British Columbia Greenhouse Gas Offset Protocol: Methane from Waste

Version 1.0 [Effective Date:]

PUBLIC CONSULTATION DRAFT

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1.0 GUIDANCE

The purpose of the Protocol is to quantify the Emission Reductions associated with the collection and destruction of methane from facilities in B.C. The Protocol applies to facilities that do not have a regulated requirement to install or expand a collection and destruction system and/or facilities that install or expand a collection and destruction system in advance of being subject to regulatory requirements.

The Project Proponent must ensure that the Project Plan meets the requirements of the Protocol, and the Gas Emission Control Regulation (the Regulation) under the *Greenhouse Gas Industrial Reporting and Control Act* (the Act) and that the required forms are complete. Project plans that do not meet these requirements will not be approved.

This Protocol has the effect of a regulation. In cases where the requirements of this Protocol differ from those of the Regulation, the Protocol takes precedence concerning the project types covered by the Protocol.

For a Project that involves both biogas collection and use in a fuel switch project, the Project Plan may be prepared in accordance with this Protocol and the B.C. Fuel Switch GHG Offset Protocol.

The Project Proponent is responsible to understand the interactions and limitations associated with pursuing a project under the Protocol in relation to the B.C. Low Carbon Fuel Standard.

The Project Proponent is responsible to ensure that the handling, treatment and use of waste materials and the operation of all facilities and equipment involved in the management of waste materials be done in accordance with the Agricultural Environmental Management Code of Practice, and/or the Landfill Gas Management Regulation, and/or the Organic Matter Recycling Regulation as appropriate.

The Project Proponent is responsible to provide justification where any assumptions or estimates are used in the Project Plan.

The Project Proponent is responsible to ensure the Validation Body selected for a Project using this Protocol is accredited by the Standards Council of Canada for the specific project type.

- For Organics Diversion, Wastewater Treatment and Manure Management projects, the Validation Body should be accredited to Technical Sector F: Decomposition of Waste Material, Handling and Disposal or by the American National Standards Institute to Sector Group *6: GHG Waste Handling and Disposal.*
- For Landfill Gas Management projects, the Validation Body should be accredited to *Standards Council of Canada Sector A / ANSI Sector Group 1: GHG Emission Reductions from Fuel consumption.*

Unless otherwise specified, the guidance and requirements provided in the following sections apply to all project types recognized by the Protocol.

2.0 DEFINITIONS AND ABBREVIATIONS

This section provides the intended definition and abbreviations for terms used in the Protocol.

2.1 DEFINITIONS

In the Protocol, the capitalization of terms where the capitalization is not solely performing a grammatical function indicates a defined term in the Act, Regulation, or this section.

"Act" means the *Greenhouse Gas Industrial Reporting and Control Act.*

"**Aerobic"** means in the presence of oxygen.

"Aerobic Composting" means the controlled biological oxidation and decomposition of organic matter which meets the requirements of Schedule 1 of the *Organic Matter Recycling Regulation*, B.C. Reg. 18/2002 (OMRR).

"**Agricultural composting process**" as described in the Agricultural Environmental Management Code of Practice, means a process other than a process conducted in accordance with the requirements of the *Organic Matter Recycling Regulation*, whereby agricultural by-products, wood residue, mortalities or processing waste, or a combination of any of them, are:

(a) mixed or layered, and
(b) managed to decompose aerobically with either periodic turning or forced aeration.

"Anaerobic" means related to or caused by the absence of oxygen.

"Anaerobic Digestion" means the controlled biological conversion of solid, liquid, and dissolved organic matter to biogas in the absence of oxygen.

"Baseline" refers to the Greenhouse Gas Emissions generated and activities on the proposed Project Site that would most likely occur in the absence of a proposed Project.

"Baseline Emissions" means the amount of Greenhouse Gas Emissions, established by, or estimated in accordance with, the Protocol that would occur from all selected Sources were the Project not carried out.

"Baseline Removals" means amount of Greenhouse Gas, established by, or estimated in accordance with, the Protocol that would be removed from the atmosphere by all selected Sinks were the Project not carried out.

"Baseline Scenario" means a hypothetical reference case that best represents the conditions most likely to occur in the absence of a proposed Project.

"**Biogas**" means the combustible mixture of different gases produced by the breakdown of organic matter in the absence of oxygen.

“Biogas Control System” “BCS” means a system that is designed to generate, capture and destroy biogas that is produced by the Anaerobic treatment of dairy or swine manure and / or other organic material or Wastewater.

“Biogenic” means originating from non-fossilized organic matter.

“Bioreactor” means a municipal solid waste (MSW) landfill or portion of a MSW landfill where any liquid other than leachate (leachate includes LFG condensate) is added in a controlled fashion into the waste mass (often in combination with recirculating leachate) to reach a minimum average moisture content of at least 40 percent by weight to accelerate or enhance the anaerobic (without oxygen) biodegradation of the waste”.

“BOD_5” means the carbonaceous 5-day biochemical oxygen demand

“Centralized Digester” means an Operation that has a BCS that integrates waste from more than one livestock facility or other organic material sources.

“Chemical Oxygen Demand” “COD” means a measure of that portion of a Wastewater stream that will readily oxidize by a chemical oxidant such as an acid.

"Crediting Period" refers to the 10-year period through which the Primary Activity occurs, and when Project Emissions are calculated.

"Compost" means a product which is

a) a stabilized earthy matter having the properties and structure of humus,
b) beneficial to plant growth when used as a soil amendment,
c) produced by composting, and
d) only derived from organic matter.

"Director" means the government employee designated in writing by the minister as Director for the purposes of the *Greenhouse Gas Industrial Reporting and Control Act*.

“Eligible Waste” means degradable non-hazardous organic material that originates from residential, industrial, commercial, or institutional sources listed in Schedule 12 of the *Organic Matter Recycling Regulation* (OMRR)[1], or in the Agricultural Environmental Management Code of Practice (AEM)[2].

"Emissions" means Greenhouse Gases**.**

"Emission Reductions" means Baseline Emissions minus Project Emissions.

“Enclosed Vessel” means a complete mix, fixed film, or plug-flow digester that is topped by a cover that provides a complete enclosure to the digester itself.

“Final Diversion Investment Decision” means a final decision

a) to contract for, purchase, lease or construct a substantial portion of the capital or services necessary to implement a new program to manage Eligible Waste that would otherwise

[1] OMMR - https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/35_18_2002
[2] AEM - https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/8_2019

have gone to a landfill, or to increase the scope and capacity of an existing Eligible Waste management program,

b) made for the purposes of managing waste and increasing diversion rates of waste from landfills, and
c) that involves a substantial financial commitment of the relevant Local Government to deliver such services.

“Fuel” includes electricity and material that is combusted or transformed to generate usable energy or do work.

“Fossil Fuel” means Fuel extracted from the Earth and formed from decayed organic material**.**

“Fugitive Emissions” means the unintended or incidental emissions of GHGs from the transmission, processing, storage, use or transportation of Fossil Fuels, GHGs or other.

“Functionally Equivalent” means quantification of Baseline Emissions and Project Emissions provide the same function and quality of products or services to enable meaningful comparison.

“Greenfield Manure Management Project” means a Project that is implemented at a new Operation with no manure management system prior to the Project.

“Greenfield Wastewater Treatment Project” means a Project that is implemented at a new Wastewater treatment Operation in the Project Scenario that has no Wastewater management system prior to the Project.

"Greenhouse Gases" means carbon dioxide, methane, and/or nitrous oxide; measured in metric tonnes of carbon dioxide equivalent.

“Historic Activities Diversion Rate” means, in relation to the Baseline Scenario, the highest annual rate of diversion of Eligible Waste that Local Government achieved in the three years prior to the Project Start Date, but not before 2014.

“**Incremental**” means, in relation to diversion of Eligible Waste, a diversion rate beyond the baseline diversion rate as established under sections 5 and 8 of the Protocol.

“Ineligible Waste” means organic waste that is not Eligible Waste.

“Integrated Grid” means an electrical distribution system that is connected to a transmission system operated by BC Hydro or FortisBC.

“**Initial Testing Period”** means the period between post-system installation and the system becomes operational.

“**Land Application”** means the application to land, after biosolids treatment or composting, of managed organic matter.

“Landfill Gas (LFG)” means a mixture of gases generated by the decomposition of municipal solid waste.

“Landfill Gas Regulation” means the Landfill Gas Management Regulation, B.C. 903/2008

“Leakage” means the increase in Greenhouse Gas Emissions that occur from outside the Project Site as a direct result of the Primary Activity.

“Local Government” has the same meaning as in the *Local Government Act*.

“Local Government Area” means the geographic area of the municipal corporation of a Local Government.

“Manure Management Anaerobic Handling System” means a pre-project manure management Operation that consists of one or more designed and constructed surface impoundments and meets the eligibility requirements in Section 3.3.2.

“Manure Management Project” means manure management Operation that meets the eligibility conditions of Section 3.2.

“Materiality Threshold” means the quantitative threshold for verification purposes under section 21(4)(c) of the Regulation.

“Monitoring” means the continuous or periodic assessment and documentation of GHG Emissions and Removals or other GHG-related data.

“Municipal Wastewater” has the same meaning as defined in the Municipal Wastewater Regulation 230/2012[3].

"Offset Units" means one verified tonne of Emissions reduction or Removal achieved as part of and in accordance with an accepted Emission offset Project in respect of which the Director has received a report of the outcome of the Project and a verification statement in relation to the report.

“Operation” means a facility(s) or process(es) where the Primary Activity of Project Scenario occurs, or Primary Activity of the Baseline Scenario would occur.

“Operational” in relation to a flare, means thermocouple readings that are above 260° C.

“Organic matter” means those materials set out in Schedule 12 of the *Organic Matter Recycling Regulation* (OMRR)[4], that are suitable for composting

“Organic Waste Management Facility” (OWMF) includes any land or building, and any machinery, equipment, device, tank, system or other works that processes organic waste in order to generate compost, a fertilizer product, energy, or a fuel product.

“Performance Standard” means a technical, activity or performance measure used to calculate Baseline Emissions or a component of Baseline Emissions, determined in accordance with Section 5.1.

“**Primary Activity”** means the main activity or set of activities in the Project Scenario that result in the majority of Emissions Reduction from the Baseline Scenario.

[3] MWR - https://www.bclaws.ca/civix/document/id/complete/statreg/87_2012
[4] OMMR - https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/35_18_2002

“Program of Activities” means a type of Project that is not Stand-Alone where a group of similar Project Instances are covered by a single Project Plan and additional Project Instances may be added to the Project over the course of the Project Crediting Period.

"Project" means a Greenhouse Gas reduction Project as described in the Project Plan.

"Project Emissions" means:

- In relation to a Project Plan, the amount of Greenhouse Gas Emissions, estimated in accordance with the applicable Protocol, that would occur from all selected Sources were the Project carried out; and
- In relation to a Project Report, the amount of Greenhouse Gas Emissions, determined in accordance with the Project Plan, that occurred from all selected Sources in the Project Report Period.

“Project Instance”, in relation to a Program of Activities, means a single instance of a Project Scenario that, in combination with other similar Project Instances, is covered by the same Project Plan.

“Project Plan” means a plan prepared in accordance with section 14 of the Regulation (Project Plans).

“Project Proponent” means a person or organization who submits to the Director, directly or though a validation body, a plan for an Emission offset Project that the person proposes to or does carry out. The Project Proponent also refers to any non-controlling shareholder that directs or partially directs day-to-day operations or reporting.

"Project Reduction" means the total of the Emissions Reduction and the Removals Enhancement, less any discounts applied in accordance with the Protocol, that are estimated to occur or that have occurred in the Crediting Period and Monitoring Period.

"Project Removals" means:

- In relation to a Project Plan, the amount of Greenhouse Gases estimated in accordance with the Protocol that, were the Project carried out, would be removed by all selected Sinks; and
- In relation to a Project Report, the amount of Greenhouse Gas, determined in accordance with the Project Plan, removed by all selected Sinks in the Project Report Period.

"Project Report" means a report described in the Regulation that meets the prescribed requirements of both the Regulation and the Protocol for each Project Report Period.

“**Project Report Period**” means, each period for which a separate Project report is or must be prepared.

“Project Scenario” means the activities taken by the Project Proponent that reduce or remove greenhouse gas emissions and constitute the estimation of the Project Emissions.

“Project Site” means the physical footprint where the Primary Activity occurs.

“Project Specific” means an approach to establish the Baseline Scenario that is specific to the Project.

“Protocol” means the British Columbia Greenhouse Gas Offset Protocol: Methane Management (MMOP).

“Qualified Organic Waste Management Facility” means an OWMF which meets the criteria specified in Section 3.2 of the Protocol.

“Regulation” means the Greenhouse Gas Emission Control Regulation.

“Regulatory Requirement” refers to any operational requirements of a regulated facility set out in laws, regulations, bans, by-laws, and/or permitting or licensing requirements. Performance objectives or goals are not considered to meet this definition.

“Residual Waste” means organic waste disposed at a landfill from an Organic Waste Management Facility, including waste in the form of digestate, effluent, or any other post-treatment form of organic waste, as well as Ineligible Waste and untreated Eligible Waste.

“Sink” means a physical unit or process that removes Greenhouse Gas from the atmosphere.

“Source” means any process or activity through which a GHG is released into the atmosphere.

“Stand-Alone” means a type of Project where all instances of the Primary Activities of the Project Scenario are identified in the validated Project Plan.

“Transmission Grid” means those parts of the B.C. electricity transmission and distribution system that are connected to the North American transmission grid.

“Unqualified Organic Waste Management Facility” means an OWMF which is not a Qualified OWMF.

