Greenhouse Gas and Carbon Sequestration

Kentson Yan
Joel Nodelman, P.Eng.
Daryl McCartney, Ph.D., P.Eng.

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Foreword

- City of Edmonton and Alberta Capital Region Wastewater Commission are investigating strategies to increase the processing capacity
  - ideally through the beneficial use of biosolid products.
- Project goal:
  1. Present overview of the offset credit and carbon trading market
  2. To estimate greenhouse gas (GHG) offset credits for selected biosolids management options

Outline

- Carbon trading
  - Terminology
  - Current markets
- Offset credit estimates
  - Carbon accounting
  - Options and calculation
  - Recommendations/Conclusion

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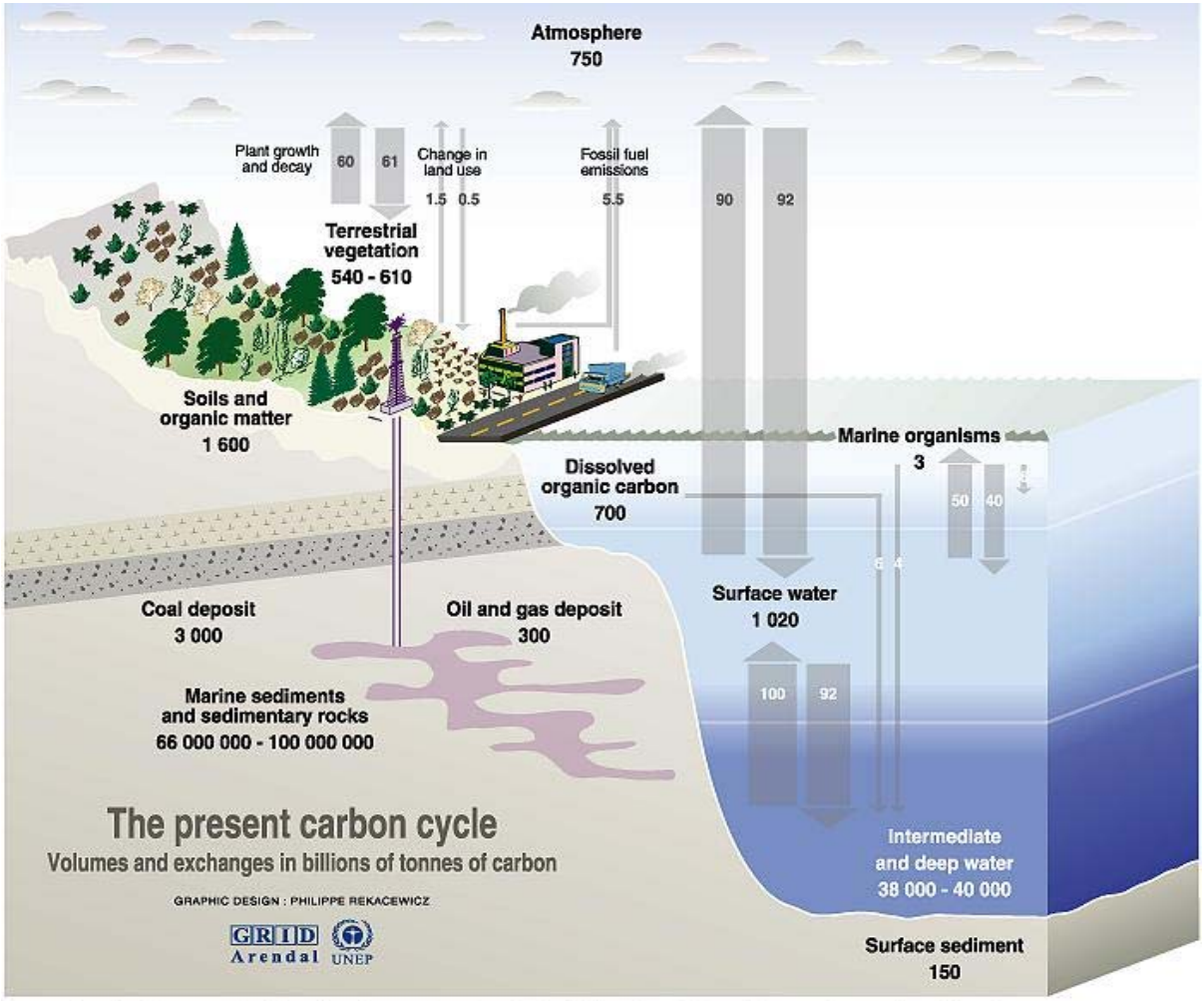
Terminology



