The Biosolids Emissions Assessment Model (BEAM) was developed by the Canadian Council of Ministers of the Environment (CCME) for use primarily by Canadian biosolids generators.

The model was developed to allow operators, engineers and managers the ability to assess potential greenhouse gas (GHG) emissions from a range of biosolids management scenarios. The model can be used to:

- estimate a programs' GHG emissions, including establishing a baseline;
- compare emissions from different biosolids management scenarios within a program;
- estimate the impacts on GHG emissions resulting from changes in a biosolids management
- understand the factors that have the greatest impact on increasing or reducing GHG emissions.

These types of assessments are especially important for agencies seeking to become "carbon neutral" or better, and for determining the potential financial implications (e.g., costs, carbon credits) of changes to biosolids management strategies based on GHG implications. For information about how to use the tool, please refer to *Biosolids Emissions Assessment Model: User Guide, CCME 2009.*

Acknowledgement

This document is based on work done by SYLVIS Environmental under contract to CCME, as revised by the Biosolids Task Group.

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Version 1.1

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Summary of Wastewater Treatment Inputs and CO_2 Equivalent Totals

Jurisdiction:	CRD
Wastewater Treatment Plant:	Core Area
Date of calculation:	18/07/2018
Calculations by:	Joshua Frederick

updated 5/16/2019 by SYLVIS

WWT & Solids Characteristics

Treatment and Solids Characteristics	Inputs
Amount of Wastewater Treated (million liters/day or MLD)	108.00
Amount of Wastewater Treated (m^3/day)	108,000
Population served by Wastewater Treatment Plant	380,000
Influent BOD_5 (mg/L)	260
Location (by province)	BC
Weighted GHG Emissions for Power Generation by Province (g/kWh)	11

Key	
Input	0
Default from reference values	0
Data used to calculate default (FYI only)	0
Process output	0

CO_2eq Totals (Mg/year)

Unit Process	Enter "x" for all applicable processes:	Scope 1	Scope 2	Scope 1 & 2	Scope 3	Biomass combustion*	Total
Storage	x	0	16	16	0	NA	**16**
Conditioning/Thickening	x	0	1	1	738	-	**740**
Aerobic Digestion		NA	NA	NA	NA	NA	**NA**
Anaerobic Digestion	x	26	27	53	0	3,202	**53**
Dewatering	x	0	7	7	927	-	**934**
Thermal Drying	x	103	25	128	0	-	**128**
Alkaline Stabilization		NA	NA	NA	NA	NA	**NA**
Composting		NA	NA	NA	NA	NA	**NA**
Landfill Disposal		NA	NA	NA	NA	NA	**NA**
Combustion	x	-6,242	15	-6,227	-8	9,386	**-6,236**
Land Application		NA	NA	NA	NA	NA	**NA**
Transportation 1	x	122	122	NA	122	NA	**122**
TOTALS		**-5,991**	**212**	**-6,022**	**1,779**	**12,589**	**-4,243**

Scope 1 - direct emissions
Scope 2 - purchased electricity, heat, or steam
Scope 3 - production of purchased materials and uses of end products

Instructions and Notes

General: Enter data for the wastewater treatment process, as well as the province in which your program's electricity consumption occurs. Complete only those pages of the BEAM that apply to unit processes marked with "x" above. Greenhouse gas emissions, including totals and scope subtotals, for the entire biosolids management program are summarized above. For all calculator sheets enter data starting at the top of each sheet. Use actual data and enter into the green cells whenever possible.

* Biomass combustion emissions are not included in total CO_2 equivalents. See User's Guide for more information.

Storage Prior to Processing

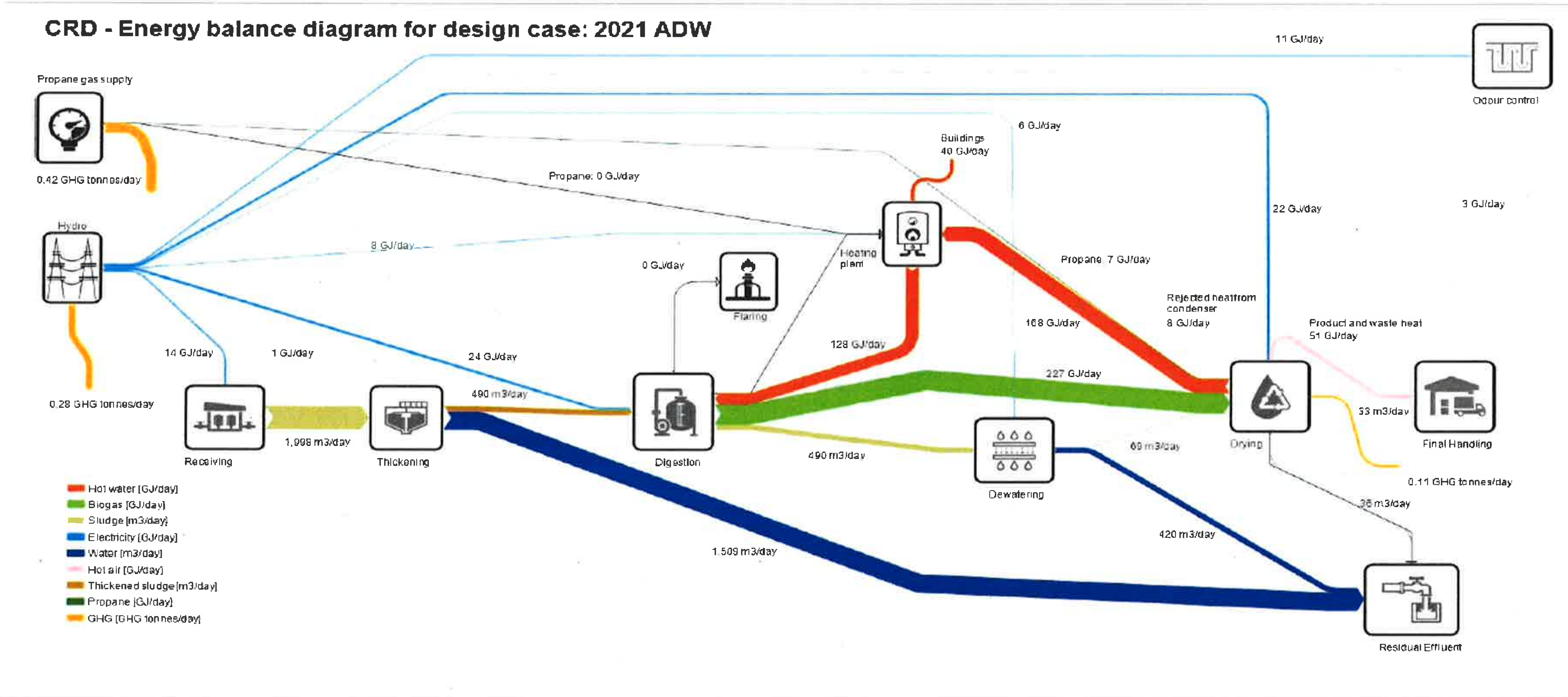
Unit Processes & Inputs	Inputs & Daily Emissions	Default Input (Optional)
Storage Input		
Volume of sludge to unit process (m^3/day)	2,000	
Mass of BOD_5 to storage (kg/day)	17,958	25,272
Process Options		
Is the storage lagoon or tank aerated with aerators?	yes	no
Is the depth of the lagoon **less than** 2 meters (on average)?	no	no
Electricity Use		
Electricity use (kWh / day)	3,889	269
CO_2 emissions from electricity used (Mg/day)	**0.043**	
Methane Emissions		
CO_2 emissions equivalents from released CH_4 (Mg/day)	**0.00**	

CO_2 equivalents (Mg/year)	**16**
Scope 1	**0**
Scope 2	**16**
Scope 1 & 2	**16**
Scope 3	**0**
Biomass combustion	**-**

Instructions and Notes

General: Enter data for any form of long-term solids storage, in lagoons or in tanks from which air or gas escapes to the atmosphere.