“Wastewater Anaerobic Handling System” means a pre-project Wastewater treatment Operation that consists of one or more designed and constructed surface impoundments and meets the eligibility requirements in Section 3.1.1.

“Wastewater Treatment Project” means Wastewater treatment Operation that meets the eligibility conditions of Section 3.3.1.

2.2 ABBREVIATIONS AND ACRONYMS

"AEM"	Agricultural Environmental Management Code of Practice, B.C. Reg. 8/2019
"ANSI"	American National Standards Institute
"ATM"	atmosphere
"B.C."	British Columbia
"BCS"	biogas control system
"BE"	Baseline Emission
"BOD"	biological oxygen demand
"C"	carbon
"CAR"	Climate Action Reserve
"CEMS"	continuous emissions monitoring systems
"CH_4"	methane
"CO_2"	carbon dioxide
"COD"	chemical oxygen demand
"EMA"	Environmental Management Act
"ENV"	(BC) Ministry of Environment and Climate Change Strategy`
"GGECR"	Greenhouse Gas Emission Control Regulation, B.C. Reg. 250/2015
"GGIRCA"	Greenhouse Gas Industrial Reporting and Control Act
"GHG"	greenhouse gas
"GJ"	gigajoule
"GPS"	global positioning system
"GWP"	global warming potential
"HDD"	heating degree day
"HHV"	higher heating value
"IPCC"	Intergovernmental Panel on Climate Change
"ISO"	International Standards for Organization
"KM"	kilometre
"kPa"	kilo pascal
"MWR"	Municipal Wastewater Regulation, B.C. Reg. 87/2012
"LFG"	landfill gas
"LHV"	lower heating value
"MJ"	megajoule
"MSW"	municipal solid waste
"N_2O"	nitrous oxide
"OMRR"	Organic Matter Recycling Regulation, B.C. Reg. 18/2002
"PE"	project emissions
"PoA"	program of activities
"QA/QC"	quality assurance/ quality control
"SCC"	Standards Council of Canada
"SCM"	standard cubic meters
"SSR"	source, sinks and reservoirs
"STP"	standard temperature pressure
"VVB"	validation / verification body
"WCI"	Western Climate Initiative

2.3 EQUATIONS

2.4 TABLES

3.0 ELIGIBILITY

This section presents the general eligibility criteria for projects and project facilities for each project type covered under the Protocol. The criteria presented apply to both Stand-Alone and Program of Activities (PoA) projects, unless otherwise specified.

Projects that meet the criteria below for a specific project type are eligible to use the corresponding Performance Standard Baseline Scenario for that project type as outlined in section 5.0.

Projects that began before the release of the Protocol have 12 months after the Effective Date of the Protocol to submit a Project Plan in accordance with section 10 (6) of GGIRCA.

3.1 GENERAL CRITERIA – LANDFILL GAS (LFG) MANAGEMENT

1. The Project must:

   a) Complete an LFG generation assessment using the ENV Landfill Gas Generation Estimation tool;[5]

   b) Meet the applicable requirements of the Regulation;

   c) Meet all the applicable requirements including all regulations, standards and codes that occur at the Municipal, Provincial and Federal levels;

   d) Meet the eligibility criteria specified below in Section 3.1.1, if any;

2. Project Reductions must not result from:

   a) a Bioreactor;

   b) reductions in GHGs other than CO_2, CH_4, or N_2O;

   c) landfills that add any liquid other than leachate into the waste mass in a controlled manner.

3. The Primary Activities of the Project Scenario are:

   a) collection and destruction of landfill gas using an eligible destruction device specified in Section 10.1.1;

3.1.1 Qualified Landfill Gas Management Facility Criteria

The following section describes the eligibility start dates at which LFG collection and destruction systems are required.

[5] Landfill Gas Generation Estimation Tool - calculation tool (XLS)

For landfills required to submit an Initial Landfill Gas Generation Assessment Report, and which are under the generation threshold of 1,000 tonnes of CH_4 per year, a Supplementary Assessment Report is required five years after the submittal of the initial report (BC Landfill Gas Management Regulation).

If the supplementary report identifies a CH_4 generation rate of greater than 1,000 tonnes of CH_4 per year, then an LFG collection and destruction system is required to be installed and operated within five years after the submittal deadline for the supplementary Report.

Projects that are required to install an LFG collection and destruction system are eligible to generate Offset Units so long as the capture efficiency installed or operating on-site as a result of the Project Activities, whichever is higher, continues to exceed regulatory requirements. See section 3.4 for more information.

3.2 General Criteria – Organic Waste Diversion

1. The Project must:

    a) Involve both the incremental diversion of Eligible Waste from a landfill to an Organic Waste Management Facility and the processing of that waste at that facility, and

    b) Meet the Organic Waste Management Facility qualification criteria specified in Section 3.2.1.

2. Project Reductions must not result from:

    a) Waste that has been previously landfilled and is removed; or

    b) Composting of Eligible Waste using non-aerated, static or passive pile composting; or

    c) Reductions in GHGs other than CO_2, CH_4 and N_2O.

3. The Primary Activities of the Project Scenario are:

    a) Diversion of Eligible Waste from a landfill to a Qualified Organic Waste Management Facility for treatment, and

    b) Treatment of Eligible Waste at a Qualified Organic Waste Management Facility.

3.2.1 Qualified Organic Waste Management Facility Criteria

A Qualified Organic Waste Management Facility must be operated in accordance with applicable legislation and regulations and must satisfy the following requirements.

The Organic Waste Management Facility must process Eligible Waste by one or both of the following processes as the Primary Activity in the Project Scenario.:

- Aerobic Composting,
- Anaerobic Digestion,
- Another resource recovery process which converts diverted organic material into a product (e.g. – pelletization, hydrothermal carbonization, pyrolysis, or gasification).

Where an Organic Waste Management Facility uses both Aerobic Composting and Anaerobic Digestion processes, the Project Proponent must assess Project eligibility against both the requirements for Aerobic Composting in Section 3.2.1.1 and the requirements for Anaerobic Digestion in Section 3.2.1.2.

3.2.1.1 Aerobic Composting

Acceptable composting technologies include, but are not limited to:

- Windrow with mechanical turning
- Aerated static pile
- Aerated and covered static pile
- In-vessel systems

All Eligible Waste must be handled and stored according to the requirements set out in AEC, OMRR and Canadian Council of Ministers of the Environment (CCME) Compost Quality Guidelines.

3.2.1.2 Anaerobic Digestion

For Projects where methane production processes are enhanced, the Organic Waste Management Facility must manage the risk of fugitive emissions in accordance with the guidance provided in the Canadian Standards Association (CSA) Code for Digester Gas, Landfill Gas, and Biogas Generation and Utilization (ANSI/CSA B149.6-15).

All biogas captured from the Anaerobic Digestion technology must either be used at the Organic Waste Management Facility, sold, or transferred to other parties off-site, or flared. All venting or fugitive release of biogas that occurs at the Organic Waste Management Facility must be quantified and reported according to the methodologies included in the Protocol.

The handling, storage and use of the digestate produced from Anaerobic Digestion, are regulated under AEC and OMRR.

3.3 General Criteria – Wastewater and Manure Management Facilities

1. The Project must fall within one of the following categories:

    a) prior to the Project, existing facilities must have operated an eligible historic system, i.e., Wastewater Anaerobic Handling System that meets the requirements of Section 3.1.1 or Manure Management Anaerobic Handling System that meets the requirements of 3.1.2, (including replacement of an existing equipment or processes at an existing Operation) or Wastewater Anaerobic sludge treatment, or

    b) the Project involves construction or installation of a BCS, and the Project Proponent can demonstrate, in accordance with the Protocol that the Primary Activity of the Baseline Scenario would have been an eligible Wastewater Anaerobic Handling System or Manure Management Handling System, or

    c) the Project meets Performance Standard eligibility requirements, if any.

2. Project Reductions must not result from:

    a) GHGs other than CO_2, CH_4 and N_2O.

3. The Primary Activities of the Project Scenario are the following:

    a) the installation and operation of a device, or set of devices, including an Enclosed Vessel or a covered lagoon, associated with the capture and destruction of methane (i.e., a BCS),
    b) the capture of biogas that would otherwise have been emitted to the atmosphere in the absence of the Project from uncontrolled Anaerobic treatment and / or storage of manure or Wastewater,
    c) the destruction the captured methane through an eligible end-use management option listed in Table 7 of the Protocol.

3.3.1 Wastewater Anaerobic Handling System Criteria

1. Eligible pre-project Wastewater Anaerobic Handling System(s) must demonstrate that it / they meet all the following criteria:

    a) treated Municipal Wastewater for at least three months of the year,
    b) for the year prior to the Start Date of the Project, the ambient temperature of the Wastewater Anaerobic Handling System was above °15.0 Celsius at least during part of the year, on a monthly average basis with data obtained from the closest weather station, with available data, located in the same air basin, if applicable;
    c) the depth of the pre-project Wastewater Anaerobic Handling System was greater than two meters at its shallowest point and not aerated for at least part of the previous year; and
    d) the minimum interval between two consecutive sludge removal events was 30 days.

3.3.2 Manure Management Anaerobic Handling System Criteria

1. Eligible pre-project Manure Management Anaerobic Handling System(s) must demonstrate that it / they meet all the following criteria:

    a) managed Eligible Waste at the Manure Management Project,
    b) for the year prior to the Start Date of the Project, the ambient temperature is above °15.0 Celsius at least during part of the year, on a monthly average basis with data obtained from the closest weather station, with available data, located in the same air basin, if applicable;
    c) the depth of the Manure Management Anaerobic Handling System is greater than one meter at its shallowest point and not aerated for at least part of the previous year.

3.4 DEMONSTRATING ADDITIONALITY

Offset units will only be issued for actions that are considered additional to those that could reasonably be assumed to have happened without the Project.

In the Project Plan and for each period covered by a Project Report, the Project Proponent must assert that:

- The Primary Activities of the Project will result in Emission Reductions that exceed reductions required by any law, regulation, permitting conditions or other legally binding mandate associated with the related activity or Project Site to reduce emissions.

- The Project has not received any financial incentive on a per unit of reduction basis; and

- Any finished fuel, using the gas collected by the Project as the feedstock, is not receiving a credit for the avoiding the release of methane as part of fuel lifecycle recognized by a B.C. Low Carbon Fuel (BCLCF) code under B.C.'s Low Carbon Fuel Standard.

In cases where the gas feedstock is being credited in a BCLCF, Offset units will be issued based on the quantity of the collected gas that is supplied for stationary combustion (i.e. – not transportation). See section 8.0 for more information.

It is strongly recommended that the Project Proponent arrange a data-sharing agreement as part of any gas off-take agreement, prior to applying for an Offset Project.

3.5 START DATE

The Start Date is the date upon which the Project Proponent began the primary activities of the project as defined by the project type. The Start Date must be within five (5) years of the Effective Date of the Protocol in accordance with section 10 (6) of GGIRCA.

3.6 CREDITING PERIOD

The Crediting Period is up to 10 years. The Project Proponent must provide justification for the requested length of the Crediting Period based on the analysis used to establish Baseline and Project Scenarios.

Crediting Periods may be extended up to a total of 20 years so long as the Project continues to meet the requirements of section 3.4.

3.7 Project Report Period

The first Project Report Period covers the 12-month period beginning on the Project Start Date. Subsequent Project Reports are required at least every three years and must be organized by 12-consecutive-month periods (e.g., October 16, 2021 – Oct 15, 2022).

3.8 Materiality

For the purpose of this Protocol any errors, omissions or misrepresentations are considered material as per sections 15 (3) (c) and 21 (4) (c) of the Regulation if the individual or aggregate effects result in an overestimation of the Project Reductions of more than 5%.

4.0 Project Boundary

4.1 Description of the Project

The Project Proponent must provide a detailed technical description of the Project including where the Project will be carried out and where the Emissions Reduction will occur, including the following information:

- GPS coordinates (latitude and longitude). Street address and postal code must be provided, if available.
- If there is more than one facility at the given location, a written description of the Project Site that clearly identifies at which facility the Primary Activities will occur.
- A map at a scale of enough detail (e.g., 1:2500) to identify the location of the applicable facility operation.

The Project Plan must indicate whether the Project type is Stand-Alone or Program of Activities.

4.2 Identification of the Project Location

4.2.1 Stand-alone Location(s)

For Stand-Alone Project type and for each Project Instance determined at the time of validation of Program of Activities Project type, Project Plans must include global positioning system (GPS) coordinates (latitude and longitude) for the locations where the Primary Activities of the Project Scenario will be carried out and any other information allowing for the unique identification of the Primary Activities of the Project Scenario.

4.2.2 Program of Activities (PoA) Locations

Project Plans for Projects involving a PoA must identify the geographic boundary within which the Primary Activities of the Project Scenario will be occurring, and how each Project Instance will be uniquely identified in Project Reports.

Project Plans of PoA must describe how the approach that will be used for identification of Project Instances that are not determinable when the Project Plan is validated will meet the requirements of the Regulation. Project Plans must include a description of how this approach will enable future audits and inspections to identify individual Project Instances and source locations for all Eligible Wastes.

4.2.3 Location Identification - Landfill Gas Management

The Project Plan for Landfill Gas Management Projects must also provide the following information:

1. A description of the LFG collection and destruction systems in place at each location where the Primary Activities of the Project Scenario take place including:
    - all wells, pipes, blowers, caps, and other technologies that enable or enhance the collection of LFG and convey it to a destruction technology.