Sources: Center for climatic research, Institute for environmental studies, university of Wisconsin at Madison; Okanagan university college in Canada, Department of geography; World Watch, November-December 1998; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

Terminology

- Source
- Sink

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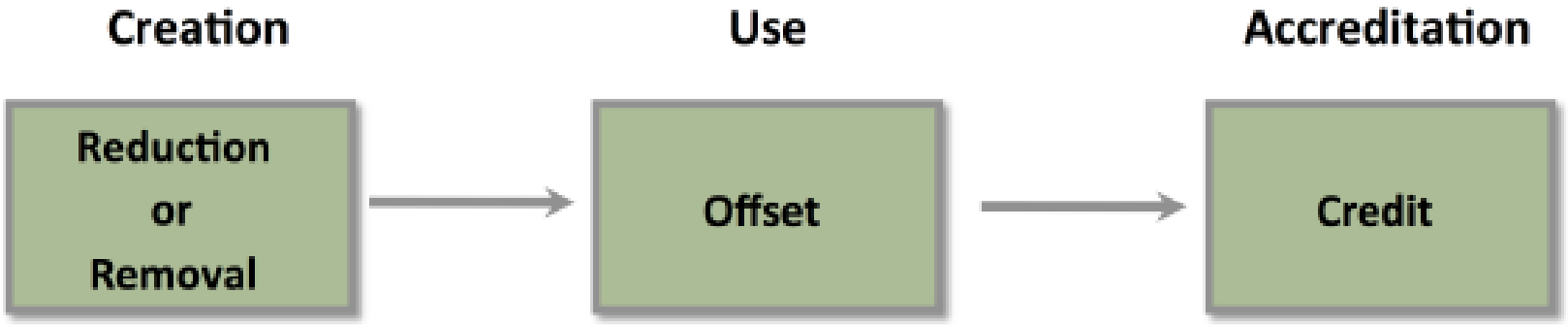
Terminology – cont'd

- Upstream emissions (or removals)
  - activities that occur **before** the project
  - e.g. electricity and fossil fuel production to power a facility
- Downstream emissions (or removals)
  - activities that occur **after** the project
  - e.g. carbon sequestration in soil

Offset credits = baseline emission – project emission

Carbon Market

The emission credit creation process:



Seller has excess reductions or removals.

Ownership transferred to buyer.

Buyer receives reductions and removals as offsets.

Offsets used for compliance.

Regulator gives credit to offsets for compliance purposes.

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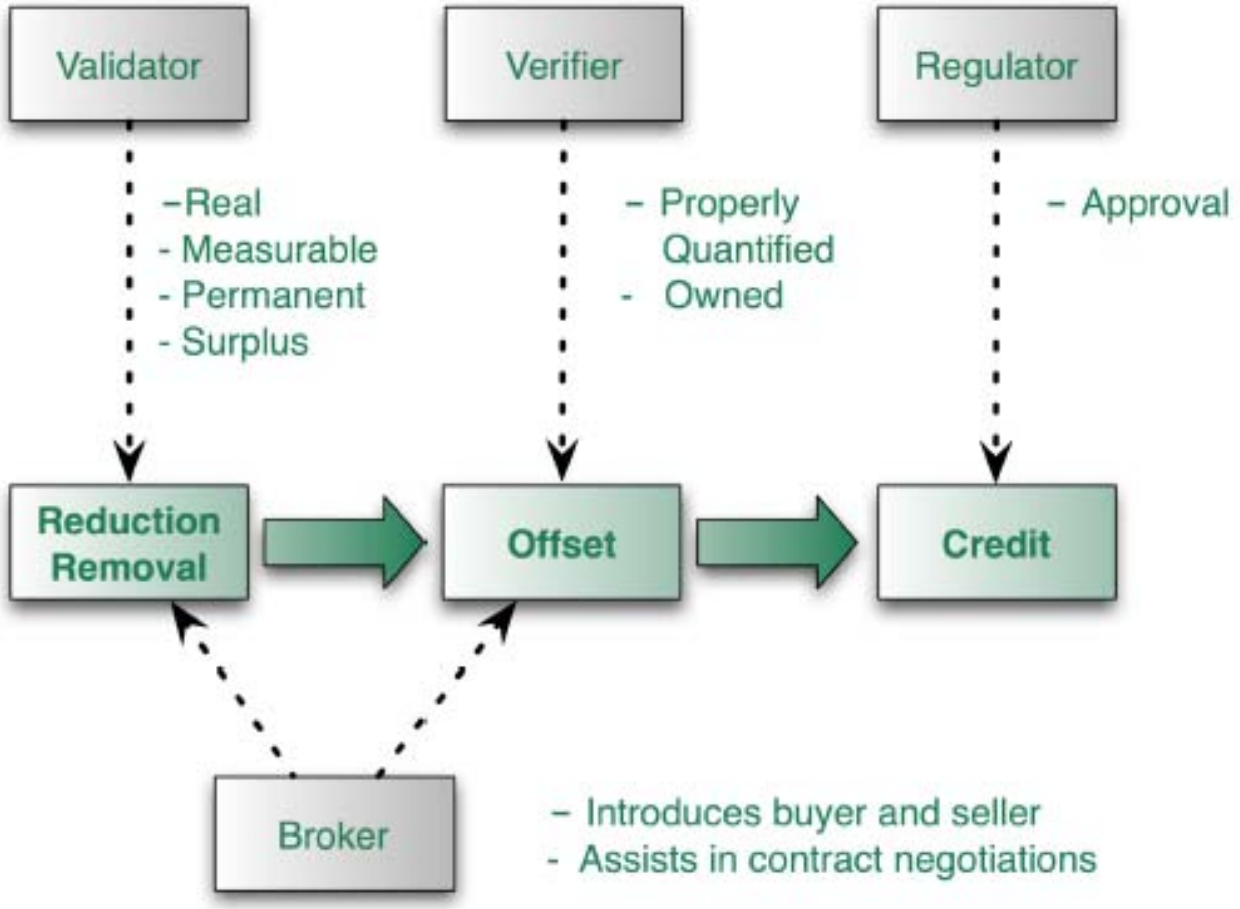
Carbon Market – cont'd