Key	
Input	0
Default from reference values	0
Process output	**0**


CRD - Energy balance diagram for design case: 2021 ADW
Propane gas supply
0.42 GHG tonnes/day
Hydro
0.28 GHG tonnes/day
11 GJ/day
Odour control
6 GJ/day
Buildings
40 GJ/day
Propane: 0 GJ/day
22 GJ/day
3 GJ/day
8 GJ/day
0 GJ/day
Heating plant
Flaring
Propane: 7 GJ/day
Rejected heat from condenser
8 GJ/day
168 GJ/day
Product and waste heat
51 GJ/day
14 GJ/day
1 GJ/day
24 GJ/day
128 GJ/day
227 GJ/day
490 m3/day
53 m3/day
1,998 m3/day
Receiving
Thickening
Digestion
490 m3/day
Dewatering
69 m3/day
Drying
Final Handling
0.11 GHG tonnes/day
36 m3/day
420 m3/day
1,509 m3/day
Residual Effluent
Hot water [GJ/day]
Biogas [GJ/day]
Sludge [m3/day]
Electricity [GJ/day]
Water [m3/day]
Hot air [GJ/day]
Thickened sludge [m3/day]
Propane [GJ/day]
GHG [GHG tonnes/day]

Conditioning/Thickening

Unit Processes & Inputs	Inputs & Daily Emissions	Default Input (Optional)
Conditioning / Thickening Input		
Amount of sludge to be thickened (m^3/day)	2,000	
Solids content of sludge (%)	1.499%	1.0%
Quantity (Mg/day-dry)	29.97	
Type of thickener	other	other
Polymer use (kg/day)	225	150
CO_2 equivalents in polymer used (Mg/day)	**2.0**	
Electricity Use		
Electricity Use (kWh/day)	278	147
CO_2 Emissions from electricity used (Mg/day)	**0.003**	

CO_2 equivalents (Mg/year)	**740**
Scope 1	**0**
Scope 2	**1**
Scopes 1 & 2	**1**
Scope 3	**738**
Biomass combustion	**-**

Instructions and Notes

General: Enter data for wastewater solids thickening, and conditioning for thickening (using polymers; ignore other conditioners such as ferric chloride or alum). Do not use this page for dewatering (separate sheet).

Key	
Input	0
Default from reference values	0
Process output	**0**

Anaerobic Digestion

Unit Processes & Inputs	Inputs & Daily Emissions	Default Input (Optional)
Digester Input		
Sludge quantity fed to digestors (m^3/day)	490	
Average sludge volume in digestors any given day (m^3)	14,000	7,350
VS (%- wet weight)	4.78%	
VS (kg/day) - dry wt.	23,446	
Digester Output		
Sludge quantity (m^3/day)	490	
VS (%- wet weight)	2.632%	
VS (kg/day) - dry wt.	12,895	
VS destroyed (kg/day) - dry wt.	10,551	
% VS destruction	45%	
Energy Balance		
Biogas Yield (m^3/day)	9,848	9,496
Methane Yield (m^3/day)	6,401	6,401
% Biogas Used for Heat	100%	65%
% Biogas Used to Generate Electricity	0%	0%
% Biogas Flared	0%	35%
% Biogas Fugitive Emissions	0%	
Natural gas for heating avoided (m^3/day)		6,325
Electricity generated (kWh/day)		0
Heating requirements of the digestors (m^3-natural gas/day)		2,264
Electricity requirements of the digestors (kWh/day)		2,184
Net natural Gas used (m^3/day)	0	-4,061
Net electricity used (kWh/day)	6,667	2,184
CO_2 emissions from natural gas (net) used (Mg/day)	**0.00**	
CO_2 Emissions from electricity (net) purchased (Mg/day)	**0.07**	
CO_2 eq emissions from fugitive methane during combustion (Mg/day)	**0.07**	**0.26**
CO_2 emissions from biomass (biogas) combustion (Mg/day)	**8.77**	

CO_2 equivalents (Mg/year)	**53**
Scope 1	**26**
Scope 2	**27**
Scopes 1 & 2	**53**
Scope 3	**0**
Biomass combustion*	**3,202**

Instructions and Notes

General: Enter combined data from all anaerobic digesters. Be sure to enter in the green cells actual data from measurements at a facility, if available. Use defaults if necessary, especially when previous data inputs have resulted in a calculated default value.

*Biomass combustion emissions are not included in total CO_2 equivalents.

Key	
Input	0
Default from reference values	0
Data used to calculate default (for information only)	0
Process output	**0**

De-watering

Unit Processes & Inputs	Inputs & Daily Emissions	Default Input (Optional)
De-watering Input		
Amount of sludge to be de-watered (m^3/day)	490	
Solids content of sludge (%)	3.84%	4.0%
Quantity (Mg/day-dry)	18.8	
Type of de-watering equipment	centrifuge	other
Polymer use (kg/day)	282	94
CO_2 equivalents in polymers used (Mg/day)	**2.5**	
Electricity Use		
Energy use (kWh/day)	1,667	1,909
Return centrate pumping energy use (kWh/day)		
Total energy use (kWh/day)	1,667	
CO_2 emissions from electricity used (Mg/day)	**0.019**	

CO_2 equivalents (Mg/year)	**934**
Scope 1	**0**
Scope 2	**7**
Scopes 1 & 2	**7**
Scope 3	**927**
Biomass combustion	**-**

Instructions and Notes

General: Enter combined data for all like dewatering units. If a passive drying system with no polymers is used (e.g. drying beds), either estimate the energy use (in kWh equivalents/day) or assume zero emissions.

Key	
Input	0
Default from reference values	0
Process output	**0**

Thermal Drying

Unit Processes & Inputs	Inputs & Daily Emissions	Default Input (Optional)
Thermal Drying Input		
Quantity (Mg/day-wet)	79.0	
Solids content going in to dryer (%)	23.3%	
Solids content coming out of dryer (%)	94.0%	
Quantity (Mg/day-dry)	18.4	
Energy Balance		
Energy requirements of the drying-evaporating water (BtU/day)		238,060,826
Fuel Use		
Natural gas use (m^3/day)	183	6,565
CO_2 emissions from natural gas used (Mg/day)	**0.283**	
Electricity Use		
Electricity requirements of dryer (kWh/day)	6,111	3,947
CO_2 emissions from electricity used (Mg/yr)	**0.07**	

CO_2 equivalents (Mg/year)	**128**
Scope 1	**103**
Scope 2	**25**
Scopes 1 & 2	**128**
Scope 3	**0**
Biomass combustion	**-**

Instructions and Notes

General: Enter data for thermal drying processes (e.g. rotary drum dryers), whether indirectly or directly heated. Enter actual natural gas and electricity use per day, if available.