4.2.4 Location Identification - Organic Diversion

The Project Plan for Organic Diversion Projects must also provide the following information:

1. Locations for all sources of Eligible Wastes, for which the following must be specified:
    - Local Government Areas from which the Eligible Wastes are sourced.
    - The types of operations from which the Eligible Wastes are sourced in enough detail to allow confirmation by validation and verification bodies that the waste in the Project is Eligible Waste diverted from a landfill.
    - A map showing the location from where the Eligible Waste is sourced at an appropriate scale to determine its location within the Local Government area.

4.2.5 Location Identification - Wastewater and Manure Management

The Project Plan for Wastewater and Manure Management Projects must also provide the following information:

1. A description of the type of device, or set of devices, employed in the collection and destruction systems in place at each location where the Primary Activities of the Project Scenario take place.

5.0 BASELINE SCENARIO DETERMINATION

The Baseline Scenario describes the activities on the Project Site and quantity of emissions that would have occurred from selected sources had the Project not been implemented. The Baseline Scenario is either determined using a Project-Specific assessment of Baseline Scenario candidates or set using a pre-established Performance Standard depending on the project type.

5.1 BASELINE SCENARIO – LANDFILL GAS MANAGEMENT

5.1.1 Project Specific Baseline

The Project Specific baseline approach is not available for LFG Management Projects under the Protocol.

5.1.2 Performance Standard Baseline

LFG Projects are considered to have passed the activity-based Performance Standard test if they meet the eligibility requirements of Section 3.1 and must use the Performance Standard Approach to establish the Baseline Scenario.

The Performance Standard for the Protocol is based on the methane capture efficiency threshold set by the LFG Regulation requirements. Project Proponent must use the methane capture efficiency as appropriate to their annual methane emission generation as outlined in Table 1.

Table 1: LFG Management Regulation Generation Assessment Results

Condition Number	Results of the Landfill Gas Generation	Landfill Gas Regulation Requirements	Performance Standard Capture Efficiency Threshold
1	>1,000 tonnes CH_4/year in 2016	LFG collection and destruction system required 5 years after the submittal deadline of the Landfill Gas Generation Assessment Report.	At least 75% as set out in an accepted LFG management plan.

2	<1,000 tonnes CH_4/year in 2016	LFG collection and destruction system not required from the submittal deadline of the Landfill Gas Generation Assessment Report.	0%

The Performance Standard Baseline Scenario for LFG projects assumes that all uncontrolled CH_4 emissions above the methane capture efficiency installed or operating on-site, whichever is higher, are released to the atmosphere except for the portion of CH_4 that would be oxidized by bacteria in the cover soils absent the Project[6].

5.1.3 Adjustments to Baseline - LFG

If a new methane capture efficiency rate requirement comes into effect during the Project that is higher than the rate considered in the Baseline Scenario, the Project Plan must be adjusted to reflect the new rate for the verification period immediately following the coming into force of the capture efficiency rate requirement, as described in section 7.0.

5.2 Baseline Scenario – Organics Diversion

5.2.1 Project Specific Baseline

The Project Specific baseline approach is not available for Organics Diversion Projects under the Protocol.

5.2.2 Performance Standard Baseline

Organics Diversion Projects must use the Performance Standard Approach described below to establish the Baseline Scenario. In the Project Plan, the Project Proponent must assert, for each Project Instance, the baseline diversion rate for each year of the Project Crediting Period and provide justification for this assertion. Only diversion to a Qualified Organic Waste Facility should be considered here.

The following conditions are to be applied for each Project Instance:

A Historical Activities Diversion Rate may be used for the entire Crediting Period, if at the time of the Final Diversion Investment Decision:

1. There is not a required diversion rate in place or announced for the Local Government Area from which Eligible Waste is being diverted, or

[6] Landfill cover systems incorporating a synthetic liner throughout the entire area of the final covers system must use a default CH_4 oxidation rate of zero. A 10% CH_4 oxidation factor must be used for all other landfills based on Intergovernmental Panel on Climate Change (IPCC) guidelines (2006).

2. The Local Government can demonstrate in the Project Plan that it voluntarily imposed diversion through a bylaw, or the submission of a waste management plan under section 24 of the Environmental Management Act, and, that the decision to impose the Regulatory Requirements was:
    a. at least partially based on the assumption that financial benefits from generating Offset Units from Eligible Waste diversion would help reduce obstacles to successful implementation of, or compliance with, the Regulatory Requirements, or
    b. made with the aim of reducing GHG emissions despite the implied financial costs,

If one of the above conditions is satisfied, then the Historic Activities Diversion Rate will be used up to the date when the diversion rate requirement come into force. Afterwards the Baseline diversion rate will be either the diversion rate requirement or the Historic Activities Diversion Rate, whichever is higher.

In this case, if target waste diversion rates are provided only for future dates the Project Proponent in the Project Plan will calculate annual diversion rates by assuming a linear increase in diversion year over year up until the specified future date and a constant baseline diversion rate thereafter.

5.2.3 Adjustments to Baseline - OWD

If a new diversion rate requirement comes into effect after the time of Final Diversion Investment Decision, and that rate is higher than the rate considered as part of the Final Diversion Investment Decision, the Baseline diversion rate used in the Project Plan must be adjusted for the verification period immediately following the coming into force of the new diversion rate requirement, as described in section 7.0.

5.3 Baseline Scenario – Wastewater Treatment and Manure Management

5.3.1 Project Specific Baseline

Project Plans must include a list of plausible existing and alternative project types, activities, technologies, and fuels to demonstrate that the Project Scenario is functionally equivalent to the Baseline Scenario. Baseline Scenario candidates could include a continuation of historic practice or new activities, equipment, technologies, etc., as appropriate for the conditions that are unique to the Project. Baseline Scenario candidates are the range of alternate possibilities to the Project Scenario that must be considered when selecting the Baseline Scenario.

Any climate change incentives available to the Baseline Scenario candidates must be included in the Project Plan.

5.3.1.1 Wastewater Treatment

The Baseline Scenario candidates for Wastewater Treatment Projects, either for the sludge or Wastewater, must be able to supply the same types and levels of services for the entire Crediting Period i.e., demonstrate they are functionally equivalent to the Project Scenario. Examples of other potential Baseline Scenario candidates that Wastewater Treatment Projects are, but not limited to:

- Aerobic treatment both chemical and biochemical oxidation
- Anaerobic treatment without capture and destruction
- Sedimentation without secondary or tertiary treatment

5.3.1.2 Manure Management

The Project Specific baseline approach is not available under the Protocol for this project type. Please refer to Section 5.3.2.2 for the Performance Standard baseline approach for this project type.

5.3.1.3 Identification of Baseline Scenario Candidate Obstacles

The Project Plans must identify potential obstacles associated with each of the Baseline Scenario candidates identified as per Section 5.2.1, in order to assess, as per Section 5.2.3, which of the Baseline Scenario candidates would have been the most likely to occur in the absence of the Project, considering both number and magnitude of the obstacles.

5.3.1.3.1 Baseline Scenario Candidate Obstacle Types

Project Proponents must identify obstacles that would discourage a decision to implement the Baseline Scenario candidates. Project Proponents must consider, at minimum, financial, legal and technical obstacles that each identified Baseline Scenario candidate may face.

5.3.1.4 Comparison of Baseline Scenario Candidates

Project Proponents must present a comparative assessment of obstacles for each of the Baseline Scenario candidates including the following information for each candidate identify all obstacles to implementation, and estimate the magnitude of each obstacle as per Section 5.2.2.

The magnitude of an obstacle must be quantified as much as practicable. In addition, the magnitude of an obstacle may also be characterized qualitatively using descriptive explanations and justifications for the characterization. In the Project Plan, Project Proponents must substantiate and explain the cumulative effects of the obstacles for each Baseline Scenario candidate. The results of cumulative effects must be presented so that a reasonable person could form an opinion as to which of the Baseline Scenario candidates is most likely to occur.

For clarity, Project Proponents must consider provincial or federal incentives or Regulatory Requirements relevant to any aspect of the Baseline Scenario, including reduced tax burdens, rebates, and grants. The Project Proponent must include in the assessment the financial implications of carrying out a course of action referred to in the Baseline Scenario, and any other factor relevant to justifying the assertion that the estimate of future Project Reductions will be conservative

5.3.1.5 Selection of the Baseline Scenario

5.3.1.5.1 Project Specific

Based upon the results of the comparative assessment of Baseline Scenario obstacles, a Project Proponent must determine which Baseline Scenario candidates are reasonably likely to occur.

Where there is only one scenario that is reasonably likely, the Project Plan establishes that scenario as the Baseline Scenario.

Where there are multiple scenarios that are reasonably likely, the scenario that yields the most conservative estimate of the Project Reductions must be used.

5.3.2 Performance Standard Baseline

5.3.2.1 Wastewater Treatment

The Performance Standard baseline approach is not available for Wastewater Treatment Projects under the Protocol.

5.3.2.2 Manure Management

Manure Management Projects that meet the eligibility requirements of Section 3.3.2 may use the Performance Standard baseline approach.

For Projects with historic systems that meet the definition of Manure Management Anaerobic Handling Systems, the activity-based performance standard is continuation of prior practices that considers the regulatory obligations contained in manure management plans.

Greenfield Manure Management Projects must utilize the assumptions and approach according to the conditions described in Table 16.

6.0 PROJECT AND BASELINE SOURCES, SINKS AND RESERVOIRS (SSRS)

All SSRs are categorized as controlled or related based on their relation to the Project Proponent, where the Project Proponent is assumed to control all on-site and mobile SSRs. Upstream and downstream SSRs are assumed to be controlled by others and are considered related to the Project.

Guidance for accounting for those SSRs impacted by leakage is provided in the Quantification section for the individual project types, as appropriate.

Note, emissions from biomass as these emissions are considered biogenic and can be excluded for all project types.

Sources involving emissions from the combustion of fuel and/or energy use are included for completeness only. It is expected that the difference in emissions from these sources between the Baseline and the Project scenarios will be immaterial. In such cases these emission sources can be conservatively omitted. No credits will be issued for reductions in fuel or energy use.

6.1 SSRs - Landfill Gas Management

The Project Plan must quantify each of the GHGs listed for the Baseline and Project emission sources presented in Table 2.

Emission sources are denoted as:

- B – for Baseline emission source
- P – for Project emission source

Table 2: SSRs for Baseline and Project Scenarios for LFG Management Projects

SSR	GHGs Included	Description
B1 / P1 Emissions from Fossil Fuel used for LFG Collection	CO_2 CH_4 N_2O	LFG Projects may require consumption of Fossil Fuel or electricity for LFG collection, such as the operation of blowers or vacuums, which may result in additional GHG emissions. If no additional Fossil Fuel or Electricity is consumed in the Project for LFG collection, the Project Proponent may exclude this Source from quantification. *Guidance Note: The emission factor for this value may not be available by GHG constituent for indirect electricity GHG emissions so these emissions are calculated in tonnes of carbon dioxide equivalent (CO_2e).*
B2 / P2 Grid Electricity Production, Transmission and Distribution	CO_2 CH_4 N_2O	Consumption of electricity generated off-site is a Related SSR.
B3 / P3 Emissions from Supplemental Fuel Use for Flaring	CO_2 CH_4 N_2O	Total quantity of GHG emissions from supplemental Fossil Fuel used to for the operation of the flare such as increasing CH_4 concentration or start-up. This source includes both CH_4 that is not combusted, and CO_2 from the Fossil Fuel consumed.
B4 Emissions from Waste Breakdown in the Landfill	CH_4	This source quantifies the CH_4 emissions that would be released to the atmosphere had the landfill capture and destruction system not been implemented. The GHG emissions for this source are calculated based on quantify of LFG that is destroyed in the Project Scenario. If a capture device is present in the Baseline Scenario, then this capture efficiency must be considered.

SSR	GHGs Included	Description
		If no device is used in the Baseline Scenario, the value of the destruction efficiency is set to zero.
P4 Emissions from On-site LFG Destruction Device	CH_4	CH_4 emissions from the incomplete combustion of CH_4 in the LFG from an on-site destruction device.
P5 Emissions from Upgrade of LFG	CO_2 CH_4 N_2O	Landfill Projects may result in GHG emissions from Fossil Fuels required to upgrade LFG. This source includes technologies that involve the scrubbing and conditioning of the LFG.

6.1 SSRs - Organics Diversion

The Project Plan must quantify each of the GHGs listed for the Baseline and Project emission sources presented in Table 3.

Emission sources are denoted as:

- B – for Baseline emission source
- C – for Composting Process
- D – for Digestive Process
- P – for Project emission source

Table 3: SSRs for Baseline and Project Scenarios for Organics Diversion Projects

SSR	GHGs Included	Description
Source B8 Emissions from decomposition	CH_4 N_2O	GHG emissions from the decomposition of Eligible Waste in the landfill (i.e. – not captured).
Source P3C Emissions from Composting Process	CH_4 N_2O	GHG emissions from the composting process excluding those from energy use.

SSR	GHGs Included	Description
Source P4D Emissions from Digestate Treatment	CH_4 N_2O	GHG emissions from the treatment of Digestate produced from the Anaerobic Digestor.
Source P5D Emissions from storage of effluent	CH_4	GHG emissions from the open storage of the liquid component of anaerobic digester effluent as the remaining organic carbon content is degraded.
Source P6D Emissions from venting of biogas	CH_4	GHG emissions from the venting of biogas produced by the anaerobic digester may occur during upset conditions or maintenance events, resulting in GHG emissions.
Source P7D Emissions from flaring of biogas	CH_4 N_2O	Flaring of biogas produced by the anaerobic digester may occur during upset conditions or maintenance events, or as part of normal operating conditions, resulting in GHG emissions.
Source P9D	CH_4 N_2O	GHG emissions from biogas combusted to produce thermal energy or electricity at the Qualified Organic Waste Management Facility

6.2 SSRs - Wastewater and Manure Management

The Project Plan must quantify each of the GHGs listed for the Baseline and Project emission sources presented in Table 4.