Common offset trading system criteria:

Criterion	What it Means
Real	✓ An actual reduction or removal has occurred
Measurable	✓ It can be quantified through direct measurement or rigorous calculation
Permanent	✓ It will not re-enter the atmosphere at some point in the future
Surplus	✓ It is not required for some other compliance purpose
Verifiable	✓ It is documented accurately ✓ Instrumentation is properly calibrated ✓ Data management systems are reliable
Owned	✓ The seller can prove legal ownership ✓ It hasn't already been sold or otherwise used

Carbon Market – cont'd

Players in the offset market:



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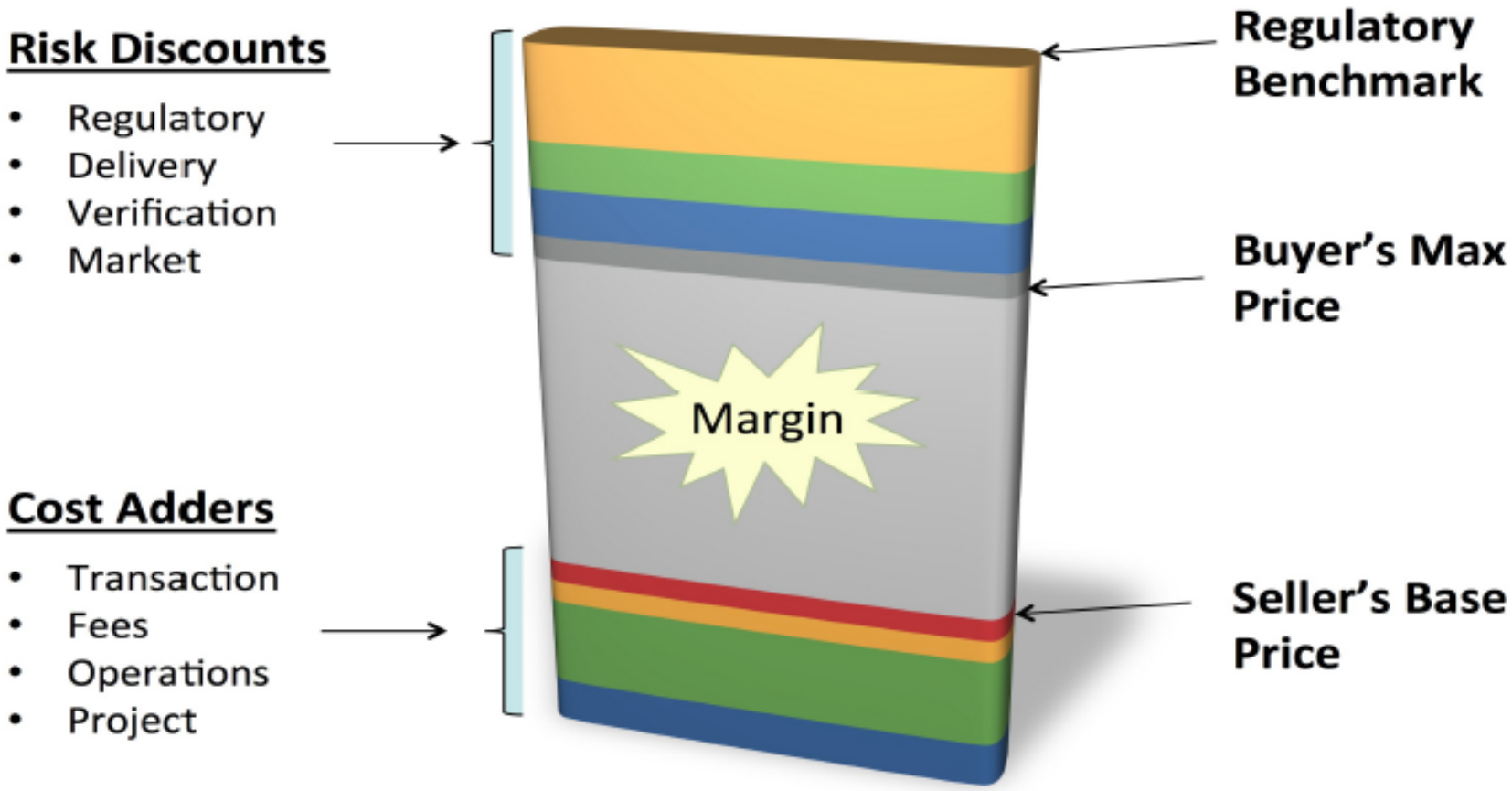
Carbon Market – cont'd

