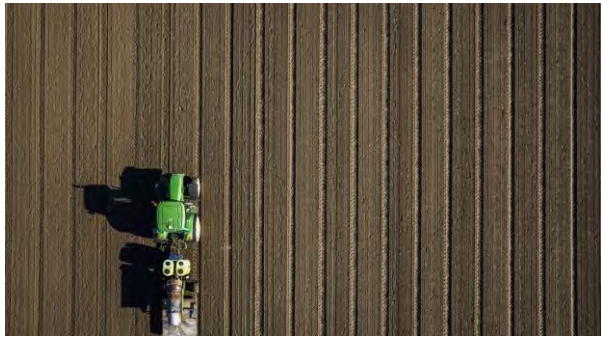
June 7, 2023

GHG 101

Measuring and Mitigating Climate Impacts from Wastewater Operations

NYWEA
LEADING THE WAY IN WATER QUALITY MANAGEMENT

NEWEA
WORKING FOR WATER QUALITY



Brown AND Caldwell

Bill Brower
585.532.9996
BBrower@BrwnCald.com

nebra
North East Biosolids & Residuals Association

Janine Burke-Wells
603.323.7654
janine@nebiosolids.org

Overview

1. Greenhouse gas accounting basic concepts
2. Sources (emissions) at WRRFs
3. Sinks (offsets) at WRRFs
4. GHG accounting tools - BEAM

Climate impacts on wastewater utilities

- Water scarcity
- Flooding of treatment plants
  - Hurricane Sandy, King County
- Increased stormwater flows, CSOs
- Power grid instability
- Unfavorable conditions for land application
- Uncertainty

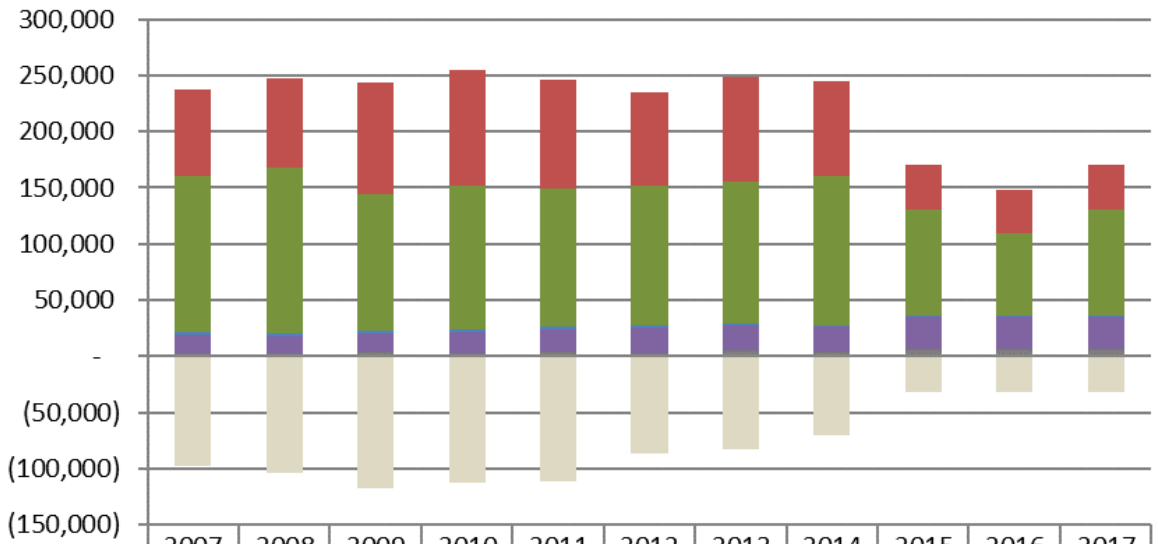
Flooding at West Point WRRF in Seattle (image from Seattle Times)

Why develop a GHG inventory?

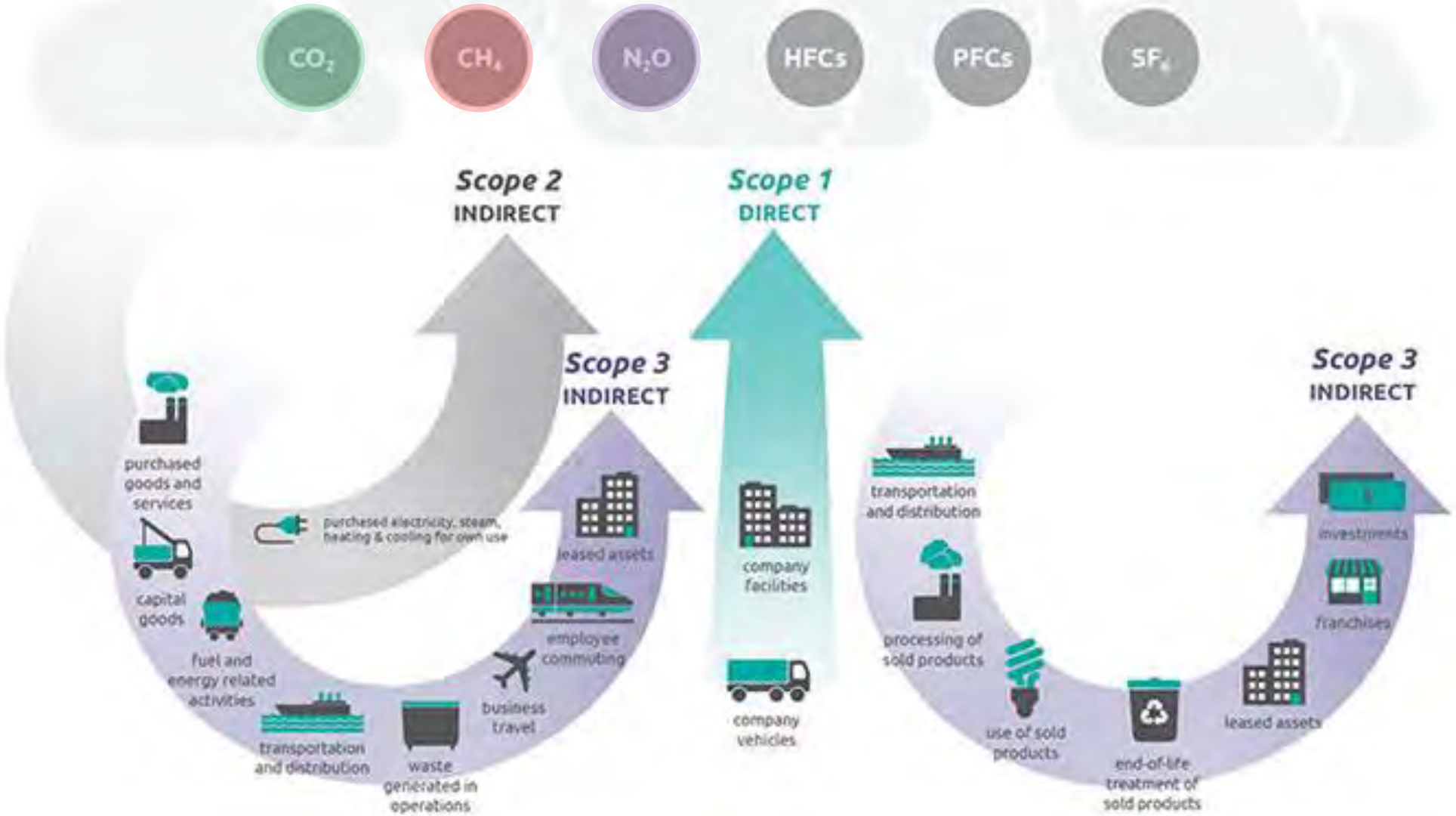
- Highlights areas where the biggest improvements can be made
- What gets measured gets acted on
- High emissions can indicate opportunities to improve energy & processing efficiency
- Immediate payback
- Carbon credits?