Emission sources are denoted as:

- B – for Baseline emission source
- P – for Project emission source

Table 4: SSRs for Baseline and Project Scenarios for Wastewater and Manure Management Projects

SSR	GHGs Included	Description
Source P1/B1 MM Emissions from manure treatment and storage (non BCS)	CO_2 CH_4 N_2O	Baseline: GHG emissions from the Manure Management Anaerobic Handling System as either one or a combination of pasture/range/paddock, daily spread, solid storage, dry lot, liquid/slurry, uncovered anaerobic lagoon, pit storage below animal confinements, burned for fuel, cattle and swine deep bedding, composting in-vessel, composting static pile, composting – intensive windrow, composting – passive windrow. Project: GHG emissions from Manure Management Projects for any non-BCS system storage including the categories mentioned above.
Source P2	CO_2 CH_4	

SSR	GHGs Included	Description
Emissions from the BCS (metered and venting)	N_2O	GHG emissions from the venting of biogas produced by the BCS during upset conditions or maintenance events, resulting in GHG emissions. Fugitives from the flow meter are determined based upon destruction efficiencies of the devices. Venting of the biogas may occur during upset conditions or during maintenance to the Anaerobic treatment system or any elements downstream of the Anaerobic unit. Additionally, venting may occur regularly as part of the BCS design to include pressure relief valves or passive vents for safety reasons to prevent excessive or unsafe gas build-ups. Emissions of methane under these circumstances would need to be considered. For non-routine venting the duration of the venting occasion, the methane production rate and the volume of biogas in the digester at the time of venting must be tracked. For routine venting as part of the system design, the Project Proponent refers to the manufacturer's collection efficiency in design documents or other industry common values for the type of BCS in place.
Source P3 / B2 Emissions from Waste Treatment Effluent and Discharge	CO_2 CH_4 N_2O	Baseline and Project Emissions may occur when the Eligible Waste exits the treatment process. Treated waste is typically stored in effluent storage units, such as ponds. This effluent pond produces some methane emissions that need to be considered. In addition, the fate of discharge of Wastewater needs to be considered for Wastewater Treatment projects.
Source P4 Emissions from Biogas Conditioning	CO_2 CH_4 N_2O	*Only applicable for Projects that condition their biogas. Project Emissions Produced biogas will likely have a higher concentration of carbon dioxide and other impurities than may be acceptable to meet the required specifications for its use. Gas conditioning equipment such as separators, filters, knock-out drums, absorption units, adsorption beds, chillers, gas dryers, blowers, condensate pumps

SSR	GHGs Included	Description
		and other equipment may be required to treat the biogas and remove impurities in order to meet any required specifications. This may require several energy inputs such as natural gas and diesel. Quantities and types of each energy input must be tracked.
Source P5 Biogas Upgrading for the Pipeline	CO_2 CH_4 N_2O	*Only applicable for Projects that upgrade their biogas onsite. GHG emissions resulting from the operation of equipment used for biogas upgrading for injection into the natural gas pipeline. As a result, this source is only applicable for Projects that upgrade their biogas for the natural gas pipeline. Additional energy inputs may be required to distribute the biogas to end users off-site via a gas distribution system. This may include supplemental energy inputs to compress the purified biogas for input into a gas distribution system such as natural gas. Quantities and types of fuels consumed to provide each energy input must be tracked.

7.0 QUANTIFICATION OF EMISSIONS REDUCTION

The Project Proponent must use the equations presented in section 7.0 to quantify Baseline Emissions, Project Emissions and Project Reductions, for each Project Instance.

Equation references to 'i' refer to a source type in the SSR tables above. Equation references to *'j'* refer to a GHG type. Equation references to *'m'* refer to a Project Report Period; to *'h'* refer to a Fuel type; to *'PI'* refer to a Project Instance.

References to quantification of 'annual' GHG emissions and to 'year *m*' are to be adapted, if applicable, to reflect the actual length of Project Report Period *m*.

References to WCI (20, 23, or 24) refer to the most current version of the *Western Climate Initiative Final Essential Requirements of Mandatory Reporting - amended for Canadian Harmonization* as published on the Ministry of Environment and Climate Change Strategy's website. For each SSR, only specific calculation methods within WCI.20 are permitted. If more than one option exists, the Project Proponent must select the most accurate quantification method unless an alternative method in the Protocol provides a result that is materially the same and the selection is justified.

Total Project Reductions for a PoA project will be calculated as the sum of the Project Reductions from the individual Project Instances.

Equation 1: Total Project Reductions

Project Reductions = Baseline Emissions - Project Emissions

Baseline and Project Emissions must be calculated using the appropriate method based on project type.

7.1 ELIGIBLE PROJECT REDUCTIONS

In some cases, the environmental benefit of capturing biogas is claimed under another regime and therefore, the project reductions that can be credited under the Offset Project must be adjusted using Equation 2.

This only applies to Projects where a portion of the biogas captured is supplied under a B.C. Low Carbon Fuel (BCLCF) Code, and that BCLCF code includes a credit for the capture of the biogas.

Equation 2: Eligible Reductions

$$Eligible\ Reductions = P_R\ X\ (1 - \text{Supplied}_{BCLCF})$$

Where,

P_R = Total project reductions calculated using Equation 1 (tonnes CO_2e)

Supplied_{BCLCF} = Percentage of the total biogas captured, supplied under a BCLCF including a credit for methane avoidance

7.2 QUANTIFICATION - LANDFILL GAS (LFG) MANAGEMENT

In the following section, provides a calculation method for quantifying the GHG emissions associated with each of the SSRs for LFG projects listed in Table 2.

Equation 3: Total Emissions for SSR i

$$T_i = \sum_{i,j} (T_{i,j} \times GWP_j)$$

Where,

T_i = Total emissions in tonnes CO_2e (carbon dioxide equivalent) for SSR i

$T_{i,j}$ = Total GHG emissions for SSR i and GHG j

GWP_j = 100-year global warming potential for GHG j for a carbon dioxide referent

For Global warming potentials (GWP) for GHG j, the latest values from the B.C. Carbon Neutral Government Regulation[7] must be used.

7.2.1 Project Emissions and Removals

7.2.1.1 Emissions from Fossil Fuel used for LFG Collection (LFG-P1)

This emission source is the direct combustion or transformation of Fossil Fuel to provide non-electricity generation services specifically for functioning of the Operation, such as providing building heat. Emissions associated with this SSR must be calculated using Equation 4:

Equation 4: Emissions from Fossil Fuel Use for LFG Collection (LFG-P1)

$$T_{P1,j,m} = \sum_{h,j,k} EF_{FC,j,h} \times AL_{col,k,h,m}$$

Where,

$T_{P1,j,m}$ = Total emissions of GHG j (emissions of CO_2, CH_4, and N_2O are to be assessed) for Project Report Period m

$EF_{FC,j,h}$ = Fuel combustion emission factor of GHG j (e.g., tonnes of GHG j / litre) based on Fossil Fuel type h

$AL_{col,k,h,m}$ = Activity Level which is Quantity of Fossil Fuel type h consumed at each landfill k for LFG collection (e.g., litres) for Project Report Period m

Determining the emission factor ($EF_{FC,j,h}$)

A default emission factor from the latest version of relevant emission factors under General Stationary Combustion of the Greenhouse Gas Emission Reporting Regulation (WCI.020) must be used[8]. The emission factor must be relevant to the Fossil Fuel type used.

Determining the activity level ($AL_{col,k,h,m}$)

There are two approaches to determine the quantity of Fossil Fuel consumed:

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[7] Source: http://www.bclaws.ca/Recon/document/ID/freeside/392_2008

[8] Source: https://www2.gov.bc.ca/assets/gov/environment/climate-change/ind/quantification/wci-2012.pdf

1) direct measurements of Fossil Fuel combusted, e.g., using flow meters, weigh scales, etc., or

2) purchase records and invoices.

The preferred method for determining activity levels is the direct measurement of Fossil Fuel delivered to the combustion unit(s). If direct forms of measurement are not economically feasible, Fossil Fuel sales records may be used. If Fossil Fuel sales records or invoices are used, the Project Proponent must demonstrate in each Project Report that there is no diversion of the purchased Fossil Fuels for other uses beyond Fossil Fuel emission sources covered by this SSR. The Project Proponent must also demonstrate in each Project Report that Fossil Fuels purchased for other purposes are not diverted for use in the Project combustion unit.

In the case where Fossil Fuels vary in their characteristics over time, a consistent unit of measure must be adopted for quantifying the activity level and the emission factor.

7.2.1.2 Grid Electricity Production, Transmission and Distribution (LFG-P2)

The source quantities the GHG emissions associated with generation and transmission of the electricity consumed by the landfill during the Project Scenario and is calculated using Equation 5.

Equation 5: Grid Electricity Emissions (LFG-P2)

$$T_{P2,j,m} = \sum_{k,j} EF_{elec,j} \times AL_{elec,k,m}$$

Where,

$T_{P2,j,m}$	=Total emissions of GHG j (emissions of CO_2, CH_4, and N_2O are to be assessed) due to electricity consumption for Project Report Period m (tCO_2e)
$EF_{elec,m}$	= Emission factor for GHG j producing, transmitting, and distributing electricity (e.g., tonne CO_2e / MWh) in Project Report Period m
$AL_{elec,m}$	= Activity Level which is total electricity consumed (e.g. MWh) by each landfill k for Project Report Period m

Determining an Emission Factor **(**$EF_{elec,m}$)

The Project Proponent must use the latest version of the B.C. Transmission Grid emission factor derived from the equation found in Schedule E of the Greenhouse Gas Emission Reporting Regulation[9] for the Project Report Period published on the Ministry of Environment's website.

Determining the Activity Level ($AL_{elec,m}$)

The activity level corresponds to the metered quantity of electricity consumed by the landfill resulting from the implementation and operation of the Primary Activity.

7.2.1.3 Emissions from Supplemental Fuel Use for Flaring (LFG-P3)

Fossil Fuel may be used to supplement the operation of the flare. Both CO_2 emissions and CH_4 fugitive emissions must be considered. Emissions associated with this SSR must be calculated using Equation 6.

[9] Source: https://www.bclaws.ca/civix/document/id/lc/statreg/249_2015#ScheduleE

Equation 6: Emissions from Use of Supplemental Fossil Fuel (LFG-P3)

$$T_{P3,j,m} = \sum_{x} \left(SF_{x,m} \times C_{CH4,ff} \times 0.0006775 \left[\left((1 - DE_x) \times GWP_{CH4} \right) + \left(DE_x \times \frac{12}{16} \times \frac{44}{12} \right) \right] \right)$$

Where,

$T_{P3,j,m}$	= Total emissions from supplemental Fossil Fuel for each GHG j during the Project Report Period m including both uncombusted CH_4 and CO_2 emissions (tCO_2e)
$SF_{x,m}$	= Total quantity of supplemental Fossil Fuel (scm) delivered to the destruction device x during the Project Report Period m
$C_{CH4,ff,m}$	= Average CH_4 concentration of the supplemental Fossil Fuel ff (scm of CH_4 / scm of Fossil Fuel) in Project Report Period m
0.0006775	= Density of CH_4 at standard temperature and pressure (tonnes of CH_4 / scm of CH_4)
DE_x	= Destruction efficiency of CH_4 of destruction device x from Appendix A Table 7
GWP_{CH4}	= Global warming potential of CH_4 taken from the B.C. Carbon Neutral Government Regulation[10]
12/16	= Carbon ratio of CH_4 (C/CH_4)
44/12	= Carbon ratio of carbon dioxide (CO_2/C)

Determining the Supplement Fuel consumption ($SF_{x,m}$)

The quantity of Fossil Fuel used as supplemental for the purposes of flaring may be established through two approaches:

1) direct measurements of Fuel combusted, e.g. using flow meters, weigh scales, etc., or

2) purchase records and invoices.

If Fossil Fuel sales records or invoices are used, the Project Proponent must demonstrate that there is no diversion of the purchased Fossil Fuels for other uses beyond Fossil Fuel emission sources covered by this SSR. The Project Proponent must also demonstrate that Fossil Fuels purchased for other purposes are not diverted for use in the Project combustion unit.

Where Fossil Fuels vary in their characteristics over time, a consistent unit of measure must be adopted for quantifying the activity level and the emission factor.

7.2.1.4 Emissions from on-site LFG Destruction Device (LFG-P4)

GHG emissions associated with the emissions from incomplete combustion of CH4, i.e., those emissions not destroyed by the destruction device x, must be calculated using Equation 7.

Equation 7: Emissions from Landfill Gas Fugitives (LFG-P4)

$$T_{P4,m} = \sum_{x} \left(LFG_{x,ma,t} \times t \times C_{CH4,LFG,ma,m} \times 0.0006775 \left((1 - DE_x) \times GWP_{CH_4} \right) \right)$$

Where,

[10] Source: http://www.bclaws.ca/Recon/document/ID/freeside/392_2008

$T_{P4,m}$ = Total emissions from incomplete combustion of CH_4 in LFG during the Project Report Period m (tCO_2e)
$LFG_{x,ma,t}$ = Adjusted landfill gas flow rate flowing to destruction device x in period t (scm of LFG / hour)
t = Time interval for which LFG flow and concentration measurements are aggregated (hours)
$C_{CH4,LFG,ma,m}$ = Average CH_4 concentration of LFG (scm of CH_4 / scm of LFG) using monitoring approach ma (see Section 7.2.3 to Section 7.2.5) in Project Report Period m
0.0006775 = Density of CH_4 at standard temperature and pressure (tonnes of CH_4 / scm of CH_4) Calculated in Section 7.2.3 to Section 7.2.5.
DE_x = CH_4 destruction efficiency of destruction device x. Appendix A
GWP_{CH4} = Global warming potential of CH_4 taken from the B.C. Carbon Neutral Government Regulation[11]

Determining LFG sent to destruction device x ($LFG_{x,ma,t}$)

This parameter is calculated based upon selected monitoring procedures in Section 7.2.3 to Section 7.2.5.