Key	
Input	0
Default from reference values	0
Data used to calculate default (for information only)	0
Process output	**0**

Biosolids Transportation - Truck and BC Ferry emissions

Unit Processes & Inputs	Enter total diesel fuel (L/yr) use for all solids transportation	OR...enter total distance (km/yr) for all solids transportation	OR...enter requested data for each destination										
Transportation input			**Destination 1**	**Destination 2**	**Destination 3**	**Destination 4**	**Destination 5**	**Destination 6**	**Destination 7**	**Destination 8**	**Destination 9**	**Destination 10**	**Total**
Sludge/biosolids to this destination (Mg-wet/yr)	NA	NA	7,097.7										
Average biosolids weight per load (Mg-wet)	NA	NA	21										
Vehicle efficiency km/L	NA	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	
Round trip distance (km) one-way if backhaul used	NA	0											
Fuel usage (L/yr)		0	46176	0	0	0	0	0	0	0	0	0	**46,176**
Percent of fuel usage that is biodiesel (%)	0%	0%	5%										
Subtotal - CO_2 equivalents (Mg/yr')	**0.0**	**0.0**	**121.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**122**

CO_2 equivalents (Mg/year)	**121.6**
Scope 1	**121.6**
Scope 2	**NA**
Scopes 1 & 2	**121.6**
Scope 3	**NA**
Biomass combustion	**6.4**

2.1	default average truck mileage (km/L, heavy-duty diesel)
2.1	truck mileage (km/L, heavy-duty diesel)

Key	
Input	0
Default from reference values	0
Process output	**0**

Instructions and Notes

General: Include all transportation of wastewater solids and biosolids, including within the wastewater treatment plant, to processing and storage facilities, and to final end use and disposal sites. Do not include diesel fuel used for applying biosolids to land or managing it in a landfill. If biodiesel or other non-fossil fuel is used, enter the percentage used in the appropriate row.

Combustion (incineration, thermal oxidation)

Unit Processes & Inputs	Inputs & Daily Emissions	Default Input (Optional)
Solids Input (to incinerator)		
Quantity (Mg/day-wet)	19.4	
Solids content (%)	94.0%	
Quantity (Mg/day-dry)	18.3	
Is sludge digested prior to incineration?	yes	no
Total nitrogen (%-dry weight)	3.0%	5.0%
Total phosphorus (%-dry weight)	1.9%	1.9%
TVS(%-dry weight)	68.5%	51.0%
Type of incinerator	Fluidized Bed	Fluidized Bed
Recovered energy to electricity (%)	0%	
Recovered energy as heat (%)	100%	
Disposition of ash - Is it used to replace phosphorus fertilizer or in cement or brick?	cement	none
Is a urea-based selective noncatalytic reduction emissions system being used?	no	no
Average high (freeboard) temperature of combustion (^oC)	850	850
Energy Balance		
Energy requirements of the incinerator-evaporating water (BtU/day)		4,976,372
Energy potential of sludge (Btu/day)		261,609,719
Fuel Use - (Coal Replacement)		
Coal needed to evaporate water in sludge (kg/day)		199
Avoided coal use from recovered energy (kg/day)		10,483
Net coal used (kg/day)	-10,283	-10,283
CO_2 emissions from coal used (Mg/day)	**-21.29**	
Electricity Use		
Electricity requirements of incinerator (kWh/day)		3,656
Net Electricity used (kWh/day)	3,656	3,656
CO_2 emissions from electricity used (Mg/day)	**0.04**	
Electricity Generation		
Electricity generated (kWh/day)	0	0
CO_2 emissions from electricity generated (Mg/day) - provincial GHG factor	**0.00**	
CO_2 from electricity generated (Mg/day) - natural gas combustion factor	**0.00**	
Methane emissions		
CO_2 emissions equivalents from released methane (Mg/day)	**0.02**	
Methane emissions avoidance from coal replacement (Mg/day)		
Nitrous Oxide Emissions		
N_2O emitted during incineration (Mg/day)	0.035	0.035
N_2O emission adjustment for SNCR based on urea (Mg/day)	0.000	
N_2O emission adjustment for moisture content of sludge (Mg/day)	-0.021	
N_2O emissions avoidance from coall replacement (Mg/day)		
CO_2 emissions equivalents from released N_2O (Mg/day)	**4.17**	
Cement Replacement Value		
CO_2 replacement value from cement manufacture (Mg CO_2/day)	**-0.02**	
Fertilizer Off-set Credits		
From phosphorus applied to soil (Mg CO_2/day)	**0.00**	
Biomass Combustion		
CO_2 Emissions equivalents from burning sludge (Mg/day)	**25.72**	

CO_2 equivalents (Mg/year)	**-6,236**
Scope 1	**-6,242**
Scope 2	**15**
Scopes 1 & 2	**-6,227**
Scope 3	**-8**
Biomass combustion*	**9,386**

Instructions and Notes

General: Enter combined data for all operating incinerators. The data input with the most impact is the average high (freeboard) temperature of combustion. Electricity and natural gas used should include energy to operate the incinerator and to operate any pollution control systems associated with the incinerator. Also important is whether or not a urea-based selective non-catalytic reduction air emissions control system is used.

*Biomass combustion emissions are not included in total CO_2 equivalents.

Key	
Input	0
Default from reference values	0
Data used to calculate default (for information only)	0
Process output	**0**

Assumptions and Calculations

(orange)	number used in BEAM calculations
(yellow)	numbers found in literature, but not used in BEAM calculations

Fuel

CO_2E diesel (g/L)	2772	Canadian default CO_2 emissions factors for transport fuels - Climate Registry General Reporting Protocol V. 1.1
Average truck miles/gal (diesel)	5	King County (Washington State, USA)
Average truck km/l (diesel)	2.1	calculated from numbers above

Propane

CO_2E from combustion of propane (g/m^3)	1548	BCBPMQGHG	p12

Natural Gas

CO_2E from combustion of natural gas(g/m^3)	1937	BCBPMQGHG	p12
Heat content (Btu/m^3)	36263	Canadian default CO_2 emissions factors for combustion of natural gas - Climate Registry General Reporting Protocol V. 1.1	

Methane

molecular weight of methane (g/mol)	16.043		
density of methane gas at 35 C^o (L/mol)	25.29		
density of methane gas (kg / m3) - at 35^{o}C	0.634	calculated from numbers above	
density of methane gas (kg / m3) - at standard temp. and pressure	0.707	EPA 2006, Solid Waste Management and GHG Emissions	
Heat content of methane (Btu/m^3)	35830	EPA 2004, Unit Conversions, Emissons Factors, and Other Reference Data	
Biogas CO2 emission factor from combustion of methane portion (kg CO2/m^3)	0.0112665	BCBPMQGHG	p11
Biogas CO2 emission factor from combustion of methane portion (kg CO2/m^3)	0.9267	The Climate Registry Local Govt Ops Protocol, 2008, p. 174 - and converted from ft3 to m3	
Percentage of methane emitted directly to the atmosphere when biogas is burned or flared - normal efficient combustion	0.3%	Smith et al, 2000; Foley & Lant, 2007	
Percentage of methane emitted directly to the atmosphere when biogas is burned or flared - inefficient process	1%	U. S. EPA, 2007, Inventory of Greehouse Gas Emissions and Sinks p. 8-8	