Factors applied to establish offset price:



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Carbon Accounting

ISO 14064-2 (GHG project level)

1. Identify sources and sinks (SS)
2. Select quantification methodology
3. Collect activity data
4. Select/develop emission/removal factor
5. Calculate each SS emission/removal

Carbon Accounting

ISO 14064-2 (GHG project level)

1. **Identify sources and sinks (SS)**
2. Select quantification methodology
3. Collect activity data
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Carbon Accounting: LCA – Biosolids Management

Upstream SS's During Project

- Biosolids Generation
- Collection and Transportation
- Fuel Delivery
- Fuel Extraction/Processing
- Chemical Production and Transportation
- Off Site Material Processing
- Electricity Usage

Upstream SS's Before Project

- Development of Site
- Transportation of Equipment
- Construction on Site
- Building Equipment
- Testing of Equipment

On Site SS's During Project

- Processing and Treatment
- Residue Handling
- Feedstock Handling

Downstream SS's After Project

- Site Decommissioning

Downstream SS's During Project

- Biosolids Transportation
- Biosolids Utilization
- Residue Disposal
- Carbon Sequestration

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Carbon Accounting: LCA – Biosolids Management

Upstream SS's During Project

Collection and Transportation

Fuel Extraction/Processing

Chemical Production and Transportation

Electricity Usage

Upstream SS's Before Project	On Site SS's During Project	Downstream SS's After Project
	Processing and Treatment	

Downstream SS's During Project

Biosolids Utilization

Carbon Sequestration

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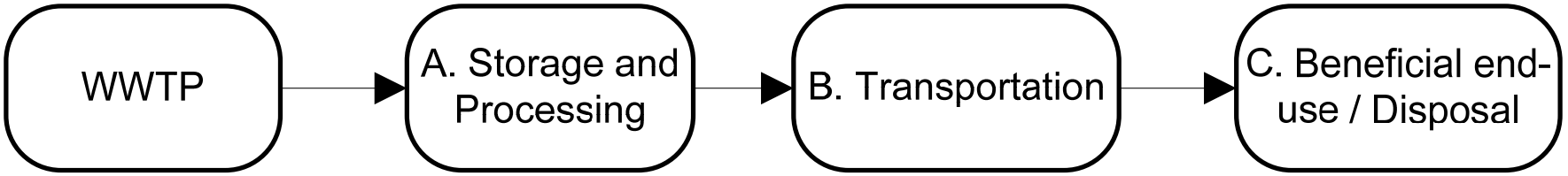
Carbon Accounting: General Process Flow – Biosolids Management



End-use (or disposal) investigated:

- Land application
- Composting
- Biosolids cake storage
- Thermal energy
- Landfill disposal

Carbon Accounting

ISO 14064-2 (GHG project level)

1. Identify sources and sinks (SS)
2. **Select quantification methodology**
3. **Collect activity data**
4. **Select/develop emission/removal factor**
5. Calculate each SS emission/removal