Determining Average LFG CH_4 Concentration ($C_{CH4,LFG,ma,m}$)

This parameter is calculated based upon selected monitoring procedures in Section 7.2.3 to Section 7.2.5.

7.2.1.5 Emissions from Upgrade of LFG (LFG-P5)

This emission source is the direct emission from the combustion or transformation of Fossil Fuel that provides services relating to upgrading of LFG consumption. Emissions associated with this SSR are calculated using Equation 8:

Equation 8: Emissions from Fossil Fuel Use Upgrade of LFG (LFG-P5)

$$T_{P5,j,m} = \sum_{h,j,k} EF_{FC,j,h} \times AL_{upg,k,h,m}$$

Where,
$T_{P5,j,m}$ = Total emissions of GHG j (emissions of CO_2, CH_4, and N_2O are to be assessed) for Project Report Period m (tCO_2e)
$EF_{FC,j,h}$ = Fuel combustion emission factor of GHG j (e.g. tonnes of GHG j / litre) based on Fossil Fuel type h
$AL_{upg,k,h,m}$ = Activity Level which is the quantity of Fossil Fuel of type h consumed for upgrading at each landfill k (e.g. litres) for Project Report Period m

Determining the emission factor ($EF_{FC,j,h}$)

A default emission factor from the latest version of relevant emission factors under General Stationary Combustion of the Greenhouse Gas Emission Reporting Regulation (WCI.020) must be used[12.] The emission factor must be applicable to the Fuel type used.

[11] Source: http://www.bclaws.ca/Recon/document/ID/freeside/392_2008
[12] Source: https://www2.gov.bc.ca/assets/gov/environment/climate-change/ind/quantification/wci-2012.pdf

Determining the activity level ($AL_{upg,k,h,m}$)

The quantity of Fuel used may be established through two approaches:
1. direct measurements of Fuel combusted, e.g. using flow meters, weigh scales, etc., or
2. purchase records and invoices.

Direct measurement of Fuel delivered to the combustion unit(s) must be used if physically and economically feasible. If direct forms of measurement are not physically or economically feasible, Fuel sales records may be used. If Fuel sales records or invoices are used, the Project Proponent must demonstrate, for each Project Report Period, that there is no diversion of the purchased Fuels for other uses beyond Fuel emission sources covered by this SSR. The Project Proponent must also demonstrate that Fuels purchased for other purposes are not diverted for use in the Project combustion unit.

Where Fuels vary in their characteristics over time, a consistent unit of measure must be adopted for quantifying the activity level and the emission factor.

If Fossil Fuel cannot be separated by function, all Fossil Fuel emissions must be calculated using Equation 4 and emissions from the upgrading of LFG can be excluded from further consideration.

7.2.2 Baseline Emissions and Removals

7.2.2.1 Emissions from Waste Breakdown in Landfill (LFG-B1)

The Baseline Scenario assumes that all uncontrolled CH_4 emissions are released to the atmosphere except for the portion of CH_4 that would be oxidized by bacteria in the soil in covered sections of the landfill in the absence of the activities of the Project[13]. Therefore, Baseline Emissions are equal to the sum of all CH_4 destroyed by eligible destruction devices during the Project Report Period.

Equation 9: Baseline Emissions from Waste Breakdown in Landfill (LFG-B1)

$$T_{B1,m} = (CH_4Dest_{PR}) \times (1 - OX) - CH_4Dest_{Base} \times \ (1 - OX)$$

Where,

$T_{B1,m}$	= Total baseline CH_4 emissions during Project Report Period m (tCH_4)
CH_4Dest_{PR}	= Total CH_4 destroyed by the Project LFG collection and destruction system during the Project Report Period m calculated using Equation 9
OX	= Factor for the oxidation of CH_4 by soil bacteria. Equal to 0.10 for all landfills except those that incorporate synthetic liners throughout the entire area of the final cover system, where OX = 0
CH_4Dest_{Base}	= Destruction of LFG in the baseline condition. If there is no destruction of LFG in the baseline condition this is equal to zero.

The term CH_4Dest_{PR} represents the amount of CH_4 destroyed by the Project. This parameter must be calculated using Equation 10.

[13] Landfill cover systems incorporating a synthetic liner throughout the entire area of the final covers system should use a default CH_4 oxidation rate of zero. A 10% CH_4 oxidation factor must be used for all other landfills and is based on Intergovernmental Panel on Climate Change (IPCC) guidelines (2006).

Equation 10: Total CH_4 Emissions Destroyed

$$CH_4Dest_{PR} = \sum_x (CH_4Dest_m) \times 0.0006775$$

Where,

$CH4\ Dest_{PR}$	= Total CH_4 destroyed by the Project LFG collection and destruction system during the Project Report Period m (tCH_4)
$CH_4Dest_{x,m}$	= The quantity of CH_4 destroyed by destruction device x (e.g. flare, engine, boiler, upgrade, etc.) during the Project Report Period m (e.g. scm of CH_4) calculated using Equation 11.
0.0006775	= Density of CH_4 at standard temperature and pressure (tonnes CH_4 / scm of CH_4)

Equation 11: Quantity of CH_4 Destroyed by Destruction Device x

$$CH_4Dest_m = \sum_x \left(Q_{x,ma,m} \times DE_x\right)$$

Where,

CH_4Dest_m	= The quantity of CH_4 destroyed by destruction devices (flare, engine, boiler, upgrade, etc.) during the Project Report Period m
$Q_{x,ma,m}$	= Total quantity of landfill CH_4 from monitoring approaches ma 1, 2, or 3, sent to destruction device x during the Project Report Period m (scm)
DE_x	= Default CH_4 destruction efficiency for device x[14] from Table 7

Determining Total Quantity of Landfill CH_4 ($Q_{x,ma,m}$)

The parameters used to calculate total quantity of landfill CH_4 sent to destruction device x during the Project Report Period m ($Q_{x,ma,m}$) may be determined depending upon the monitoring approach ma of key parameters of the landfill. Project Proponents must assert in the Project Plan the monitoring procedures that they intend to follow for the Project Crediting Period.

Where methane is destroyed in the baseline condition and the PoA consists of a new Project Instance, Project Proponents are required to account for the methane that would have been destroyed in the absence of the Project by using Equation 12.

This applies to Projects/PoA where methane was collected and destroyed prior to the project start date and therefore the baseline deduction shall be applied. The same reporting period and requirements applies to the baseline deduction (CH_4Dest_{Base}) as the total methane destroyed (CH_4Dest_{PR}).

The baseline deduction (CH_4Dest_{Base}) is calculated using the same method identified in Equation 10 and Equation 11 with specific values for $Q_{x,ma,m}$ and DE_x that apply to the baseline condition.

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[14] If available, the official source tested CH_4 destruction efficiency must be used in place of the default CH_4 destruction efficiency. Otherwise, project developers have the option to use either the default CH_4 destruction efficiencies provided, or the site-specific CH_4 destruction efficiencies as provided by a province or local agency accredited source test service provider, for each of the combustion devices used in the Project.

Monitoring approaches are presented in Sections 7.2.3 through 7.2.5 in increasing levels of accuracy. Project Proponents may adopt the more accurate monitoring approaches stated in the Protocol throughout the Project Crediting Period, e.g., Project using monitoring approach 1 installs a flow meter and adopts monitoring approach 2.

7.2.3 Monitoring Approach 1

Note: This approach is the least accurate method presented in the Protocol.

Equation 12: Total Quantity of Landfill CH_4 using Monitoring Approach 1

$$Q_{x,ma1,m} = MIN\left(Q_{modeled,m}\right), Q_{measured,m}$$

Where,

$Q_{x,ma1,m}$	= Total quantity of landfill CH_4 from landfill using monitoring approach 1 (ma1) sent to destruction device x in Project Report Period m
$Q_{modeled,m}$	= Total quantity of modeled landfill CH_4 from landfill using monitoring approach ma1 sent to destruction device x in Project Report Period m
$Q_{measured,m}$	= Total quantity of measured landfill CH_4 from landfill using monitoring approach ma1 sent to destruction device x in Project Report Period m

7.2.3.1 Determining Quantity of Modeled Landfill CH_4 ($Q_{modeled,m}$)

Modeled landfill CH_4 must be estimated using the ENV Landfill Gas Generation Estimation tool. The Project Proponent must assert in the Project Report that tool input parameters are representative of and specific to the landfill being assessed for Project Report Period m.

7.2.3.2 Determining Quantity of Measured Landfill CH_4 ($Q_{measured,m}$)

Quantity of landfill CH_4 is calculated using Equation 13.

Equation 13: Quantity of Landfill CH_4 Monitoring Approach 1

$$Q_{measured,m} \sum_{x,t} T_{m,ma1} \times LFG_{x,ma1,t} \times DMC_{x,ma1}$$

$Q_{measured,m}$	= Total quantity of measured landfill CH_4 from landfill using monitoring approach 1 ma 1 sent to destruction device x in Project Report Period m
$T_{m,ma1}$	= Time the destruction device for a landfill using monitoring approach 1 ma1 is operational in Project Report Period m (hours)
$LFG_{x,ma1,t}$	= Adjusted landfill gas flow rate flowing to destruction device x in period t (scm of LFG / hour)
$DMC_{x,ma1}$	= Default CH_4 concentration for landfills using monitoring approach 1 ma 1 – minimum CH_4 concentration threshold the destruction device x requires to be operational (scm CH_4 / scm of LFG)

7.2.3.3 Determining Landfill Gas Flow Rate ($LFG_{x,ma1,t}$)

There are two options for determining LFG flow rate:

1) Manufacturer's minimum operational default value

2) Established the lower bound of a fixed rate flow, e.g. using an inline vacuum blower

The flow rate must be quantifiable at any required time and must be recorded via on-site reading at minimum three times a year. If the flow rate is found to be less than the asserted constant flow rate at any of the on-site readings, the Project Proponent must calculate using the manufacturer's default value Option 1 for the period of time up to the previous reading that the stated constant flow rate was correct. The manufacturer's default value may only be applied for the time period where the flare was on.

7.2.4 Monitoring Approach 2

Equation 14: Quantity of Landfill CH_4 Monitoring Approach 2

$$Q_{x,ma2,m} = \sum_{x,t} \left[LFG_{x,ma2,t} \times t \times C_{CH_4,LFG,ma2,t} \times (1 - DF) \right]$$

Where,

$Q_{x,ma2,m}$	= Total quantity of landfill CH_4 from landfill using monitoring approach 2 ma2 sent to destruction device x in Project Report Period m
$LFG_{x,ma2,t}$	= Adjusted landfill gas flow rate flowing to destruction device x in period t (scm of LFG / hour)
t	= Time interval for which LFG flow and concentration measurements are aggregated (hours)
$C_{CH4,LFG,ma2,t}$	= The average CH_4 concentration of LFG from a landfill using monitoring approach 2 ma2 in time interval t (scm of CH_4 / scm of LFG)
DF	= Discount factor to account for uncertainty (20%)

Corrected values to standard conditions must be used in Equation 13. Project Proponents must use Equation 11 if the LFG flow metering equipment does not internally correct for temperature and pressure.

7.2.4.1 Determining Landfill Gas Volume Monitoring Approach 2 ($LFG_{x,ma2,t}$)

Measured continuously by a continuous flow meter and recorded at least once every 15 minutes. Data must be aggregated by time interval t. The project must ensure a sustainable and constant LFG flow rate. Constant LFG flow rate can normally be secured though utilization of a driving force to overcome barometric pressure fluctuations, as well as resistance and/or head loss caused by flow of gas through the proposed flare system. The value of the constant LFG flow rate must be less than the actual gas generation occurring within the landfill to avoid excessive extraction of gas from the field and related operational issues. The flow rate must be quantifiable at any required time and must be recorded at minimum 3 times a year.

7.2.4.2 Determining CH_4 Concentration Monitoring Approach 2 ($C_{CH4,LFG,ma2,t}$)

Project Proponents that select monitoring approach 2 for a landfill may use a monthly sampling approach using portable instruments to collect CH_4 concentration of LFG.

A portable instrument must either:

1. acquire Project data (e.g. a handheld CH_4 analyzer is used to take monthly CH_4 concentration measurements), or
2. be used to field check the calibration accuracy of equipment that acquires Project data and the portable instrument produces a data output that is or could be used in emission reduction calculations, i.e., portable gas flow meter and a portable CH_4 analyzer.

The portable LFG flow meter must be installed as close to the LFG combustion device as possible to measure the amount of gas reaching the device.