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)

	other	*digested*	*limed*	
Total nitrogen (%-dry weight)	4.0%	5.0%	3.2%	
Total phosphorus (%-dry weight)	1.5%	1.9%	1.2%	WWTP plant data
TVS(%-dry weight)	70.0%	51.0%	56.0%	

Undigeste	Digested	Limed
1.5	1.9	1.2
70	51	56

Storage and Lagoons

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 using 0.2 for MCF
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 using maximum MCF (0.67), per NACWA recommendation, 2008 (replaces 0.8 in Canada inventory and 2006 IPCC Guidelines for National Greenhouse Gas Inventories)
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/L)+5

De-watering and Thickening

Thickening electricity use - gravity, gravity belt and drum (kWh/Mg-sludge dry)	4.9	Mark Gould, CDM personal communication - average of gravity, gravity belt and drum thickening on blended sludge electricity use calculations
Thickening electricity use - centrifuge (kWh/Mg-sludge dry)	101.4	Mark Gould, CDM personal communication
De-watering electricity use - belt filter press and rotary (kWh/Mg-sludge dry)	11.3	Mark Gould, CMD personal communication - average of belt filter press and rotary de-watering on blended sludge electricity use calculations
De-watering electricity use - centrifuge (kWh/Mg-sludge dry)	101.4	Mark Gould, CDM personal communication - using the thickening value for centrifuge electricity use
Polymer use for belt thickening of WAS (kg/Mg of dry solids treated)	5	Metcalf & Eddy, 2003, p. 1498 (average of 3-7)
Polymer use for de-watering (kg/Mg of dry solids treated)	5	Metcalf & Eddy, 2003, p. 1556 (range is 1 - 10 for primary, WAS, belt filter press, centrifuge)
CO2 equivalents of Polymer manufacture (Mg CO2eq/Mg polymer)	9.0	Carnegie Mellon Green Design Inst. (http://www.eiolca.net/accessed March 2010)
Density of de-watered sludge (kg/m^3)	950	Sylvis experience for Canada (1000 is alternate default value using density of water at 5^{o}C)

Aerobic Digestion

Typical design electricity use for aerobic digester systems (kW/m3 of digester volume)	0.03	Metcalf & Eddy, 2003, p. 1536
Typical design electricity use for aerobic digester systems (kW/m3 of digester volume) - high end	0.15	Metcalf & Eddy, 2003, p. 1536
Default sludge retention time (SRT) for aerobic digestors (days)	15	Metcalf & Eddy, 2003, p. 1537 - average of range typically used for design

Anaerobic Digestion

Methane in anaerobic digester gas (% by volume)	65%	Monteith et al. 2005 in Water Env. Research (77(4): 309-403) as referenced in Energy Consumption Implications for Wastewater Treatment in Canada - Hydromantis 2006. Also U.S. EPA, 2007, p. 8-8.
Digester gas consumed (% by volume)	65%	Monteith et al. 2005 in Water Env. Research (77(4): 309-403) as referenced in Energy Consumption Implications for Wastewater Treatment in Canada - Hydromantis 2006.
Digester gas flared (% by volume)	35%	Monteith et al. 2005 in Water Env. Research (77(4): 309-403) as referenced in Energy Consumption Implications for Wastewater Treatment in Canada - Hydromantis 2006.
Biogas yield (m^3/kg-VS destroyed)	0.9	Design of Municipal Wastewater Treatment Plants, WEF Manual of Practice No. 8, 4th Edition, 1998 - this is the average of the range that they reference of 0.8 - 1.0
Heating requirements for digestor (m^3 natural gas/m^3 sludge to digestor)	4.62	Metcalf & Eddy, 2003, example p. 1527 for heat required, assuming natural gas provides 36.5 MJ/m3 and the heat exchange from natural gas to sludge is 80% efficient.
Typical design electricity use for anaerobic digester mixing systems (kW/m3 of digester volume)	0.0065	Metcalf & Eddy, 2003, p. 1519
Default sludge retention time (SRT) for anaerobic digestors (days)	15	Metcalf & Eddy, 2003, p. 1510 - states that insignificant further VS destruction is expected after 15 days at 35^{o}C
Btu per kWh conversion (kWh/Btu)	0.00009	EPA Landfill Methane Outreach Program Benefits calculator www.epa.gov/lmop/
Net capacity factor to be applied to conversion of methane to electrictiy	85%	EPA 2006, Solid Waste Management and GHG Emissions

Thermal Drying

Electricity Use (kWh/Mg-dry)	214	From Windsor, Canada data

Alkaline Stabilization

Emissions associated with lime production (Mg CO_2E/Mg lime)	0.9	Carnegie Mellon Green Design Inst. (http://www.eiolca.net/accessed March 2010)
Amount of lime added to sludge for Class B stabilization (Mg lime/Mg sludge-dry wt.)	0.2	estimate based on experience with Blue Plains WWTP, District of Columbia
Amount of lime added to sludge for Class A stabilization (Mg lime/Mg sludge-dry wt.)	0.3	data from Halifax, Nova Scotia N-Viro process
Electricity use for Class B stabilization (kWh/Mg-**wet**)	4.9	Mark Gould, CDM personal communication
Electricity use for Class A stabilization (kWh/Mg-**wet**)	218.2	Mark Gould, CDM personal communication

Composting

Set up and Break Down piles

Fuel -windrow (L/Mg feedstock- wet)	5	Recycled Organics Unit (2006) as referenced in Brown et al, JEQ 2008
Fuel -Aerated Static Piles (ASP) (L/Mg feedstock- wet)	2.5	Brown et al, JEQ 2008
Fuel -for grinding (L/Mg feedstock- wet)	3.3	Brown et al, JEQ 2008

Emissions During Composting

CH_4 emissions from composting - uncovered (% of initial C content)	2.5%	Brown et al, JEQ 2008
CH_4 emissions from composting - covered or biofilter (% of initial C content)	0.0%	Brown et al, JEQ 2008
N_2O emissions from composting with low C:N (% of initial N content)	1.5%	Brown et al, JEQ 2008
N_2O emissions from composting (% of initial N content)	1.3%	Czepiel, 1996
N_2O emissions from composting (% of initial N content)	4.6%	Fukumoto, 2003
N_2O emissions from composting high C:N (% of initial N content)	0.0%	Brown et al, JEQ 2008
Solids content above which no CH_4 or N_2O is generated during composting	55%	BEAM default
Cut-off between low and high C:N	30	BEAM default

Electricity Requirements for Composting

Complete in-vessel electricity use (kWh / dry Mg sludge)	291	Beecher, 2008, based on Merrimack electricity bill for full composting building, including aeration, turning, office space lighting, and biofilter
Complete in-vessel electricity use (kWh / Mg waste composted)	40	Wannholt, 1998 cited by Smith et al. 2001
Aeration electricity use ASP (kWh/dry Mg sludge in compost blend)	180	90 is the value in Brown et al, JEQ 2008 - the reference within the study is Steve Diddy personal communication - and this 180 is assuming that, on a dry weight basis, biosolids and wood feedstocks will be mixed 1 to 1