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Carbon Accounting – Basis of Calculation

2) quantification methodology
   - Biosolids Emission Assessment Model (BEAM) adopted by CCME

3) data
   - Stantec report (2011)
   - analytical reports
   - City of Edmonton & ACRWC personnel

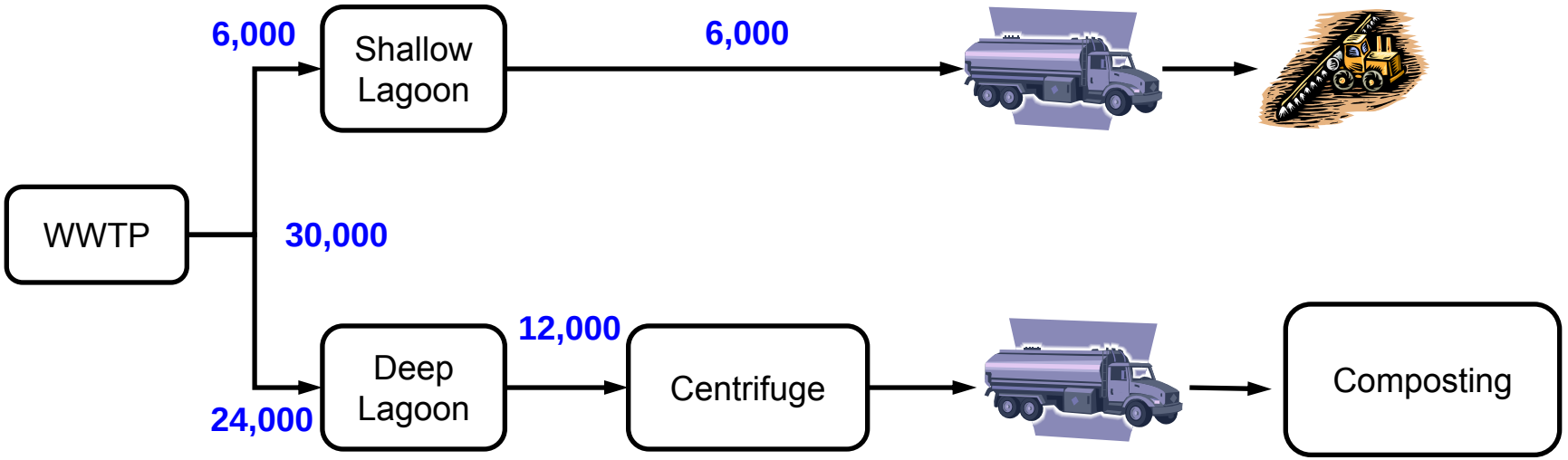
4) factors
   - default/typical values from BEAM

Carbon Accounting

ISO 14064-2 (GHG project level)

1. Identify sources and sinks (SS)
2. Select quantification methodology
3. Collect activity data
4. Select/develop emission/removal factor
5. **Calculate each SS emission/removal**

Carbon Accounting - Baseline (current practice)