7.2.5 Monitoring Approach 3

Equation 15: Quantity of Landfill CH_4 Monitoring Approach 3

$$Q_{x,ma3,m} = \sum_{x,t} \left[LFG_{x,ma3,t} \times t \times C_{CH_4,LFG,ma3,t} \right]$$

Where,

$Q_{x,ma3,m}$	= Total quantity of landfill CH_4 from landfill using monitoring approach 3 ma3 sent to destruction device x in Project Report Period m
$LFG_{x,ma3,t}$	= Adjusted landfill gas flow rate flowing to destruction device x in period t (SCM of LFG / hour)
t	= Time interval for which LFG flow and concentration measurements are aggregated.
$C_{CH4,LFG,ma3,t}$	= The average CH_4 concentration of the LFG in time interval t (scm of CH_4 / scm of LFG) using monitoring approach 3 ma3

If any of the LFG flow metering equipment does not internally correct for the temperature and pressure of the LFG, separate pressure and temperature measurements must be used to correct the flow measurement. Corrected values must be used in all equations. Project Proponents must use Equation 16 only if the LFG flow metering equipment does not internally correct for temperature and pressure.

Equation 16: Adjusted LFG for Temperature and Pressure

$$LFG_{adjusted,t} = LFG_{unadjusted,t} \times \frac{288.705}{T_{meas,t}} \times \frac{P_{meas,ti}}{1.00}$$

Where,

$LFG_{adjusted,t}$	= Average volumetric flow of LFG sent to destruction device x in time interval t adjusted to standard temperature and pressure (scm / hour)
$LFG_{unadjusted,t}$	= Average volumetric flow of LFG for time interval t (m^3 of LFG / hour)
288.705	= °Kelvin standard temperature (°15.5 celsius)

$T_{meas,t}$ = Measured temperature of the LFG for time interval t (°Kelvin)
$P_{meas,t}$ = Measured pressure of the LFG for the time interval t (atm)

7.2.6 Accounting for Leakage

Not Applicable.

7.2.7 Project Reductions

Total Project Emissions are calculated as shown in Equation 17 and total Baseline Emissions are calculated by using

Equation 18 (except that some terms may not be required where SSRs have been excluded due to circumstances that are specific to the Project).

Equation 17: Total Project Emissions

(Project Emissions) = T(LFG-P1) + T(LFG-P2) + T(LFG-P2) + T(LFG-P3) + T(LFG-P4) + T(LFG-P5)

Where,
T(LFG-P1) = GHG emissions from Fossil Fuel used for LFG Collection SSR P1 in tonne CO_2e
T(LFG-P2) = GHG emissions from Project from Grid Electricity Generation, Transmission and Distribution SSR P2 in tonne CO_2e
T(LFG-P2) = GHG emissions from Project supplemental Fossil Fuel use SSR P2 in tonne CO_2e
T(LFG-P3) = GHG emissions from Project emissions from waste breakdown in landfill SSR P3 in tonne CO_2e
T(LFG-P4) = GHG emissions from Project LFG from Destruction Device SSR P4 in tonne CO_2e
T(LFG-P5) = GHG emissions from upgrade of LFG SSR P5 in tonne CO_2e

Equation 18: Total Baseline Emissions

(Baseline Emissions) = T(LFG-B1)

Where,
T(LFG-B1) = Baseline Emissions from Waste Breakdown in Landfill in tonnes CO_2e

Total Project Reductions due to a Project are calculated using Equation 1.

7.3 QUANTIFICATION - ORGANICS DIVERSION

In the following section, provides a calculation method for quantifying the GHG emissions associated with each of the SSRs for Organics Diversion projects LFG listed in Table 3.

For each Project Instance *PI*, for year *m*, convert individual GHG totals into total GHG emissions in units of tonnes of CO_2 equivalent (tCO_2e) using Equation 19:

Equation 19: Conversion to tCO_2e

$$T_{i,PI,m} = \sum_{j} \left(T_{i,j,PI,m} \times GWP_j\right)$$

Where,

$T_{i,PI,m}$ = Total GHG emissions for source type *i* for Project Instance *PI* for Project Report Period *m* (tonnes of CO_2e).

$T_{i,j,PI,m}$ = Total emissions of GHG *j* for source type *i* for Project Instance *PI* for Project Report Period *m* (tonnes of CO_2, tonnes of CH_4, tonnes of N_2O).

GWP_j = 100-year global warming potential for GHG *j* relative to CO_2.

Global warming potentials for GHG *j* must use the latest values set out in B.C. Carbon Neutral Government Regulation.[15]

7.3.1 Eligible Waste Quantification

The steps for quantifying eligible waste described below must be performed for each Project Instance *PI* for each year *m* in a Project Crediting Period.

Step 1 – Assert total Eligible Waste diverted

The total amount of Eligible Waste $M_{TotalDiversion,PI,m}$ diverted in Project Instance *PI* in year *m* must include all diversion of Eligible Waste.

Step 2 – Assert total Eligible Waste diverted to qualified and to unqualified facilities

The total amount of Eligible Waste diverted in Project Instance *PI* in year *m* to Qualified Organic Waste Management Facilities $M_{ToQualifiedOWMFs,PI,m}$ and to Unqualified Organic Waste Management Facilities $M_{ToUnqualifiedOWMFs,PI,m}$ must sum up to $M_{TotalDiversion,PI,m}$.

Step 3 - Assert baseline diversion rate

Assert baseline diversion rate $M_{BaselineDR,PI,m}$ from Section 5.2.2.

[15] Source: http://www.bclaws.ca/Recon/document/ID/freeside/392_2008

Step 4 - Adjust baseline diversion rate for new Regulatory Requirements, that were not voluntarily imposed

The adjusted baseline diversion rate $M_{Baseline,PI,m}$ is determined using Equation 20.

Equation 20: Adjusted Baseline Diversion Rate

$$\boldsymbol{M_{Baseline,PI,m} = M_{BaselineDR,PI,m} + max\{(M_{NewReg,PI,m} - M_{Plan,PI,m}), 0\}}$$

Where,

$M_{Baseline,PI,m}$	= Adjusted baseline diversion rate of eligible waste in Project Instance *PI* for year *m* (tonnes)
$M_{BaselineDR,PI,m}$	= Baseline diversion rate for Project Instance *PI* in year *m* as in Section 5.1(tonnes)
$M_{NewReg,PI,m}$	= Total amount of Eligible Waste that is required to be diverted in Project Instance *PI* in year *m* to meet Regulatory Requirements imposed since the Final Diversion Investment Decision (tonnes). If no new Regulatory Requirements are in effect, this value is zero.
$M_{Plan,PI,m}$	= Total amount of Eligible Waste in Project Instance *PI* planned to be diverted in year *m* resulting from a Final Diversion Investment Decision and stated in the Project Plan (tonnes).

Step 5 – Determine total incremental diversion of Eligible Waste

The increase, relative to the baseline, in Eligible Waste $M_{IncrDiversion,PI,m}$ is determined using Equation 21.

Equation 21: Total incremental diversion of Eligible Waste

$$M_{IncrDiversion,PI,m} = M_{TotalDiversion,PI,m} - M_{Baseline,PI,m}$$

Where,

$M_{IncrDiversion,PI,m}$	= Increase in Eligible Waste diversion, relative to the baseline, achieved in Project Instance *PI* in year *m* (tonnes);
$M_{TotalDiversion,PI,m}$	= Total amount of Eligible Waste diverted in Project Instance *PI* in year *m* (tonnes);
$M_{Baseline,PI,m}$	= Baseline amount of Eligible Waste diverted in Project Instance *PI* in year *m* (tonnes).

Step 6 – Determine the total diverted Eligible Waste that is available for Offset Units

The total amount of diverted Eligible Waste that is available for Offset Units $M_{TotalOffsetAvailable,PI,m}$ is determined using Equation 22.

Equation 22: Eligible Waste available for Offsets

$$M_{TotalOffsetAvailable,PI,m} = \min\{M_{IncrDiversion,PI,m}, (M_{ToQualifiedOWMFs,PI,m} - \Delta M_{ToUnqualifiedOWMFs,PI,m})\}$$

Where,

$M_{TotalOffsetAvailable,PI,m}$	= Total amount of Eligible Waste diverted in Project Instance *PI* in year *m* that is available for Offset Units (tonnes);
$M_{IncrDiversion,PI,m}$	= Increase in Eligible Waste diversion, relative to the baseline, achieved in Project Instance *PI* in year *m* (tonnes);
$M_{ToQualifiedOWMFs,PI,m}$	= Total amount of Eligible Waste diverted in Project Instance *PI* in year *m* to Qualified Organic Waste Management Facilities (tonnes);
$\Delta M_{ToQualifiedOWMFs,PI,m}$	= Decrease from the year before the first Project Crediting Period to year m, in amount of Eligible Waste diverted in Project Instance *PI* to Unqualified Organic Waste Management Facilities (tonnes), determined using Equation 23.

Equation 23: Eligible Waste leakage

$$\Delta M_{ToUnqualifiedOWMFs,PI,m} = max\{(M_{ToUnqualifiedOWMFs,PI,0} - M_{ToUnqualifiedOWMFs,PI,m}), 0\}$$

Where,

$M_{ToUnqualifiedOWMFs,PI,0}$	= Total amount of Eligible Waste diverted in Project Instance *PI* to Unqualified Organic Waste Management Facilities (tonnes) in the year before the first Project Crediting Period;
$M_{ToUnqualifiedOWMFs,PI,m}$	= Total amount of Eligible Waste diverted in Project Instance *PI* in year *m* to Unqualified Organic Waste Management Facilities (tonnes).

Step 7 – Determine the fraction of Eligible Waste available for Offsets out of total diverted

The fraction of diverted Eligible Waste available for Offset Units as a portion of all Eligible Waste diverted to Organic Waste Management Facilities $r_{OffsetAvailable,PI,m}$ is determined using Equation 24.

Equation 24: Fraction of Eligible Waste available for Offsets

$$r_{OffsetAvailable,PI,m} = \frac{M_{TotalOffsetAvailable,PI,m}}{M_{TotalDiversion,PI,m}}$$

Where,

$r_{OffsetAvailable,PI,m}$	= Fraction of diverted Eligible Waste available for Offset Units out of all Eligible Waste diverted to Organic Waste Management Facilities in Project Instance *PI* in year *m;*

$M_{TotalOffsetAvailable,PI,m}$	= Total amount of Eligible Waste diverted in Project Instance *PI* in year *m* that is available for Offset Units (tonnes);
$M_{TotalDiversion,PI,m}$	= Total amount of Eligible Waste diverted in Project Instance *PI* in year *m* to Organic Waste Management Facilities (tonnes).

Step 8 – Determine the fraction of Eligible Waste available for Offset Units out of total waste at facility

$R_{Available,f,PI,m}$ is determined using Equation M6. Where an Organic Waste Management Facility *f* only processes waste available for Offset Units, $R_{Available,f,PI,m} = 1$; where some of the waste processed at OWMF *f* is Eligible Waste not available for Offset Units or is Ineligible Waste, $R_{Available,f,PI,m} < 1$.

Equation 25: Fraction of Eligible Waste available for Offsets out of total waste at facility

$$R_{Available,f,PI,m} = r_{OffsetAvailable,PI,m} \times \frac{M_{Eligible,f,PI,m}}{M_{Total,f,m}}$$

Where,

$R_{Available,f,PI,m}$	= Fraction of diverted Eligible Waste available for Offset Units in Project Instance *PI* out of all organic waste processed at Organic Waste Management Facility *f* in year *m*;
$r_{OffsetAvailable,PI,m}$	= Fraction of diverted Eligible Waste available for Offset Units out of all Eligible Waste diverted to Organic Waste Management Facilities in Project Instance *PI* in year *m.*
$M_{Eligible,f,PI,m}$	= Amount of Eligible Waste in Project Instance *PI* processed at Organic Waste Management Facility *f* in year *m* (tonnes);
$M_{Total,f,m}$	= Amount of organic waste, including Ineligible Waste, processed at Organic Waste Management Facility f in year *m* (tonnes);

7.3.2 Project Emissions and Removals

7.3.2.1 Fuel Delivery to Organic Waste Management Facility (OD-P1)

This emission source ($T_{P1,PI,m}$) consists of GHG emissions from all non-electricity Fuel consumption associated with the transportation of Fuel used at all Project Organic Waste Management Facilities in year *m,* in Project Instance *PI*.

Equation 26 must be used to calculate non-electricity Fuel delivery emissions.

Equation 26: Fuel Delivery (OD-P1)

$$T_{P1,j,PI,m} = \sum_{f} R_{Available,f,PI,m} \times \left\{ \sum_{h} EF_{P1,j,h} \times AL_{P1,h,f,m} \right\}$$

Where,

$T_{P1,j,PI,m}$ = Total Fuel delivery emissions of GHG *j* in Project Instance *PI* in year *m* from all Project OWMFs (tonnes of GHG *j*);

$R_{Available,f,PI,m}$ = Fraction of diverted Eligible Waste in Project Instance *PI* available for Offset Units out of all organic waste at Organic Waste Management Facility *f* in year *m*;

$EF_{P1,j,h}$ = Non-electricity Fuel transportation emission factor for GHG *j* for non-electricity Fuel type *h* (tonnes of GHG *j* / litres of Fuel *h*).

$AL_{P1,h,f,m}$ = Amount of non-electricity Fuel type *h* combusted to transport Fuel to Organic Waste Management Facility *f* for Project Report Period *m* (litres of Fuel *h*).

Results from this equation must be converted to tCO_2e using Equation 19.

Emission factor $EF_{P1,j,h}$

Quantification must use a mobile combustion emission factor for GHG *j* for Fuel type *h* from Canada's most recent National Inventory Report: Greenhouse Gas Sources and Sinks in Canada.

If it is demonstrated to be a more accurate quantification method, then GHG emissions for CO_2 may be determined using WCI.23 and GHG emissions for CH_4 and N_2O emissions may be determined using WCI.24.