Compost Feedstocks Typical Characteristics	***Sawdust***	Sawdust density, solids and nitrogen data from On-Farm Composting Handbook 1992 average values, TVS from Bill Seekins data (ME Dept. Ag)
Density (kg/m^3)	250	
Solids content (%)	61.0%	Sawdust density, solids and nitrogen data from On-Farm Composting
Total nitrogen (%-dry weight)	0.2%	Handbook 1992 average values, TVS from Bill Seekins data (ME Dept. Ag)
TVS(%-dry weight)	92.5%	
Organic carbon(%-dry weight)	51.8%	

Carbon Sequestration

From biosolids/compost applications (Mg CO_2/dry Mg-biosolids)	0.25	BEAM default
From biosolids applications - annual loading (Mg CO_2/dry Mg-biosolids)	0.23	Tian et al. 2009
From biosolids applications - annual loading (Mg CO_2/dry Mg-biosolids)	1.6	Kurtz, M.S. thesis 2010
From biosolids applications - reclamation (Mg CO_2/dry Mg-biosolids)	0.3	Kurtz M.S. thesis 2010
From biosolids applications - reclamation (Mg CO_2/dry Mg-biosolids)	1.74	Kurtz M.S. thesis 2010
From biosolids applications - reclamation (Mg CO_2/dry Mg-biosolids)	0.11	Trlica, M.S. thesis 2010
From biosolids applications - reclamation (Mg CO_2/dry Mg-biosolids)	1.3	Trlica, M.S. thesis 2010
From biosolids applications - reclamation (Mg CO_2/dry Mg-biosolids)	0.85	Trlica, M.S. thesis 2010
From biosolids applications - reclamation (Mg CO_2/dry Mg-biosolids)	1.15	Trlica, M.S. thesis 2010

Fertilizer Off-set Credits

Credit for Nitrogen (kg CO_2/kg N)	4	Recycled Organics Unit, 2006
Credit for Nitrogen (kg CO_2/kg N)	3.6	Murray et al. 2008
Credit for Nitrogen (kg CO_2/kg N)	3.1 - 4.7	Kim and Dale, 2008
Credit for Nitrogen (kg CO_2/kg N)	1.3	IPCC, 2006
Credit for Nitrogen (kg CO_2/kg N)	4.5	Schlesinger, 1999
Credit for Phosphorus (kg CO_2/kg P)	2	Recycled Organics Unit, 2006 - as per SLB, we will not go into nutrient availability indices; a kg of N or P is simply a kg of N or P
Credit for Phosphorus (kg CO_2/kg P)	3	Brown and Leonard, 2004
Credit for Phosphorus (kg CO_2/kg P)	4.86	Murray et al. 2008

Landfill Disposal

Landfill gas recovery, average U. S.	75.0%	U. S. EPA, The Climate Registry Local Govt Protocol, 2008
Landfill gas recovery	45.0%	IPCC default (avg. of default range of 40-50%)
Landfill gas recovery, most efficient reported	99.2%	Spokas, et al. 2006 - clay cover with gas recovery system
Using same N_2O emissions from composting- <30:1 C:N (% of initial N content) for landfilling (1.5%)		Brown et al, JEQ 2008
f - model correction factor to account for uncertainties	90%	CDM - Tool to determine methane emissions avoided from dumping waste as a solid waste disposal site (version 2).
OX - oxidation factor based on amount of methane oxidized by soil cover - if high quality soil or compost cover	25%	BEAM default
OX - oxidation factor based on amount of methane oxidized by soil cover - if low quality soil cover	10%	CDM - Tool to determine methane emissions avoided from dumping waste as a solid waste disposal site (version 2).
OX - oxidation factor based on amount of methane oxidized by soil cover - no soil or compost used	0%	CDM - Tool to determine methane emissions avoided from dumping waste as a solid waste disposal site (version 2).
F - fraction of methane in landfill gas	50%	CDM - Tool to determine methane emissions avoided from dumping waste as a solid waste disposal site (version 2).
DOC_f - fraction of degradable organic carbon that can decompose	50%	CDM - Tool to determine methane emissions avoided from dumping waste as a solid waste disposal site (version 2).
DOC_f - fraction of degradable organic carbon that can decompose - undigested/uncomposted solids	80%	Brown, et al., 2008; Metcalf & Eddy, 2003, p. 1514 - equation calculated out to 100 days
MCF - methane correction factor - anaerobic managed landfills	1	CDM - Tool to determine methane emissions avoided from dumping waste as a solid waste disposal site (version 2).
MCF - methane correction factor - semi-aerobic landfills	0.5	CDM - Tool to determine methane emissions avoided from dumping waste as a solid waste disposal site (version 2).
MCF - methane correction factor - unmanaged landfills with deep and/or with high water tables	0.8	CDM - Tool to determine methane emissions avoided from dumping waste as a solid waste disposal site (version 2).
MCF - methane correction factor - unmanaged landfills - shallow	0.4	CDM - Tool to determine methane emissions avoided from dumping waste as a solid waste disposal site (version 2).
K-decay rate constant for DOC in biosolids - MAT < 20°C and MAP/PET <1 - ***cool dry***	0.06	CDM - Tool to determine methane emissions avoided from dumping waste as a solid waste disposal site (version 2).
Amount of decomposable TDOC decomposed in 3 years using ***cool dry*** decay rate	16.5%	calculated from numbers above
K-decay rate constant for DOC in biosolids - MAT < 20°C and MAP/PET >1 - ***cool wet***	0.185	CDM - Tool to determine methane emissions avoided from dumping waste as a solid waste disposal site (version 2).
Amount of decomposable TDOC decomposed in 3 years using ***cool wet*** decay rate	42.6%	calculated from numbers above
K-decay rate constant for DOC in biosolids - MAT > 20°C and MAP/PET <1 - ***warm dry***	0.085	CDM - Tool to determine methane emissions avoided from dumping waste as a solid waste disposal site (version 2).
Amount of decomposable TDOC decomposed in 3 years using ***warm dry*** decay rate	22.6%	calculated from numbers above
K-decay rate constant for DOC in biosolids - MAT > 20°C and MAP/PET >1 - ***warm wet***	0.4	CDM-based factor for warm-wet climates and SLB-determined decay rate for all landfills based on findings indicating that landfills create their own warm-moist micro-climate regardless of the mega-climate in which they reside: for warm-wet the IPCC decay rate (as referenced in the Australian WSAA lit review is 0.35)
Amount of decomposable TDOC decomposed in 3 years using ***warm wet*** decay rate	69.9%	calculated from numbers above

MAT = mean annual temperature
MAP = mean annual precipitation
PET = potential evapotranspiration

Combustion

Methane emissions		
Methane emissions from incineration (Mg CH4 / dry Mg solids burned, assuming 20% solids)	0.0000485	IPCC, 2006, as cited in Foley & Lant, WSAA, p. 46.
N_2O Emissions		
Increase in N2O default emissions SNCR using urea catalyst	20%	BEAM default
% decrease in N2O emissions for semi-dry solids content (24-87%)	50%	BEAM default based on Suzuki et al. 2003
% decrease in N2O emissions for dry solids content (>87%)	60%	BEAM default based on Suzuki et al. 2003
% conversion N to N2O during combustion = 161.3 - 0.140*T_f where T_f = max. freeboard temp. in °K		Suzuki et al. 2003
constant 1 for above equation	161.3	Suzuki et al. 2003
constant 2 for above equation	0.14	Suzuki et al. 2003
Lowest combustion temperature to be used in Suzuki equation (°C)	750	to ensure that max levels from calculation do not exceed max reported levels in Suzuki et al. 2003
N_2O emissions from combustion (g N_2O/Mg sludge combusted - dry wt.)	990	IPCC 2006 from Chapter 5 - Incineration and Open Burning of Wastes