Example of a GHG Inventory for a Large WRRF

(Metric Tons CO2e)



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Biosolids Processing & Land App	76,386	79,742	98,971	103,523	96,598	83,547	92,593	84,396	38,746	38,746	38,746
Electricity	139,113	147,332	121,738	127,531	123,346	122,992	126,140	132,132	94,357	72,281	94,357
Vehicle (fuel usage)	2,989	2,586	2,456	2,601	2,481	3,004	2,029	1,676	1,369	1,369	1,369
Refrigerants	109	142	142	142	142	217	-	-	-	-	-
Process Emissions	15,418	14,459	16,879	18,450	19,883	21,822	22,365	22,730	29,239	29,239	29,239
Natural Gas	2,984	2,967	3,547	3,055	3,820	3,118	5,018	3,604	6,202	6,202	6,202
Carbon Credits	(97,583	(103,90	(117,49	(113,02	(111,51	(86,657	(82,369	(70,592	(32,402	(32,402	(32,402


CO_2
CH_4
N_2O
HFCs
PFCs
SF_6
Scope 2
INDIRECT
Scope 1
DIRECT
Scope 3
INDIRECT
Scope 3
INDIRECT
purchased goods and services
capital goods
fuel and energy related activities
transportation and distribution
waste generated in operations
business travel
employee commuting
leased assets
purchased electricity, steam, heating & cooling for own use
company facilities
company vehicles
transportation and distribution
processing of sold products
use of sold products
end-of-life treatment of sold products
leased assets
franchises
investments

Greenhouse Gas Potency

Industrial designation or common name	Chemical formula	GWP values for 100-year time horizon		
		Second Assessment Report (SAR)	Fourth Assessment Report (AR4)	Fifth Assessment Report (AR5)
Carbon dioxide	CO_2	1	1	1
Methane	CH_4	21	25	28
Nitrous oxide	N_2O	310	298	265
Substances controlled by the Montreal Protocol				
CFC-11	CCl_3F	3,800	4,750	4,660
CFC-12	CCl_2F_2	8,100	10,900	10,200
CFC-13	$CClF_3$		14,400	13,900
CFC-113	CCl_2FCClF_2	4,800	6,130	5,820
CFC-114	$CClF_2CClF_2$		10,000	8,590
CFC-115	$CClF_2CF_3$		7,370	7,670
Halon-1301	$CBrF_3$	5,400	7,140	6,290

Source: ghgprotocol.org

Standard Unit:
metric-tons of carbon dioxide-equivalent

1 MTCO2e

+2,500 miles driven

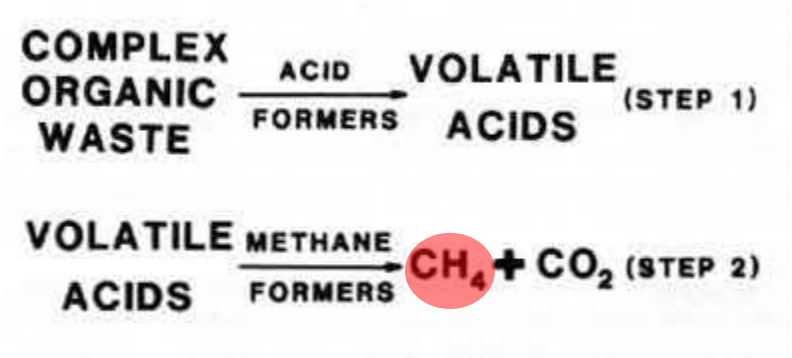
+120,000 smartphones charged

+1-acre of U.S. forests

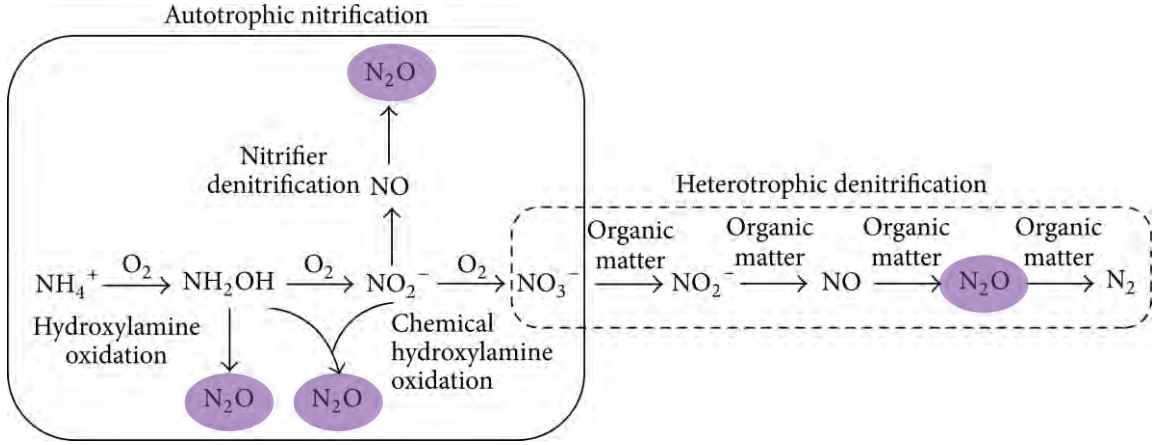
Source: EPA GHG Equivalency Calculator

When are GHGs directly produced at WRRFs?