Activity level $AL_{P1,h,f,m}$

Non-electricity Fuel consumption for transport vehicles must be measured for each Fuel type *h* used in transporting Fuel delivered for use in the operation of each OWMF *f*.

7.3.2.2 Fuel Consumption for Operation of Organic Waste Management Facility (OD-P2)

This emission source ($T_{P2,PI,m}$) consists of GHG emissions from all Project Organic Waste Management Facilities in year *m* involving the combustion of non-electricity fuel, other than flaring, and involving the use of electricity, in Project Instance *PI*. CO_2 emissions from the combustion of biogas are not included in the calculation of $T_{P2,PI,m}$ since these emissions are considered biogenic.

Quantification of non-electricity Fuel combustion emissions ($T_{P2\_FossilF,j,f,m}$) at OWMF *f*, for each Fuel type *h*, must use WCI.23(b), (c) or (e), and if applicable WCI.23(f) for CO_2 emissions, and WCI.24 for CH_4 and N_2O emissions. Then $T_{P2\_FossilF,j,f,m}$ is the sum of emissions for all non-electricity Fuels as calculated using Equation 27

Equation 27: Fuel Combustion at OWMF *f*

$$T_{P2\_FossilF,j,f,m} = \sum_{h} T_{P2\_FossilF,j,h,f,m}$$

Quantification of electricity Fuel consumption emissions ($T_{P2\_Elec,f,m}$) associated with electricity supplied by the Integrated Grid to OWMF *f* must use Equation 28. Since the electricity emission factor in Equation 28 accounts for all GHGs, it is not necessary to use Equation 19 to convert the results into tCO_2e.

Equation 28: Integrated Grid Electricity Use at OWMF *f*

$$T_{P2\_Elec,f,m} = EF_{P2\_Elec,m} \times AL_{P2\_Elec,f,m}$$

Where,

$T_{P2\_Elec,f,m}$	= Total GHG emissions in tCO_2e due to consumption of electricity supplied to OWMF *f* in year *m* (tCO_2e);
$EF_{P2\_Elec,m}$	= Emission factor for electricity supplied by the Integrated Grid in year *m* (tCO_2e / MWh);
$AL_{P2\_Elec,f,m}$	= Total electricity consumed by OWMF *f* in year *m* (MWh).

<u>Emission Factor</u> $EF_{P2\_Elec,m}$

Project Proponents must use the appropriate electricity emission factor for year *m* published on the B.C. Ministry of Environment's website in accordance with Schedule E of the Greenhouse Gas Emission Reporting Regulation.

<u>Activity Level</u> $AL_{P2\_Elec,f,m}$

Electricity consumption for each OWMF *f* must be calculated based on Project data for year *m*.

Total GHG emissions for source P2, for Project Instance *PI* for year *m*, are the sum of emissions from combustion of all non-electricity Fuels and emissions from the use of electricity, for all OWMFs, scaled by $R_{Available,f,PI,m}$:

Equation 29: Fuel Consumption Emissions attributed to Local Government (LG)

$$T_{P2,PI,m} = \sum_{f} R_{Available,f,PI,m} \times \left\{ T_{P2\_Elec,f,m} + \sum_{j} \left(T_{P2\_FossilF,j,f,m} \times GWP_j \right) \right\}$$

7.3.2.3 Aerobic Composting (OD- P3C)

This emission source ($T_{P3C,PI,m}$) consists of GHG emissions from Aerobic Composting at all Project Organic Waste Management Facilities in year *m*, in Project Instance *PI*. Aerobic Composting emissions are calculated using Equation 30. CO_2 emissions from composting are not included in the calculation of $T_{P3C,PI,m}$ since these emissions are considered biogenic.

Equation 30: Aerobic Composting

$$T_{P3C,j,PI,m} = r_{OffsetAvailable,PI,m} \times \sum_{f} \left(EF_{compost,j,f} \times M_{Eligible,f,PI,m} \right)$$

Where,

$T_{P3C,j,PI,m}$	= Emissions of GHG *j* from Aerobic Composting, where *j* is CH_4 or N_2O (tonnes of CH_4 or N_2O);
$r_{OffsetAvailable,PI,m}$	= Fraction of diverted Eligible Waste available for Offset Units out of all Eligible Waste diverted to Organic Waste Management Facilities in Project Instance *PI* in year *m*;
$EF_{compost,j,f}$	= Emission factor from Table 5: CH_4 and N_2O Emission Factors for Aerobic Composting for GHG *j* for the applicable composting technology type at Organic Waste Management Facility *f* (tonnes CH_4 or N_2O / tonne Eligible Waste);
$M_{Eligible,f,PI,m}$	= Amount of Eligible Waste in Project Instance *PI* processed at Organic Waste Management Facility *f* in year *m* (tonnes).

Results from this equation must be converted to tCO_2e using Equation 19.

Emission Factor $EF_{compost,j,f}$

The CH_4 and N_2O emission factors applicable to the composting technology at the Organic Waste Management Facility are shown below in Table 5.

Table 5: CH_4 and N_2O Emission Factors for Aerobic Composting[16]

Composting Technology		CH_4 Emission Factor (tonne CH_4 / tonne waste)	N_2O Emission Factor (tonne N_2O / tonne waste)
Turned Compost	Basic (i.e. – Uncovered, turned windrows or piles)	0.09	0.09
	Optimized (i.e - Covered with ≥15cm finished compost or other carbonaceous material for first 3 weeks of composting cycle)	0.06	0.09
Forced Aeration System (e.g. (Positive or Negative Aerated Static Pile, etc.)	Basic (i.e. - Uncovered and no biofilter)	0.06	0.06
	Optimized (i.e. - Covered with: ≥15cm finished compost or other carbonaceous material for first 2 weeks of composting cycle; or employing synthetic covers, or biofilter)	0.03	0.06

7.3.2.4 Digestate Treatment (OD- P4D)

This emission source ($T_{P4D,PI,m}$) consists of GHG emissions from the treatment of digestate at all Project Organic Waste Management Facilities in year *m*, in Project Instance *PI*.

[16] Taken from B.C. Biogas & Composting Facility Greenhouse Gas Calculation Tool

Emissions associated with the treatment of digestate are calculated using Equation 31. CO_2 emissions from digestate treatment are not included in the calculation of $T_{P4D,PI,m}$ since these emissions are considered biogenic.

Equation 31: Digestate Treatment

$$T_{P4D,j,PI,m} = \sum_{f} R_{Available,f,PI,m} \times \left(EF_{digestate,j,f} \times M_{digestate,f,m}\right)$$

Where,

$T_{P4D,j,PI,m}$ = Emissions of GHG *j* from digestate treatment, where *j* is CH_4 or N_2O (tonnes of CH_4 or N_2O);

$R_{Available,f,PI,m}$ = Fraction of diverted Eligible Waste in Project Instance *PI* available for Offset Units out of all organic waste at Organic Waste Management Facility *f* in year *m*;

$EF_{digestate,j,f}$ = Emission factor from Table 6: CH_4 and N_2O Emission Factors for Digestate Treatment for GHG *j* for the applicable digestate treatment process at Organic Waste Management Facility *f* (tonne CH_4 or N_2O / tonne wet digestate);

$M_{digestate,f,m}$ = Amount of digestate produced at Organic Waste Management Facility f with the applicable digestate treatment process (tonnes wet digestate).

Results from this equation must be converted to tCO_2e using Equation 19.

If digestate from an Organic Waste Management Facility is not treated before being sent to a landfill or is treated in non-aerated static piles, all emissions associated with that digestate are to be calculated as waste decomposition emissions under source P8 instead of this SSR emission source.

Emission Factor $EF_{digestate,j,f}$

The CH_4 and N_2O emission factors applicable to the aerobic digestate treatment technology at the Organic Waste Management Facility are shown below in Table 6.

The emission factors are applicable whether the digestate is treated at the Organic Waste Management Facility or at another facility.

Table 6: CH_4 and N_2O Emission Factors for Digestate Treatment[17]

Digestate Technology by GHG Emission Risk Level	CH_4 Emission Factor (tonne CH_4 / tonne wet digestate)	N_2O Emission Factor (tonne N_2O / tonne wet digestate)
High: • Material treated at composting facility.	0.0048	0.0003
Medium:	0.0029	0.0002

[17] Adapted from Table 5.2 of CAR Organic Waste Digestion Project Protocol, v 2.1 by dividing the CO2e emission factors by the GWPs used in that document – 21 for CH_4 and 310 for N_2O.

• Digestate treated at the Organic Waste Management Facility in aerated systems (turned windrows or aerated static piles). • Material treated at a centralized composting facility.		
Low: • Digestate treated at the Organic Waste Management Facility in an enclosed system (in-vessel) utilizing a bio-filter or biogas scrubber.	0.001	0.00006
Zero: • Digestate thermally dried upon separation from liquid effluent. • Digestate used directly as animal bedding material. • Digestate immediately blended as soil amendment.	0	0

7.3.2.5 Effluent Storage Pond (OD-P5D)

This emission source ($T_{P5D,PI,m}$) consists of CH_4 emissions from digester effluent discharged to an open storage pond from all Project Organic Waste Management Facilities in year *m*, in Project Instance *PI*.

Emissions of CH_4 from digester effluent discharged to an open storage pond are calculated using Equation 32. CO_2 emissions from the effluent storage pond are not included in the calculation of $T_{P5D,PI,m}$ since these emissions are considered biogenic. N_2O emissions are not included in the calculation of $T_{P5D,PI,m}$ since these emissions are expected to be negligible.

Equation 32: Effluent Storage Pond

$$T_{P5D,CH_4,PI,m} = \sum_{f} R_{Available,f,PI,m} \times \left\{ B_{0,eff} \times MCF_{eff} \times \sum_{q=1}^{12} \left(V_{eff,q,f} \times COD_{eff,q,f} \right) \right\}$$

Where,

$T_{P5D,CH_4,PI,m}$ = Emissions of CH_4 from the effluent storage pond (tonnes CH_4);
$R_{Available,f,PI,m}$ = Fraction of diverted Eligible Waste in Project Instance *PI* available for Offset Units out of all organic waste at Organic Waste Management Facility *f* in year *m*;
$B_{0,eff}$ = Maximum methane producing capacity of the effluent per tonne chemical oxygen demand (COD) from Table 10: Parameter Constants (tonne CH_4 / tonne COD);
MCF_{eff} = Default methane correction factor for digester effluent, from Table 10: Parameter Constants;
q = Month number during year *m*;
$V_{eff,q,f}$ = Volume of effluent discharged into the storage pond in month *q* at Organic Waste Management Facility *f* (m^3);
$COD_{eff,q,f}$ = Chemical oxygen demand of the effluent discharged into the storage pond in month *q* at Organic Waste Management Facility *f* (tonne COD / m^3).

Results from this equation must be converted to tCO_2e using Equation 19.

7.3.2.6 Venting (OD-P6D)

This emission source ($T_{P6D,PI,m}$) consists of CH_4 emissions from venting biogas during upset events from all Project Organic Waste Management Facilities in year *m*, in Project Instance *PI*.

Emissions of CH_4 from venting biogas during upset events are calculated using Equation 33. CO_2 contained in the biogas is not included in the calculation of $T_{P6D,PI,m}$ since these emissions are considered biogenic. N_2O emissions are not included in the calculation of $T_{P6D,PI,m}$ since the percentage of N_2O in biogas is typically negligible.

Equation 33: Venting

$$T_{P6D,CH_4,PI,m} = \frac{\rho_{CH_4}}{1000} \times \sum_{f} R_{Available,f,PI,m} \times \left\{ \left(V_{vessel,f} + Q_{biogas,f,m} \times t_{f,m} \right) \times r_{CH_4,vent,f,m} \right\}$$

Where,

$T_{P6D,CH_4,PI,m}$ = Emissions of CH_4 from biogas venting (tonnes of CH_4);

ρ_{CH_4} = Density of CH_4 at standard temperature and pressure (15°C and 1 atm) from Table 10: Parameter Constants (kg/m³ CH_4);

1000 = Factor to convert ρ_{CH_4} to units of tonnes/m³ CH_4;

$R_{Available,f,PI,m}$ = Fraction of diverted Eligible Waste in Project Instance *PI* available for Offset Units out of all organic waste at Organic Waste Management Facility *f* in year *m*;

$V_{vessel,f}$ = Maximum volume of biogas in storage vessel at steady state at standard temperature and pressure (15°C and 1 atm) at Organic Waste Management Facility *f* (m³);

$Q_{biogas,f,m}$ = Flow rate of biogas at steady state at standard temperature and pressure (15°C and 1 atm) at Organic Waste Management Facility *f* in year *m* (m³/hr);

$t_{f,m}$ = Amount of time in year *m* that vessel is venting at facility *f* (hr);

$r_{CH_4,vent,f,m}$ = Volume fraction of CH_4 in the vented biogas at Organic Waste Management Facility *f* in year *m*.

Results from this equation must be converted to tCO_2e using Equation 19

7.3.2.7 Flaring (OD-P7D)

This emission source ($T_{P7D,PI,m}$) consists of GHG emissions from flaring supplementary Fuels and biogas from all Project Organic Waste Management Facilities in year *m,* in Project Instance *PI*.

Quantification of supplementary Fuel flaring combustion emissions ($T_{P7D\_SupplF,j,f,m}$) at OWMF *f*, for each Fuel type *h*, must use WCI.23(b), (c) or (e), and if applicable WCI.23(f) for CO_2 emissions, and WCI.24 for CH_4 and N_2O emissions. Then $T_{P7D\_SupplF,j,f,m}$ is the sum of emissions for all flared supplementary Fuels:

Equation 34: Supplementary Fuel flaring at OWMF *f*

$$T_{P7D\_SupplF,j,f,m} = \sum_{h} T_{P7D\_SupplF,j,h,f,m}$$

Quantification of biogas flaring combustion emissions ($T_{P7D\_Biogas,j,f,m}$) at OWMF *f* must use WCI.24 for CH_4 and N_2O emissions, using the volume of CH_4 in the biogas as the Fuel volume.