Energy Recovery Potential from Sludge

MJ/Mg sludge - dry wt. - undigested (assumes a 50/50 blend of primary and secondary)	23000	Metcalf & Eddy, 2003, p. 1588 (average of undigested primary and secondary)
MJ/Mg sludge - dry wt. - digested	12000	Metcalf & Eddy, 2003, p. 1588 (average for anaerobically digested sludge)

Electricity Use

Muliple Hearth Furnace electricity use - (kWh/Mg sludge - dry wt.) - includes pollution control	285	NEORSD data from Bob Dominak personal communication
Fluidized Bed Incinerator electricity use - (kWh/Mg sludge - dry wt.) - includes pollution control	200	NEORSD data from Bob Dominak personal communication - 70% of MHF electricity requirements

Fuel Requirements

Energy required to remove water from sludge (GJ/Mg-water)	4.5	Metcalf & Eddy, 2003, p. 1588
Expected efficiency in converting chemical energy in biosolids to usable energy	80%	BEAM default
Additional fuel required for Multiple Hearth Furnace due to shut downs	20%	BEAM default

Credit for use of ash in cement manufacturing

kg-CO_2E/Mg biosolids (dry wt.)	1.2675	Murray et al. 2008 - Table S20; see calculation, below

Land Application

Emissions During Land Application

N_2O emissions from land application - coarse textured soils (% of initial N content)	0.50%	BEAM default based on an interpretation of the Rochette 2006 paper
N_2O emissions from land application - fine textured soils (% of initial N content)	2.30%	average of 1.3% and 3.3% from Rochette 2006 for incorporated and topdressed, respectively, on fine-textured soils
Minimum solids content of biosolids at which N_2O emissions is reduced on fine textured soils	80%	BEAM default
Reduction in N_2O emissions on fine-textured soils from high solids content in biosolids	50%	BEAM default
CH_4 emissions during storage of biosolids prior to land application (kg/m^3-day)	0.0091	average of uncovered raw and digested, winter and summer for cattle slurry from Clemens et al 2006 normalized to 1 day
NO_2 emissions during storage of biosolids prior to land application (kg/m^3-day)	0.00043	average of uncovered raw and digested, winter and summer for cattle slurry from Clemens et al 2006 normalized to 1 day
CO_2E from $CaCO_3$ added to soil	0.44	assuming all carbon in lime is eventually emitted to the atmosphere as CO_2
CO_2E from $CaCO_3$ added to soil	0.12	IPCC 2006
CO_2E from $CaCO_3$ added to soil	0.0059	West and McBride 2005

Fuel Use During Land Application

Tractor fuel use (l-diesel/hr)	25	http://tractortestlab.unl.edu
Time to apply (loads/hr)	3	estimate
Size of loads (m^3)	13	estimate
Mg CO_2/wet Mg of biosolids applied	0.0046	calculated from numbers above
Mg CO_2/wet Mg of biosolids applied - low	0.0032	Brown, unpublished data
Mg CO_2/wet Mg of biosolids applied - high	0.015	Brown, unpublished data

Conversions

Metric to English				
1	km	=	0.621	miles
1	liter	=	0.264	gallons
1	MJ	=	947.82	Btu
1	GJ	=	947,817	Btu
	°K	=	273.15	+ °C

MW Carbon	12	
MW Oxygen	16	
C --> CO_2 conversion	3.667	
MW Hydrogen	1	
C --> CH_4 conversion	1.3	
CO_2E of CH_4	21	The Climate Registry General Reporting Protocol; use it instead of the updated values in UKWIR, 2005 Workbook for quantifying greenhouse gas emissions. UK Water Industry Research Ltd. Report Ref # 05/CL01/3, which is an IPCC standard according to the Hydromantis, Inc. 2006 report
MW Nitrogen	14	
N --> N_2O conversion	1.57	
CO_2E of N_2O	298	The Climate Registry General Reporting Protocol; use it instead of the updated values in UKWIR, 2005 Workbook for quantifying greenhouse gas emissions. UK Water Industry Research Ltd. Report Ref # 05/CL01/3, which is an IPCC standard according to the Hydromantis, Inc. 2006 report
MW of Calcium	40	
Fraction Carbon in $CaCO_3$	0.12	
Carbon as a % of TVS	56%	On-Farm Composting Handbook, 1992, NRAES, Ithaca, NY; and based on using sugar to represent organic matter

reference input	

Power Generation

Weighted GHG Emission Factors for Power Generation by Province (g/kWh)

	CO_2	CH_4	N_2O	total CO2eq*	
AB	920	0.02762	0.01723	926	Climate Registry, Canadian Emissions Factors for Grid Electricity by Province from 3/2/09 update
BC	**10.8**	**0.003**	**0.0008**	**11**	Environment and Climate Change Canada. 2018. National Inventory Report 1990–2016: Greenhouse Gas Sources and Sinks in Canada - Part 3. Government of Canada, Ottawa, ON. **UPDATED**
MB	10	0.0004762	0.0002581	10	
NB	350	0.01714	0.00671	352	
NL	10	0	0.0002903	10	
NS	730	0.01476	0.00971	733	Climate Registry, Canadian Emissions Factors for Grid Electricity by Province from 3/2/09 update
ON	180	0.009048	0.003194	181	
PE	150	0.001905	0.003065	151	
QC	10	0.001429	0.0001613	10	
SK	800	0.03619	0.01858	806	
YT, NT, and NU	80	0.00381	0.01139	83	

CALCULATING PERCENT (%) OF YEAR WITH TEMPS ABOVE 15 C BY PROVINCE

Province	January	April	July	October	Apr, May, June hours above 15 C	Jul, Aug, Sept hours above 15 C	Total hrs/yr	Percent of year w/ T > 15 C
Alberta	0%	3%	45%	3%	367	670	1037	12%
British Columbia	0%	0%	22%	0%	158	317	475	5%
Manitoba	0%	3%	55%	3%	439	814	1253	14%
New Brunswick	0%	0%	40%	0%	288	576	864	10%
Newfoundland & Labrador	0%	0%	18%	0%	130	259	389	4%
Nova Scotia	0%	0%	32%	0%	230	461	691	8%
Ontario	0%	3%	60%	3%	475	886	1361	16%
Prince Edward Island	0%	0%	32%	0%	230	461	691	8%
Quebec	0%	0%	50%	0%	360	720	1080	12%
Saskatchewan	0%	0%	50%	0%	360	720	1080	12%
								10%

720

Atlas of Canada, http://atlas.nrcan.gc.ca/site/english/maps/environment/climate/temperature/temp_summer

Calculating ash substitution and GHG (GWE) per Murray et al. 2008

42.25	GWE listed for ash use offset in cement in Table S20
10	tons cement is used in Murray example
0.1	rate of ash substitution in cement (10% of cement material is substituted)
4.225	kg offset/10 tons of cement
0.3	percent ash from sludge that is burned
1.2675	kg offset per dry ton sludge substituted into cement

References not cited

NACWA (National Association of Clean Water Agencies). 2008. Letter to U.S. EPA quoted in California Wastewater Climate Change Report 2008

Hydromantis, Inc. 2006. Energy Consumption Implications for Wastewater Treatment in Canada. Final Report submitted to Environment Canada. March 29, 2006.