Unit: dry tonnes (DT) = Mg (dry)
Based in 2010 data and projections

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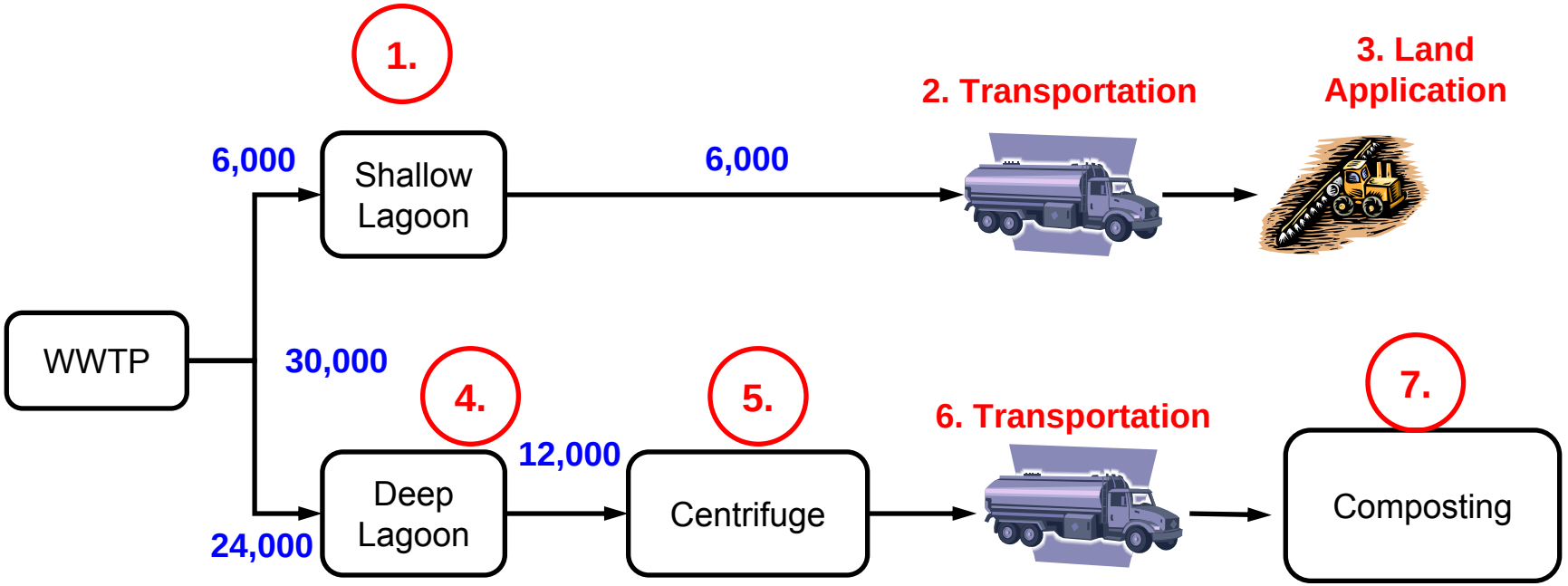
Carbon Accounting - Identifying SS



Unit: dry tonnes (DT) = Mg (dry)
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End-use (or disposal) scenarios investigated:

- Land application
- Composting
- Biosolids cake storage
- Thermal energy
- Landfill disposal

Example Calculation for One Baseline Scenario: Land Application (NutriGold)

$$E_{land\ appl} = E_{storage} + E_{fuel} + E_{land} + E_{Cseq} = 0.04 \times M$$

$$E_{storage} = M / \%solids / \rho \times storageEF \times d = 0$$

Symbol	Description	Value (ref./notes)
M	Biosolids mass	--
%solids	% of solids content	8% (Stantec)
ρ	Biosolids density	950 kg/m^3 (BEAM)
storageEF	Storage emission factor	0.324 kg CO_2e/m^3/day (BEAM)
d	Number of days stored	0 (assumed)

Condition:

If % solids > 55%, then $E_{storage} = 0$

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Example Calculation - Land Application (NutriGold) (cont'd)

$$\mathbf{E_{land\ appl} = E_{storage} + E_{fuel} + E_{land} + E_{Cseq} = 0.04 \times M}$$

$$E_{fuel} = M / \%solids / \rho / V_{truck} / t_{apply} \times HrsUse \times fuelEF = M \times 0.02$$

Symbol	Description	Value (ref./notes)
M	Biosolids mass	--
%solids	% of solids content	8% (Stantec)
ρ	Biosolids density	950 kg/m^3 (BEAM)
V_{truck}	Volume of truck (per load)	13 m^3/load (BEAM)
t_{apply}	Time require to apply biosolids	3 load/hr (BEAM)
HrsUse	Amount of fuel used in an hour	25 L/hr (BEAM)
fuelEF	Fuel emission factor (diesel)	2.772 kg CO_2e/L (BEAM)

Example Calculation - Land Application (NutriGold)

(cont'd)

$$\mathbf{E_{land\ appl} = E_{storage} + E_{fuel} + E_{land} + E_{Cseq} = 0.04 \times M}$$

$$E_{land} = E_{fine\ soil} + E_{coarse\ soil} = [M \times \%N \times \%fine \times \%N2O_{fine} \times N_{con} \times GWP_{N2O}] + [M \times \%N \times (1-\%fine) \times \%N2O_{coarse} \times N_{con} \times GWP_{N2O}] = M \times 0.27$$

Symbol	Description	Value (ref./notes)
M	Biosolids mass	--
%N	% N In biosolids	3.9% (analytical report)
%fine	% of fine texture soils in soil	50% (BEAM)
$\%N2O_{fine}$ & $\%N2O_{coarse}$	% N converted to N_2O	2.3% in fine soil & 0.5% in coarse soil (BEAM)
N_{con}	Conversion of N to N_2O	1.571(BEAM)
GWP_{N2O}	Global warming potential of N_2O	310 (IPCC)

Example Calculation - Land Application (NutriGold)
(cont'd)

$$E_{land\ appl} = E_{storage} + E_{fuel} + E_{land} + E_{Cseq} = 0.04 \times M$$