- Organic matter (carbon) breaking down in aerobic or anaerobic conditions

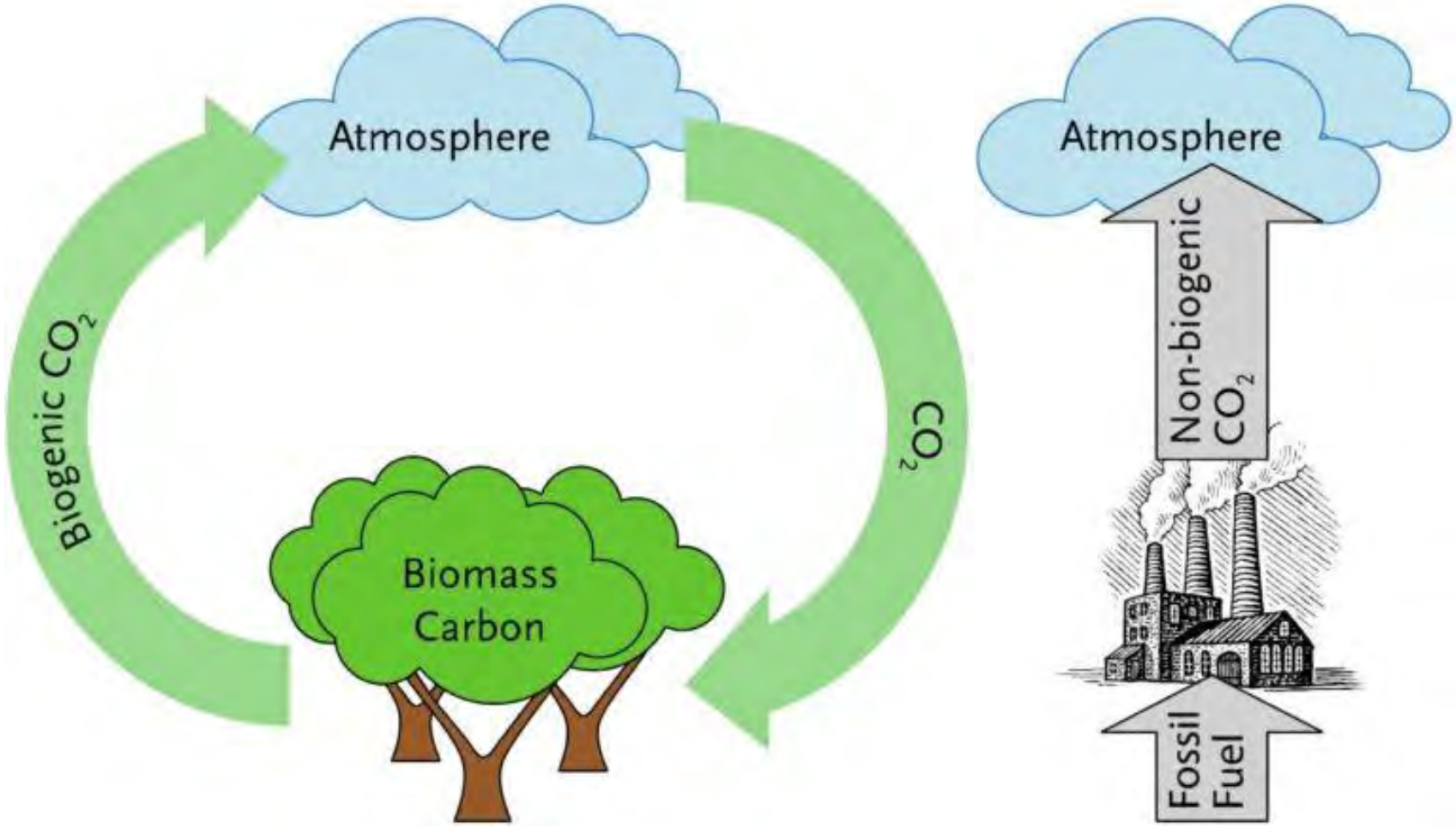


- Nitrogen conversion



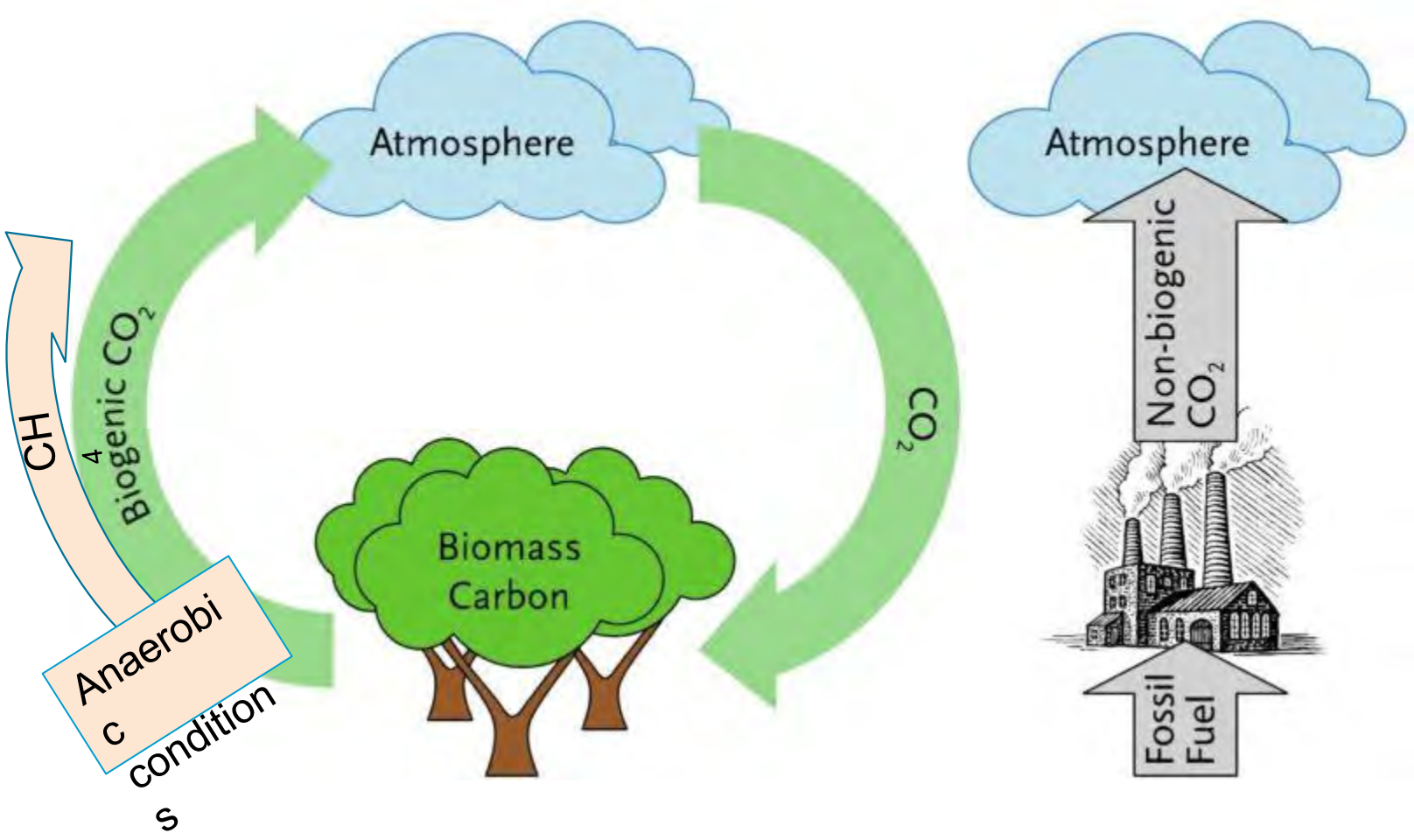
Sources: purdue.edu; Campos, et al., 2016

Biogenic Sources are Considered Net Zero…

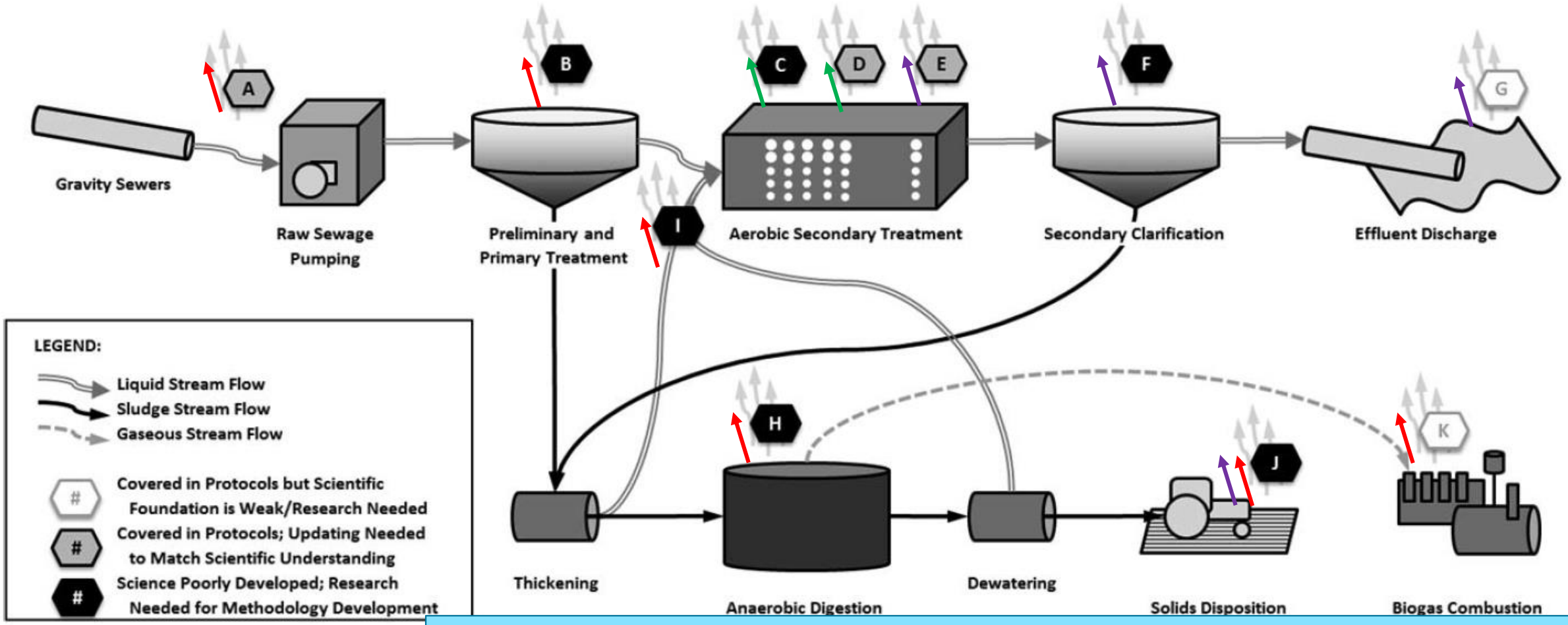


Biogenic Sources are Considered Net Zero… Unless

e.g. biogas leakage



Typical Scope 1 Process Emissions for a WRRF



Source: Willis, 2018

- A: Sewer methane
- B: Preliminary/1° production & release
- C: Industrial discharge→CO_2
- D: Carbon source→CO_2
- E: N_20 from N removal
- F: N_20 from clarifiers
- G: N_20 from effluent
- H: Fugitive digester CH_4
- I: Dissolved solids CH_4
- J: Solids end-use N_20, CH_4
- K: Uncombusted digester CH_4

Non-process Scope 1 Emissions for a Utility

- Natural gas on-site usage
- Vehicle fuel usage
- Refrigerants

Typical Scope 2 Emissions for a WRRF

Energy produced by others:

- Electricity
- Heating/cooling
- Steam

Typical Scope 3 Emissions for a WRRF

- Solids hauling
- Chemical production
- Chemical hauling

Biggest Opportunities to Improve Climate Impact

- Energy efficiency
- Improve biogas capture and utilization
- Co-digestion
- More climate-friendly biosolids management

GHG Inventory Tools

- GIZ/WaCCliM Energy Performance and Carbon Emissions Assessment and Monitoring (ECAM)
- OWWA/WEAO Climate Change Committee GHG Inventory Tool
- Ontario Water Consortium
- COMET (organics land application)
- Custom-made models
- BEAM

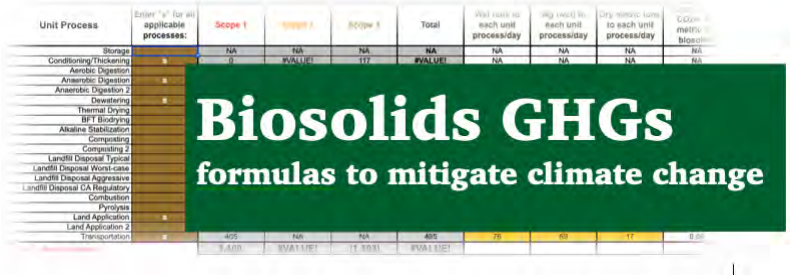
WRF project: “Establishing Industry-Wide Guidance for Water Utility Life Cycle Greenhouse Gas

Biosolids Emissions Assessment Model (BEAM)

Brown AND Caldwell

What is the Biosolids Emissions Assessment Model (BEAM)?

- Excel spreadsheet
- Calculates net GHG emissions and sinks for different biosolids treatment and end use options
  - Does not address all WRRF, utility emissions – just for solids
- Estimates Scopes 1, 2, 3 & biogenic CO_2 emissions
- Uses detailed emissions factors from published literature
  - As specific as possible to different biosolids materials
- Original published in 2010, 2011, from project by Canadian Council for Ministers of the Environment (CCME).

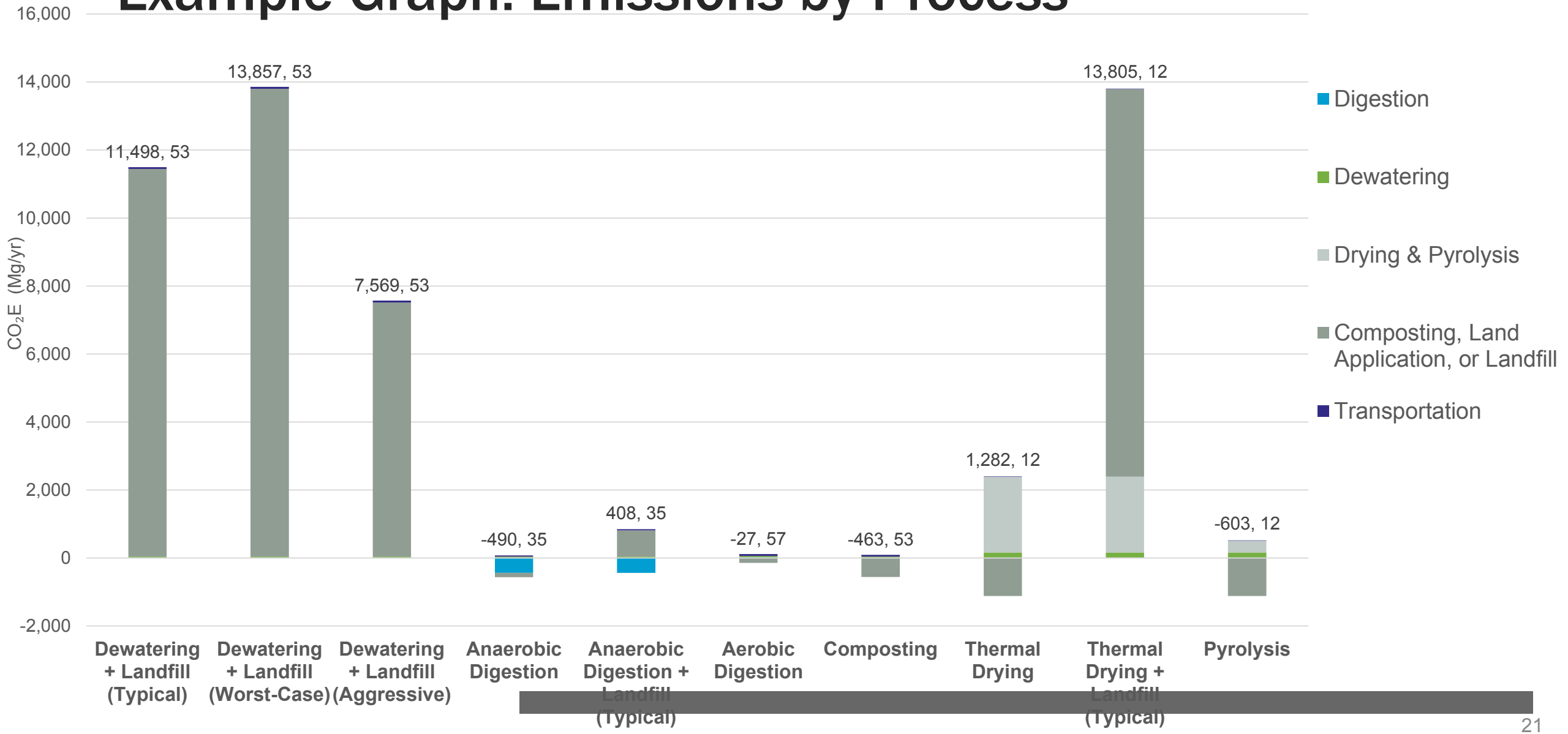


Original BEAM purpose

- **estimate a program's GHG emissions**, including establishing a baseline
- **compare different biosolids management scenarios**
- estimate **impacts from changes** in biosolids management
- understand the **factors that have the greatest impact** on GHG emissions