On-Farm Composting Handbook. 1992. NRAES-54. The National Regional Agricultural Engineering Service. Edited by Robert Rynk

West, T.O. and A.C. McBride. The contribution of agricultural lime to carbon dioxide emissions in the U.S.: dissolution, transport and net emissions. 2005. ***Ag Ecosys. And Env.*** 108. 145-154

New References for CRD Combustion Assessment

Coal Combustion

Weighted GHG Emission Factors for Power Generation by Province (g/kWh)

	CO_2	CH_4	N_2O	total CO2eq*	
Coal Coke				525	Reference

Coal Calorific Values	***Value***	***Reference***	***Source Jurisdiction***	***Notes***
GJ/tonne - Heat value - anthracite	28	Reference	Canada	p 27
GJ/tonne - Heat value - lignite	15	Reference	Canada	p 27
GJ/tonne - Heat value - subbituminous coal	19	Reference	Canada	p 27
GJ/tonne - Heat value - bituminous coal	26	Reference	Canada	p 27
BTU / kg - anthracite	28462	reference	USA	
BTU / kg - lignite	15212	reference	USA	
BTU / kg - subbituminous coal	19842	reference	USA	
BTU / kg - bituminous coal	26455	reference	USA	
BTU/kg - anthracite	26255	calculated	Canada	
BTU/kg - lignite	14217	calculated	Canada	
BTU/kg - subbituminous coal	18151	calculated	Canada	
BTU/kg - bituminous coal	24956	calculated	Canada	

Coal Emission Values	***Value***	***Reference***	***Source Jurisdiction***	***Notes***
CO_2E from combustion of coal (kg/1,000,000 BTU) - anthracite	103	EIA	USA	US mean, Table FE4
CO_2E from combustion of coal (kg/1,000,000 BTU) - lignite	98	EIA	USA	US mean, Table FE4
CO_2E from combustion of coal (kg/1,000,000 BTU) - subbituminous coal	96	EIA	USA	US mean, Table FE4
CO_2E from combustion of coal (kg/1,000,000 BTU) - bituminous coal	93	EIA	USA	US mean, Table FE4
CO2 Emission Factor (kg/kg) - coal coke	2.48	Reference	Canada	p 29
kg CO2/kg coal - BC - Canadian Bituminous	2.07	Reference	Canada	p 30
kg CO2/kg coal - BC - U.S. Bituminous	2.43	Reference	Canada	p 30
kg CO2/kg coal - BC - Sub-bituminous	1.77	Reference	Canada	p 30
CO2 / kg - anthracite	3.37	reference	USA	
CO2 / kg - lignite	1.10	reference	USA	
CO2 / kg - subbituminous coal	1.47	reference	USA	
CO2 / kg - bituminous coal	2.38	reference	USA	

Energy Recovery Potential from Heat-Dried Biosolids		
MJ/Mg SYNAGRO Granulite heat-dried biosolids	15100	Innotech Alberta - CRD Biosolids Combustion Study 2019

Aerobic Digestion

Unit Processes & Inputs	Inputs & Daily Emissions	Default Input (Optional)
Digester Input		
Sludge quantity (m^3/day)		
Average sludge volume in digesters any given day (m3)		0
VS (%- wet weight)		3.6%
VS (kg/day) - dry wt.	0	
Digester Output		
Sludge quantity (m^3/day)		
VS (%- wet weight)		
VS (kg/day) - dry wt.	0	
VS destroyed (kg/day) - dry wt.	0	
% VS destruction	#DIV/0!	
Energy Balance		
Heating requirements of the digestors, if any (m^3-natural gas/day)	0	0
Electricity requirements of the digestors (kWh/day)		0
CO_2 emissions from natural gas used (Mg/day)	**0.00**	
CO_2 emissions from electricity used (Mg/day)	**0.00**	

CO_2 equivalents (Mg/year)	**0**
Scope 1	**0**
Scope 2	**0**
Scopes 1 & 2	**0**
Scope 3	**0**
Biomass combustion	**-**

Instructions and Notes

General: Enter combined data from all aerobic digesters. If the digesters are heated (not common), enter the amount of natural gas used.

	Key
Input	0
Default from reference values	0
Process output	**0**

Alkaline Stabilization

Unit Processes & Inputs	Inputs & Daily Emissions	Default Input (Optional)
Alkaline Stabilization Input		
Mass of sludge to be stabilized-wet (Mg/day)	100	
Solids content of sludge to be stabilized (%)	25%	
Mass of sludge-dry (Mg/day)	25.0	
Degree of stabilization	Class B	
Is the lime in biosolids derived from a waste product (e.g. cement kiln dust)?	no	no
Amount of alkaline product added (Mg lime or lime equivalent/day)	5.0	5.0
CO_2 emissions equivalents from lime production (Mg/day)	**4.5**	
Fuel Use		
Natural gas use (m^3/day)	0	0
CO_2 emissions from natural gas used (Mg/day)	**0**	
Electricity Use		
Electricity requirements of alkaline stabilization (kWh/day)	487	487
CO_2 emissions from electricity used (Mg/yr)	**0.01**	

CO_2 equivalents (Mg/yr)	**1,644**
Scope 1	**0**
Scope 2	**2**
Scopes 1 & 2	**2**
Scope 3	**1,643**
Biomass combustion	**-**

Instructions and Notes

General: Enter data from alkaline stabilization processes, regardless of whether this happens before or after dewatering. Some advanced alkaline stabilization systems may use supplemental heat from natural gas combustion to achieve Class A; if so, enter amount of natural gas used. If electricity is used for supplemental heat for achieving Class A, this is included in the Class A calculation.