$E_{Cseq} = M \times csEF = M \times (-0.250)$

Symbol	Description	Value (ref./notes)
M	Biosolids mass	--
csEF	Carbon sequestration emission factor	-0.25 Mg CO_2e/DT (BEAM)

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Accounting: Summary of Emissions from Various Unit Operations & Processes – Baseline Scenario

Sources and Sinks	Biosolids Mass 'M' (dry tonnes, DT)	Factor (tonnes CO_2e/DT)	GHG Emission (tonnes CO_2e)
1. Shallow lagoon	0 (none stored)	0.04	0
2. Transportation	6,000	0.07	420
3. Land application (Nutri Gold)	6,000	0.04	240
4. Deep lagoon	12,000	0.14	1,680
5. Centrifuge	12,000	0.18	2,160
6. Transportation	12,000	0.02	240
7. Composting	12,000	0.22	2,640
	TOTAL		**7,380**

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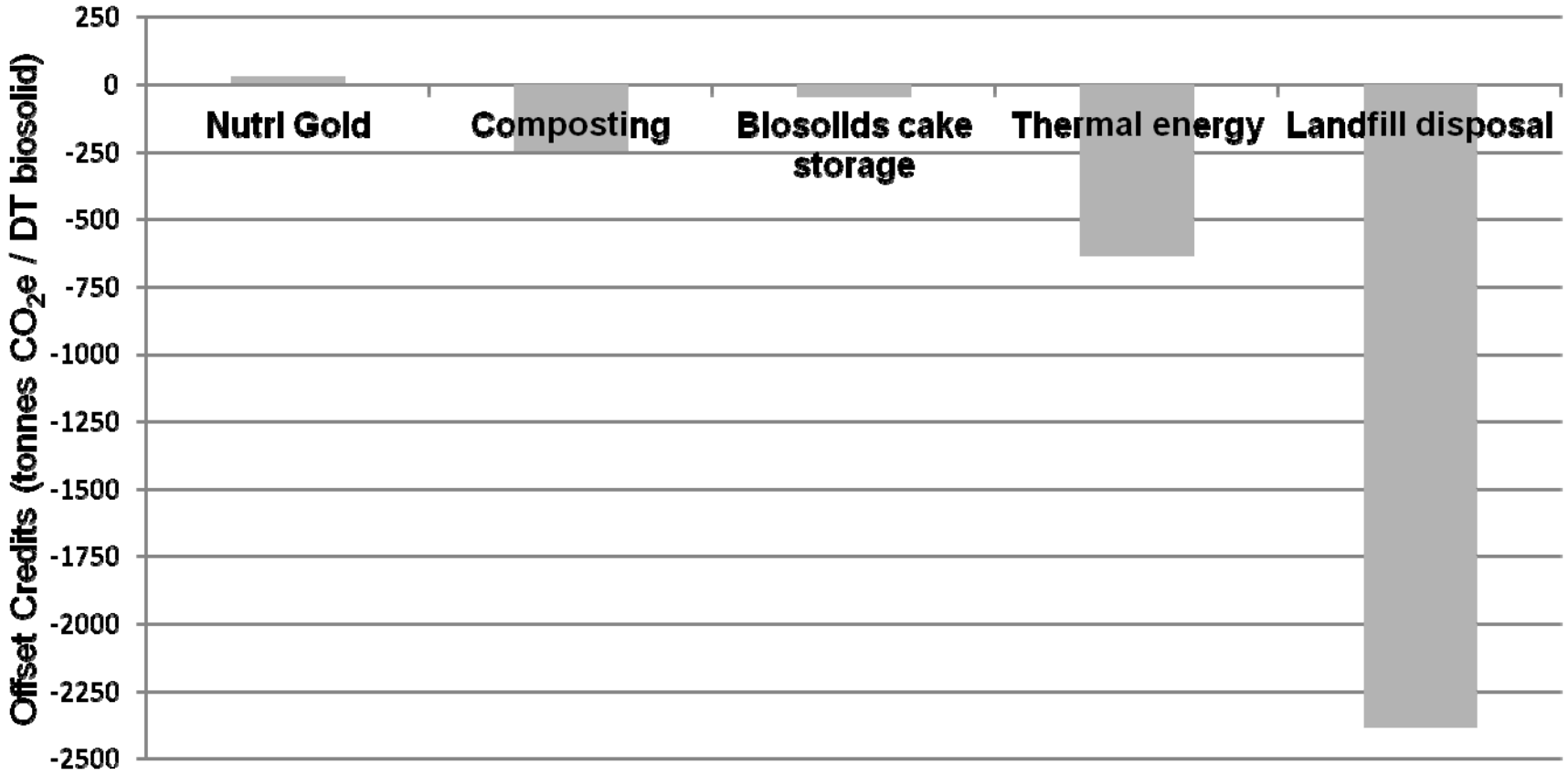
Potential offset credits – Five Scenerios (Projects) Considered (Baseline = deep lagoon storage)



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Potential offset credit – cont'd

- Lagoon storage (baseline condition) emission:
  - Under estimation
  - Lack of BOD_5 data
  - Conservative approach
  - Could be 4x larger, therefore credits 4x larger

    . . .