CCME User Guide, 2009

Example Graph: Emissions by Process



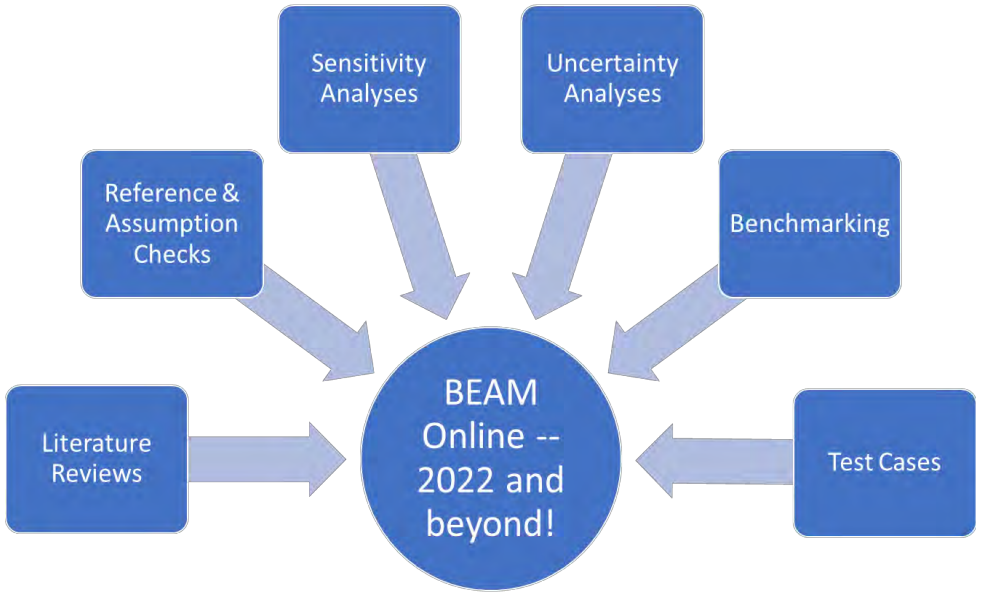
Emissions Factors

Most comprehensive resource for biosolids-specific emissions/sinks factors

Wastewater Treatment Factors				
Typical TSS in sludge after primary sedimentation (kg/1000 m³)	150	Metcalf & Eddy, 2003, p. 1456		
Expected solids concentration of combination primary/WAS unthickened sludge (%)	1.0%	Metcalf & Eddy, 2003, p. 1492		
Expected solids concentration in sludge from gravity thickener, primary and WAS (%)	4%	Metcalf & Eddy, 2003, p. 1457		
Typical Biosolids Characteristics (De-watered cake)	***unprocessed***	***digested***	***limed***	
Total nitrogen (%-dry weight)	4.0%	5.0%	3.2%	Northern Tilth suggested values if data not available
Total phosphorus (%-dry weight)	1.5%	1.9%	1.2%	
TVS(%-dry weight)	78.0%	65.0%	52.0%	
Storage and Lagoons		The 95% confidence interval range for this defau		
Default methane generation from anaerobic shallow lagoon - less than 2 m (kg CH_4/kg BOD)	0.12	IPCC, 2006. Volume 5 assuming Bo of 0.6 and		
Default methane generation from anaerobic deep lagoon - more than 2 m (kg CH_4/kg BOD)	0.40	IPCC, 2006. Volume 5 assuming Bo of 0.6 and		
Typical amount of BOD removed to sludge during wastewater treatment	90%	NACWA 2008		
Energy required for low-speed aerators in sludge aerated lagoons after primary sedimentation (kW/1000 m^3 sludge)	5.6	Metcalf & Eddy, 2003, p. 846 = 0.004xTSS (mg		
Average days per year above 15°C	41.7%	41.7% for NYC		
SSO Processing				
liters of diesel/Mg-wet SSO processed	2.38	WM CORe data - October 2018		
kWh/Mg-wet of SSO processed	17.6	WM CORe data - October 2018		
kg propane/Mg-wet of SSO processed	0.05	WM CORe data - October 2018		

Keeping BEAM Up-to-date

- Adding new processes, technologies
- Feedback requested from users via website
- Annual reviews
  - BEAM Team
  - Science Review Team (SRT)

