44
	Σ Emissions Project	-278.56	-278.56
Baseline – Project		155.6	266.9
Advanced Approach = Baseline – Project – (0.63 Mg CO₂ ha⁻¹ yr⁻¹)		154.97	266.27
Simple Approach = Baseline – Project * 0.55		85.58	146.8

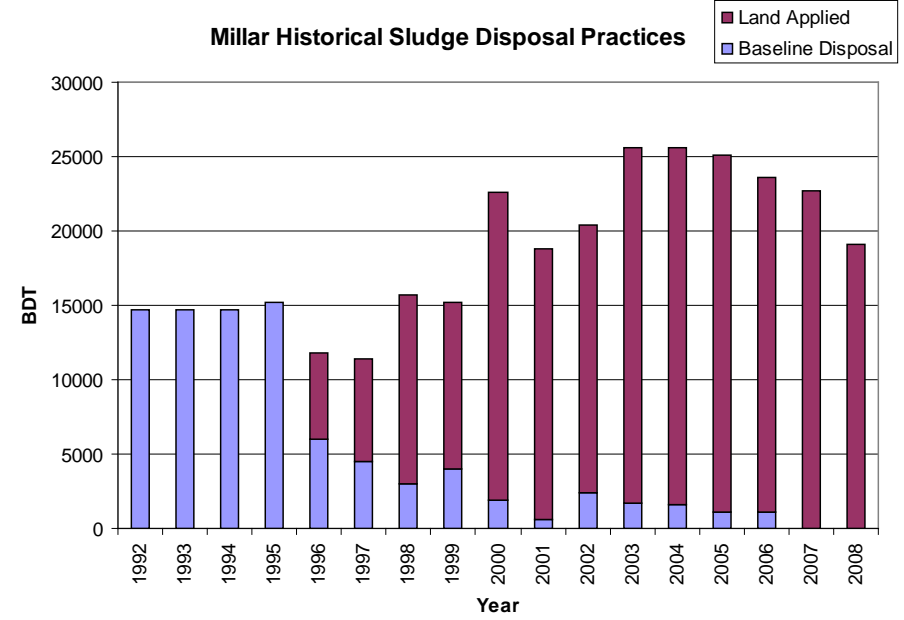
Questions ??



ANC Historical Sludge Disposal Practices



Millar Historical Sludge Disposal Practices



SLP Historical Sludge Disposal Practices