Potential gaps in BEAM

Emissions/removals excluded:

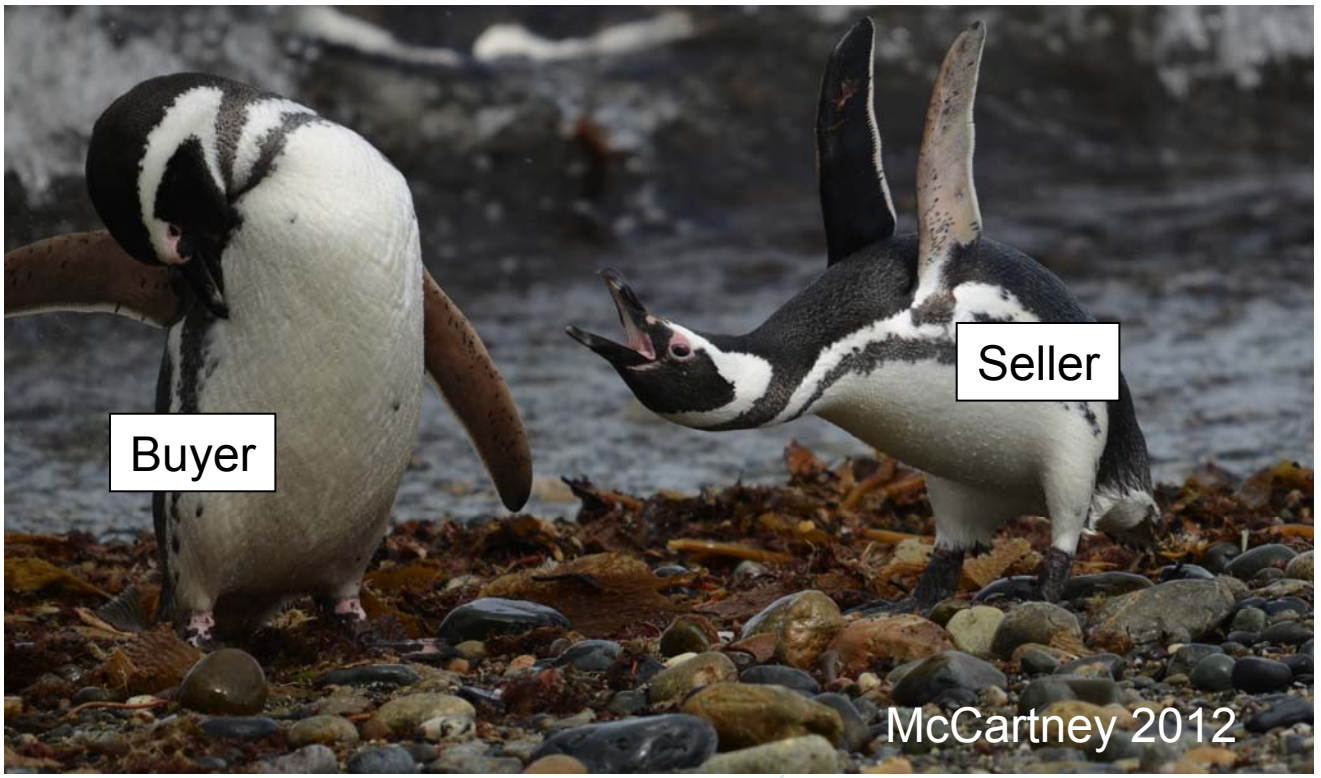
- Emissions from temporary lagoon storage
- Removal from carbon sequestration through plants
- Offsets from fertilizer replacement in land application and composting
- Offsets from replacing calcium carbonate in land application and composting
- Offsets from cement replacement in thermal energy (combustion)

Conclusions

- Quantifying offset principles
  - Real, measureable, and verifiable
- Comprehensive data management
  - Data gaps (parameters estimated)
  - What do you want the answer to be . . .

THANK YOU!

Questions?



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