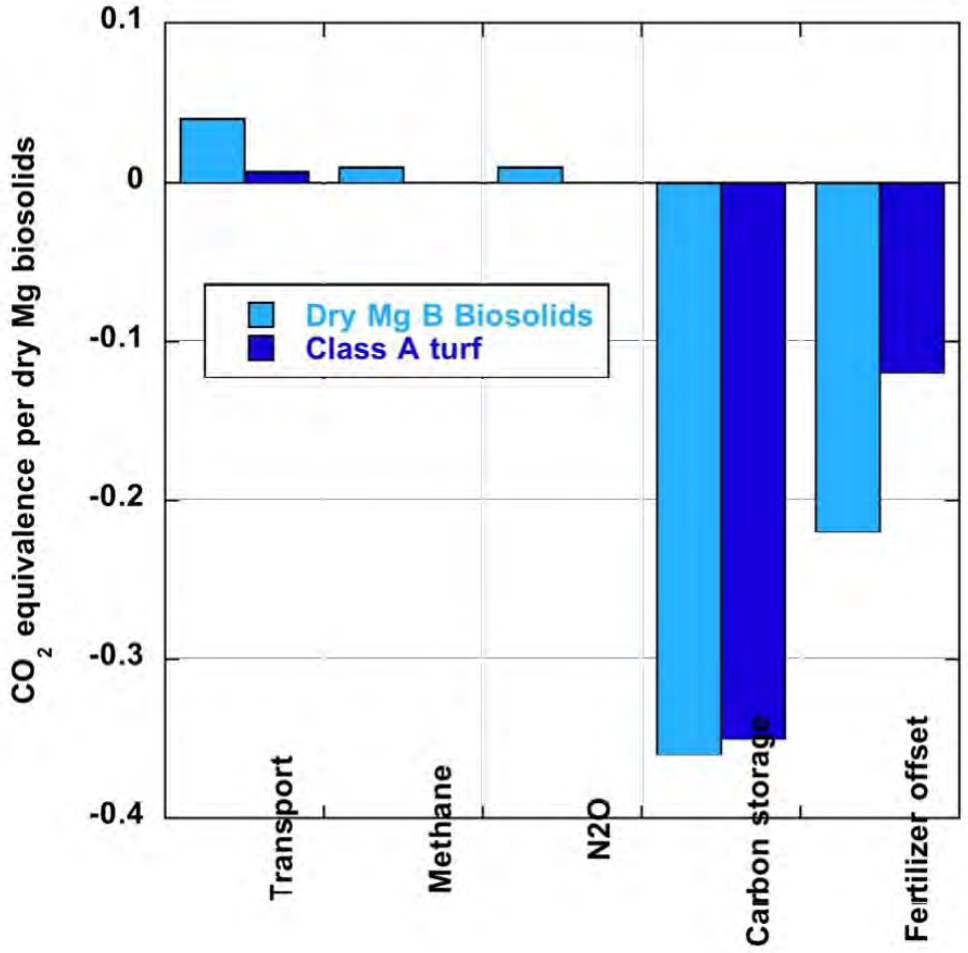


High Priority Topics for SRT Review

- Landfill methane emissions
- Carbon sequestration of land applied biosolids
- N_2O from combustion & land app
- Fugitive CH_4 from biogas combustion (engines, flares)
- AD process details (%VSR, SRT)
- Electric & heat efficiency from internal combustion engines
- Fertilizer offsets

Examples of using BEAM

Chicago: Comparing Management Options



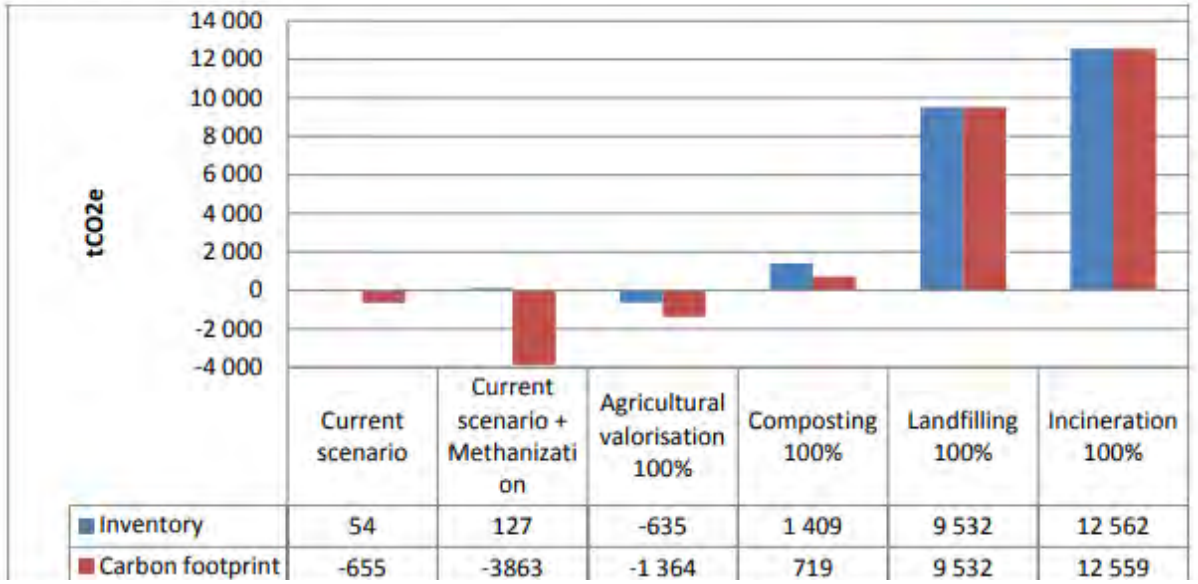
Brown & Tian; 2010. https://mwrd.org/sites/default/files/documents/M&RSeminar_07-30-2010-Seminar-Brown_Tian_MWRD_CO2.pdf

Québec: Baseline & comparing alternatives

Table 1. Summary of emissions for the current scenario

Agricultural valorisation (65%)	tCO_2e	Composting (35%)	tCO_2e
1-Process direct emissions			
Transportation	80	Transportation	41
Machinery	31	Machinery	88
CH_4 emissions	67	CH_4 emissions	221
N_2O emissions	47	N_2O emissions	360
Sequestration	-599	Sequestration	-287
2- Indirect emissions linked to energy use			
Electricity consumption	0	Electricity concumption	5
3- Other indirect emissions			
N replacement	-393	N replacement	-193
P replacement	-81	P replacement	-42
Total (1 + 2)	**54**		
Total (1 + 2 + 3)	**-655**		

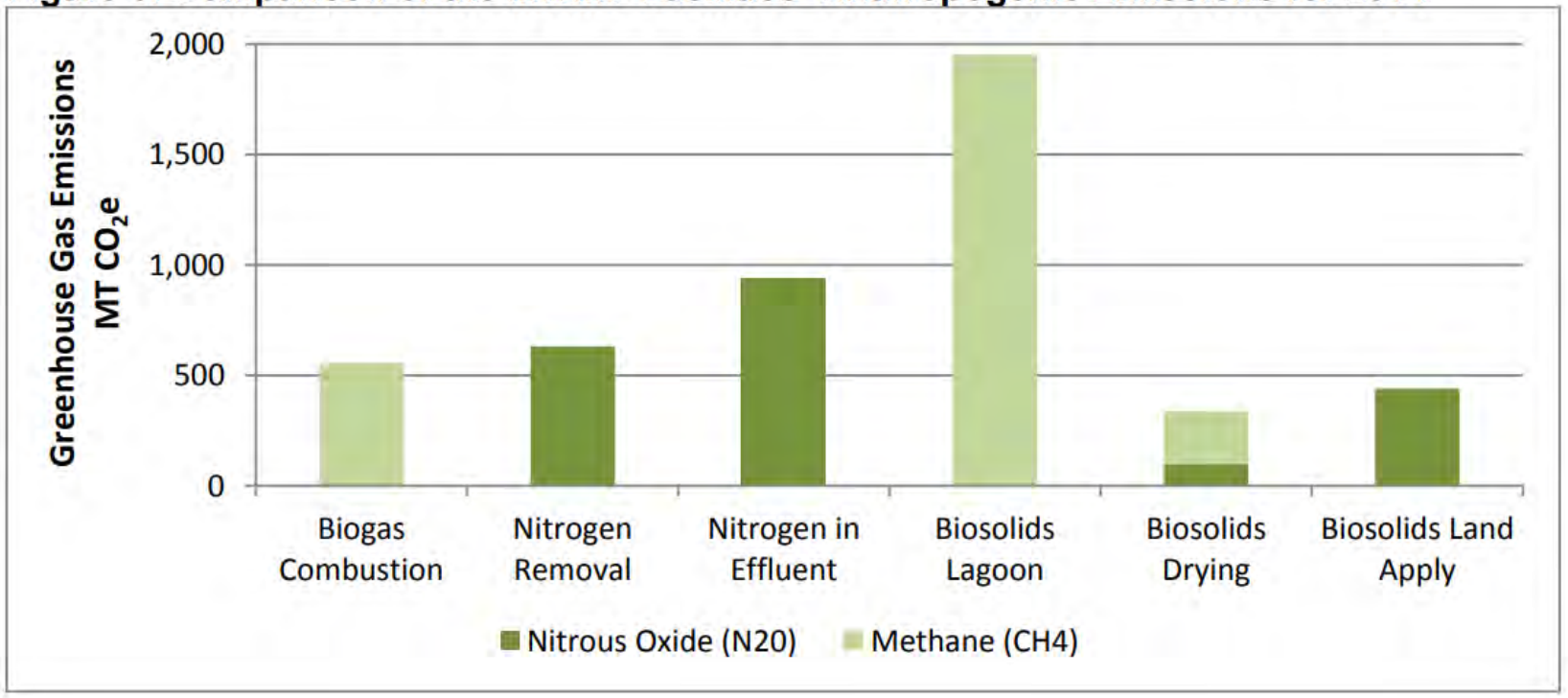
Figure 2. Comparison of annual emissions for five different scenarios of biosolids management for the city of Saguenay.