Key	
Input	0
Default from reference values	0
Process output	**0**

Composting

Unit Processes & Inputs	Inputs & Daily Emissions	Default Input (Optional)
Feedstock Input		
Material type	sludge	
Quantity of sludge going to composting (Mg/day-wet)	100	
Solids content (%)	25.0%	
Quantity of sludge going to composting (Mg/day-dry)	25.0	
Sludge density (kg/m^3)	950	950
Volume of sludge going to composting (m^3/day)	105	
Has the sludge been digested prior to composting?	no	no
Total nitrogen (%-dry weight)	4.0%	4.0%
Total phosphorus (%-dry weight)	1.5%	1.5%
Total volatile solids - TVS (%-dry weight)	70.0%	70.0%
Organic carbon (%-dry weight)	39.0%	39%
Will compost use replace commercial fertilizer use where it is applied?	yes	yes
Volumetric ratio of amendment to sludge (m^3 amendment:m^3 sludge, as is)*	3	3
Amendment grinding on-site?	yes	yes
Volume of sludge in compost (%)	25%	
Volume of amendment in compost (%)	75%	
Density of amendment (kg/m^3)**	250	250
Quantity of amendment going to composting (Mg/day-wet)	79	
Blended Feedstock Characteristics		
C:N	31	31
Solids content (%)	41%	41%
Type of composting operation	ASP	
Are active composting piles covered or is the air from them treated through a biofilter?	yes	yes
Fuel Use		
Grinding (L-diesel fuel/day)		261
Setting up and breaking down piles (L-diesel fuel/day)		447
Total fuel use for composting equipment (L-diesel fuel/day)	708	708
Applying compost to land (L-diesel fuel/day)	67	67
CO_2 Emissions from Diesel used (Mg/day)	**2.15**	
Electricity Use		
Electricity requirements of composting system (kWh/day)	4,500	4,500
CO_2 Emissions from Electricity used (Mg/day)	**0.05**	
Methane Emissions		
CH_4 emitted from compost pile (Mg/day)	0.00	
CO_2 Emissions equivalents from released CH_4 (Mg/day)	**0.00**	
Nitrous Oxide Emissions		
N_2O emitted from compost pile (Mg/day)	0.000	
N_2O emitted from applying compost to soils (Mg/day)	0.0079	
CO_2 Emissions equivalents from released N_2O (Mg/day)	**0.00**	
Carbon Sequestration		
From compost applied to soil (Mg CO_2/day)	**-6.25**	
Fertilizer Off-set Credits		
From nitrogen applied to soil (Mg CO_2/day)	**-4.00**	
From phosphorus applied to soil (Mg CO_2/day)	**-0.75**	

CO_2 equivalents (Mg/year)	**-3,213**
Scope 1	**-1,497**
Scope 2	**18**
Scopes 1 & 2	**-1,479**
Scope 3	**-1,734**
Biomass combustion	**-**

Instructions and Notes

General: Enter data for all solids that were composted. Whenever possible use data from local measurements.

*For this row, if entering a local value, enter in both the blue and orange cells.
**Default is for density of sawdust.

Key	
Input	0
Default from reference values	0
Data used to calculate default (for information only)	0
Process output	**0**

Landfill Disposal

Unit Processes & Inputs	Inputs & Daily Emissions	Default Input (Optional)
Sludge Characteristics Input		
Quantity going to landfill (Mg/day-wet)	100	
Density (kg/m^3)	950	950
Solids content (%)	25.0%	
Quantity going to landfill (Mg/day-dry)	25.0	
Has the sludge been digested prior to diisposal?	no	no
Total nitrogen (%-dry weight)	4.0%	4.0%
TVS (%-dry weight)	70.0%	70.0%
Organic carbon (%-dry weight)	39.0%	39%
Organic carbon (Mg/day-dry weight)	9.8	
Methane correction factor for landfill (DOC_f that will decompose in landfill)	1	1
Quality of soil cover at landfill (high = good organic matter content, supports vegetation well)	high	high
Oxidation of methane by soil cover - applies three years after placement of wastewater solids in landfill	25%	25%
Methane captured at landfill and flared, combusted or otherwise used - after 3 years	75%	75%
Percent of captured methane used to generate electricity	0%	0%
DOC_f - fraction of degradable organic carbon that can decompose	80%	80%
Amount of decomposable TDOC decomposed in 3 years	69.9%	69.9%
Methane Emissions		
CH_4 released from first three years after landfilling (Mg/day)	3.3	
CH_4 released after three years (Mg/day)	0.26	
Fugitive CH_4 from combusted CH_4 (Mg/day)	0.00	
CO_2 Emissions equivalents from released CH_4 (Mg/day)	**74.3**	
Nitrous Oxide Emissions		
N_2O emitted from landfilled sludge (Mg/day)	0.024	
CO_2 emissions equivalents from released N_2O (Mg/day)	**7.02**	
Carbon Sequestration		
From undecomposed carbon from landfilled sludge (Mg CO_2/day)	**-7.15**	
Electricity Generation Credit		
Electricity generated (kWh/day)	0	
CO_2 emissions avoided from electricity generated (Mg/day)	**0.00**	
CO_2 emissions from biomass (biogas) combustion (Mg/day)	**2.90**	

CO_2 equivalents (Mg/year)	**27,078**
Scope 1	**27,078**
Scope 2	**0**
Scopes 1 & 2	**27,078**
Scope 3	**0**
Biomass combustion*	**1,057**

Instructions and Notes

General: Enter data for all wastewater solids sent to a landfill for disposal.

*Biomass combustion emissions are not included in total CO_2 equivalents.

Key	
Input	0
Default from reference values	0
Process output	**0**

Land Application (of non-composted biosolids)

Unit Processes & Inputs	Inputs & Daily Emissions	Default Input (Optional)
Biosolids characteristics		
Quantity going to land application (Mg/day-wet)	100	
Solids content (%)	25.0%	
Quantity going to land application (Mg/day-dry)	25.0	
Density (kg/m^3)	950	950
Type of biosolids to be land applied	digested	limed
Total nitrogen (%-dry weight)	5.0%	5.0%
Total phosphorus (%-dry weight)	1.9%	1.9%
TVS (%-dry weight)	51.0%	51.0%
Organic carbon (%-dry weight)	28.6%	28.6%
$CaCO_3$ equivalence (%-dry weight)	0.0%	0.0%
Average number of days biosolids is stored prior to land application	25	
Will biosolids replace commercial fertilizer where it is applied?	yes	yes
Is lime in biosolids derived from a waste product (e.g. cement kiln dust)	no	no
Will the lime in biosolids replace purchased lime where it is applied?	yes	yes
Soil Texture at land appplication sites (total)		
Fine-textured (% of land application area)	50%	50%
Coarse-textured (% of land application area)	50%	
Fuel Use		
Applying biosolids to land (L-diesel fuel/day)	67	67
CO_2 emissions from diesel used (Mg/day)	**0.19**	
Methane Emissions		
CH_4 emitted from storage of biosolids prior to land application (Mg/day)	0.0216	
CO_2 Emissions equivalents from released CH_4 (Mg/day)	**0.45**	
Nitrous Oxide Emissions		
N_2O emitted from land application - fine-textured soils (Mg/day)	0.0226	
N_2O emission adjustment for dry biosolids on fine-textured soil (Mg/day)	0.000	
N_2O emitted from land application - coarse-textured soils (Mg/day)	0.0049	
N_2O emitted from storage of biosolids prior to land application (Mg/day)	0.0010	
CO_2 emissions equivalents from released N_2O (Mg/day)	**0.30**	
Carbon Sequestration		
From biosolids applied to soil (Mg CO_2/day)	**-6.25**	
Fertilizer Off-set Credits		
From nitrogen applied to soil (Mg CO_2/day)	**-5.00**	
From phosphorus applied to soil (Mg CO_2/day)	**-0.95**	
Calcium Carbonate Debit		
From $CaCO_3$ applied to soil (Mg CO_2/day)	**0.00**	

CO_2 equivalents (Mg/year)	**-4,108**
Scope 1	**-1,937**
Scope 2	**0**
Scopes 1 & 2	**-1,937**
Scope 3	**-2,172**
Biomass combustion	**-**

Instructions and Notes

On this page, enter data for all biosolids that are applied to land, but have not been composted. This may include alkaline stabilized biosolids (complete the alkaline stabilized page) or other Class A or Class B biosolids.

Key	
Input	0
Default from reference values	0
Process output	**0**