Saguenay, Villaneuve & Dessurealt; 2011: https://www.environnement.gouv.qc.ca/matieres/articles/Municipal-biosolids.pdf

Eugene & Springfield, OR: Part of modeling full plant inventory

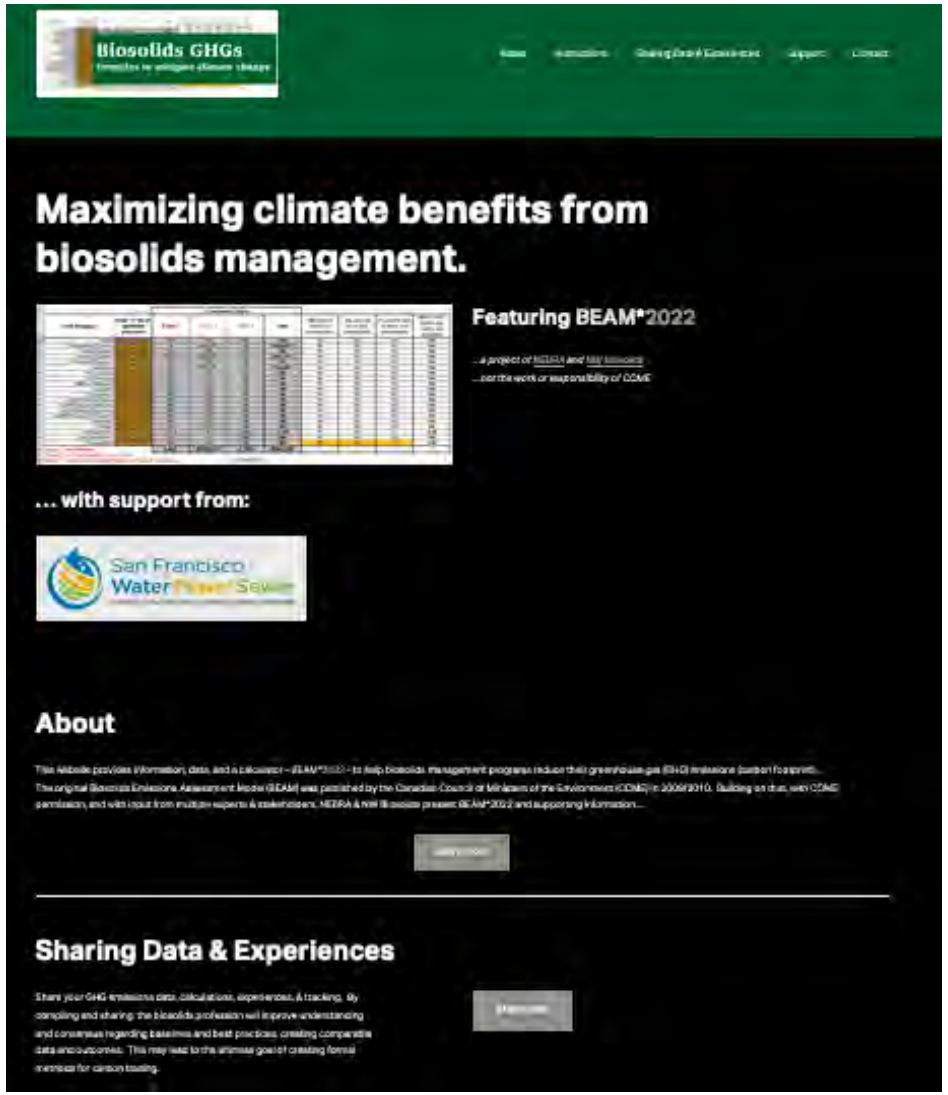
Figure 6: Comparison of the MWMC Facilities' Anthropogenic Emissions for 2014



Eugene & Springfield, OR: https://www.eugene-or.gov/DocumentCenter/View/30521/2015-MWMC-GHG-Inventory?bidId

Download & engage via website

- biosolidsghgs.org
- Space for sharing:
  - results
  - tips
  - uses of data
- Spreadsheet and supporting documents available for download
- Sliding scale recommended donation to support annual reviews, website hosting



Additional Resource Links

- How are WRRFs inventorying greenhouse gas emissions? By: Christine Polo, Tracy Chouinard, Sarah Deslauriers, Bill Brower and Manon Fisher
- Greenhouse Gas Sources and Sinks for Water Resource Recovery Facilities By: Bill Brower, Mark Lang, John Willis

Want to get involved?

- WEF RBC Greenhouse Gas Focus Group
  - Contact Maile Lono-Batura MLono-batura@wef.org
- NEBRA Carbon Trading Committee
  - Contact Janine Burke-Wells janine@nebiosolids.org
- IWA Climate Smart utilities Community of Practice
  - More info: https://climatesmartwater.org/ (must be IWA member)

Thank you.

Questions?

Brown AND Caldwell