CO_2 emissions from the combustion of biogas are not included in the calculation of $T_{P7D,PI,m}$ since these emissions are considered biogenic.

Total GHG emissions for source OD-P7D, in Project Instance *PI* for year *m*, are the sum of emissions from the flaring of all supplementary Fuels and biogas, for all OWMFs, scaled by $R_{Available,f,LG,m}$ as calculated using Equation 35

Equation 35: Flaring

$$T_{P7D,j,PI,m} = \sum_{f} R_{Available,f,PI,m} \times \{T_{P7D\_SupplF,j,f,m} + T_{P7D\_Biogas,j,f,m}\}$$

Where,

$T_{P7D,j,LG,m}$	= Emissions of GHG *j* from flaring (tonnes of GHG *j*);
$R_{Available,f,PI,m}$	= Fraction of diverted Eligible Waste in Project Instance *PI* available for Offset Units out of all organic waste at Organic Waste Management Facility *f* in year *m*;
$T_{P7D\_SupplF,j,f,m}$	= Total emissions of GHG *j* for all flared supplementary Fuels at Organic Waste Management Facility *f* in year *m* (tonnes of GHG *j*);
$T_{P7D\_Biogas,j,f,m}$	= Total emissions of CH_4 or N_2O from biogas flaring at Organic Waste Management Facility *f* in year *m* (tonnes of CH_4 or N_2O).

Results from Equation 35 must be converted to tCO_2e using Equation 19.

7.3.2.8 Residual Waste Decomposition at Landfill (OD-P8)

This emission source ($T_{P8,PI,m}$) consists of GHG emissions from anaerobic decomposition of Residual Waste disposed at all landfills from all Project Organic Waste Management Facilities in year *m,* in Project Instance *PI*.

Emissions of CH_4 from anaerobic decomposition of Residual Waste are calculated using Equation 36.

Equation 36: Residual Waste Decomposition at Landfill

$$T_{P8,CH_4,PI,m} = \sum_{f} R_{Available,f,PI,m} \times \sum_{LF} \left(EF_{RW\_Decomp,CH_4,LF,m} \times M_{ResidualWaste,f,LF,m} \right)$$

Where,

$T_{P8,CH_4,PI,m}$	= Emissions of CH_4 from Residual Waste decomposition (tonnes of CH_4);
$R_{Available,f,PI,m}$	= Fraction of diverted Eligible Waste in Project Instance *PI* available for Offset Units out of all organic waste at Organic Waste Management Facility *f* in year *m*;
$EF_{RW\_Decomp,CH_4,LF}$	= Integrated emission factor for Residual Waste decomposition at landfill *LF,* calculated using Equation 37, for Residual Waste sent to landfill *LF* in year *m* (tonne CH_4 / tonne waste);
$M_{ResidualWaste,f,LF,m}$	= Amount of Residual Waste sent to landfill *LF* from Organic Waste Management Facility *f* in year *m* (tonnes waste).

If Residual Waste is being sent to multiple landfills and the partitioning of waste between these landfills cannot be verifiably determined, the highest landfill decay date k_{LF} for organic waste of all applicable landfills is to be used for calculation of emissions from Residual Waste decomposition at all these landfills.

Results from Equation 36 must be converted to tCO_2e using Equation 19.

Equation 37: Integrated Emission Factor for Residual Waste Decomposition at a Landfill

$$EF_{RW\_Decomp,CH_4,LF,m} = r_{maxCH_4} \times A \times TDOC \times k_{LF} \times \left\{ \sum_{x=1}^{n_{max}} \left(1 - LCE_{LF,m,x}\right)\left(e^{-k_{LF} \cdot x}\right) \right\}$$

Where,

$EF_{RW\_Decomp,CH_4,LF,m}$	= Integrated emission factor for decomposition of Residual Waste disposed at landfill *LF* in year *m* (tonne CH_4 / tonne waste);
r_{maxCH_4}	= Maximum fraction of methane assumed to be generated at a landfill out of the theoretical maximum methane generation $A \times TDOC$, from Table 10: Parameter Constants;
A	= Methane production capacity of organic waste, calculated using Equation 42 (tonne CH_4 / tonne carbon);
$TDOC$	= Default fraction of total degradable organic carbon in organic waste, from Table 10: Parameter Constants (tonne carbon / tonne waste);

k_{LF}	= Decay rate for organic waste at landfill *LF*, from Table 9: Landfill Decay Rate $\boldsymbol{k_{LF}}$ for Organic Waste (years^{-1});
x	= Number of years after waste disposal in year *m* at landfill *LF*;
n_{max}	= Maximum number of years it would take for waste disposed at a B.C. landfill to reach 95% decomposition, from Table 10: Parameter Constants (years);
$LCE_{LF,m,x}$	= Fraction of methane, for each year *x* after waste disposal in year *m,* assumed to be captured or destroyed by landfill gas collection system at landfill *LF*, calculated using Equation 43;
e	= Mathematical constant that is the base of the natural logarithm, from Table 10: Parameter Constants, rounded to five decimal places;

7.3.2.9 Energy Generation (OD-P9D)

This emission source ($T_{P9,PI,m}$) consists of GHG emissions from biogas combustion for energy generation from all Project Organic Waste Management Facilities in year *m,* in Project Instance *PI*.

Quantification of emissions from biogas combustion for energy generation at OWMF *f* ($T_{P9D\_Biogas,j,f,m}$) must use WCI.24 for CH_4 and N_2O emissions, using the volume of CH_4 in the biogas as the Fuel volume.

CO_2 emissions from the combustion of biogas are not included in the calculation of $T_{P9D,PI,m}$ since these emissions are considered biogenic.

Total GHG emissions for Energy Generation (OD-P9D), in Project Instance *PI* in year *m,* are calculated using Equation 38.

Equation 38: Energy Generation from Biogas

$$T_{P9D,j,PI,m} = \sum_{f} R_{Available,f,PI,m} \times T_{P9D\_Biogas,j,f,m}$$

Where,

$T_{P9D,j,PI,m}$	= Emissions of GHG *j* from biogas combustion for energy generation (tonnes of GHG *j*);
$R_{Available,f,PI,m}$	= Fraction of diverted Eligible Waste in Project Instance *PI* available for Offset Units out of all organic waste at Organic Waste Management Facility *f* in year *m*;
$T_{P9D\_Biogas,j,f,m}$	= Emissions of CH_4 or N_2O from biogas combustion for energy generation at Organic Waste Management Facility *f* in year *m* (tonnes of CH_4 or N_2O).

Results from this equation must be converted to tCO_2e using Equation 19.

7.3.3 Baseline Emissions and Removals

7.3.3.1 Baseline Waste Decomposition at Landfill (OD-B8)

This emission source ($T_{B8,PI,m}$) consists of GHG emissions from anaerobic decomposition of baseline Eligible Waste that would have been disposed at landfills in year *m* in Project Instance *PI*.

In order to be considered functionally equivalent, the amount of organic waste that would have been disposed at landfills is assumed to be equivalent to the amount of diverted Eligible Waste treated at Organic Waste Management Facilities using Equation 39.

Equation 39: Test of Functional Equivalence

$$M_{TotalDiversion,PI,m} = \sum_{LF} M_{Eligible,LF,PI,m} = \sum_{f} M_{Eligible,f,PI,m} = \sum_{LF,f} M_{Eligible,LF,f,PI,m}$$

Where,

$M_{TotalDiversion,PI,m}$	= Total amount of Eligible Waste diverted in Project Instance *PI* in year *m* (tonnes);
$M_{Eligible,LF,PI,m}$	= Amount of Eligible Waste that would have been disposed at landfill *LF* but was diverted to Organic Waste Management Facilities in Project Instance *PI* in year *m* (tonnes waste);
$M_{Eligible,f,PI,m}$	= Amount of Eligible Waste that would have been disposed at landfills but was diverted to Organic Waste Management Facility *f* in Project Instance *PI* in year *m* (tonnes waste);
$M_{Eligible,LF,f,PI,m}$	= Amount of Eligible Waste that would have been disposed at landfill *LF* but was diverted to Organic Waste Management Facility *f* in Project Instance *PI* in year *m* (tonnes waste).

Methane emissions resulting from anaerobic decomposition of Eligible Waste that would have been disposed at landfills are to be calculated using **Error! Reference source not found.**.

Equation 40: Baseline Waste Decomposition at Landfills

$$T_{B8,CH_4,PI,m} = r_{OffsetAvailable,PI,m} \times \left\{ \sum_{LF} EF_{Decomp,CH_4,LF,m} \times \left(\sum_{f} M_{Eligible,LF,f,PI,m} \right) \right\}$$

Where,

$T_{B8,CH_4,PI,m}$	= Emissions of CH_4 from anaerobic decomposition of baseline Eligible Waste that would have been disposed at landfills in Project Instance *PI* in year *m* (tonnes of CH_4);
$r_{OffsetAvailable,PI,m}$	= Fraction of diverted Eligible Waste available for Offset Units out of all Eligible Waste diverted to Organic Waste Management Facilities in Project Instance *PI* in year *m*;
$EF_{Decomp,CH_4,LF,m}$	= Integrated emission factor for Eligible Waste decomposition at landfill *LF,* calculated using Equation 41, for Eligible Waste that would have been disposed at landfill *LF* in year *m* (tonne CH_4 / tonne waste);
$M_{Eligible,LF,f,PI,m}$	= Amount of Eligible Waste that would have been disposed at landfill *LF* but was diverted to Organic Waste Management Facility *f* in Project Instance *PI* in year *m* (tonnes waste).

If baseline Eligible Waste would have been disposed at multiple landfills in Project Instance *PI* and the partitioning of waste between these landfills cannot be verifiably determined, the lowest landfill decay date k_{LF} for organic waste of all applicable landfills is to be used for calculation of emissions from baseline Eligible Waste decomposition at all these landfills.

Results from Equation 40 must be converted to tCO_2e using Equation 19.

Equation 41: Integrated Emission Factor for Waste Decomposition at a Landfill

$$EF_{Decomp,CH_4,LF,m} = r_{maxCH_4} \times A \times TDOC \times k_{LF} \times \left\{ \sum_{x=1}^{n_{max}} (1 - LCE_{LF,m,x})(e^{-k_{LF} \cdot x}) \right\}$$

Where,

$EF_{Decomp,CH_4,LF,m}$	= Integrated emission factor for decomposition of Eligible Waste at landfill *LF,* for Eligible Waste that would have been disposed at landfill *LF* in year *m* (tonne CH_4 / tonne waste);
r_{maxCH_4}	= Maximum fraction of methane assumed to be generated at a landfill out of the theoretical maximum methane generation $A \times TDOC$, from Table 10: Parameter Constants;
A	= Methane production capacity of organic waste, calculated using Equation 42 (tonne CH_4 / tonne carbon);
$TDOC$	= Default fraction of total degradable organic carbon in organic waste, from Table 10: Parameter Constants (tonne carbon / tonne waste);
k_{LF}	= Decay rate for organic waste at landfill *LF*, from Table 9: Landfill Decay Rate $\boldsymbol{k_{LF}}$ for Organic Waste(years^{-1});
x	= Number of years after waste disposal in year *m* at landfill *LF*;
n_{max}	= Maximum number of years it would take for waste disposed at a B.C. landfill to reach 95% decomposition, from Table 10: Parameter Constants (years);
$LCE_{LF,m,x}$	= Fraction of methane, for each year *x* after waste disposal in year *m,* assumed to be captured or destroyed by landfill gas collection system at landfill *LF*, calculated using Equation 43;
e	= Mathematical constant that is the base of the natural logarithm, from Table 10: Parameter Constants, rounded to five decimal places;

Equation 42: Methane Production Capacity

$$A = DOC \times MCF_{LF} \times (1 - OX) \times \frac{16}{12} \times F_{CH_4}$$

Where,

A	= Methane production capacity of organic waste (tonne CH_4 / tonne carbon);
DOC	= Default fraction of organic waste that decomposes under anaerobic conditions, from Table 10: Parameter Constants;
MCF_{LF}	= Default methane correction factor for a landfill, from Table 10: Parameter Constants;
OX	= Default factor for the oxidation of methane by cover soil bacteria, from Table 10: Parameter Constants;
$16/12$	= Molar mass ratio of methane to carbon (tonne CH_4 / tonne C);

F_{CH_4} = Default fraction of methane in gas produced at a landfill, from Table 10: Parameter Constants.

Equation 43: Fraction of Methane captured by landfill gas collection system

$$\boldsymbol{LCE_{LF,m,x}} = \begin{cases} \mathbf{0}, & \mathbf{1} \le \boldsymbol{x} \le \mathbf{max}\left(\boldsymbol{yr_{LGCS,LF}} - \boldsymbol{m}, \mathbf{0}\right) \\ \mathbf{0.75}, & \mathbf{max}\left(\boldsymbol{yr_{LGCS,LF}} - \boldsymbol{m}, \mathbf{0}\right) + \mathbf{1} \le \boldsymbol{x} \le \mathbf{max}(\mathbf{2026} - \boldsymbol{m}, \mathbf{0}) \\ \mathbf{0.85}, & \mathbf{max}(\mathbf{2026} - \boldsymbol{m}, \mathbf{0}) + \mathbf{1} \le \boldsymbol{x} \le \boldsymbol{n_{max}} \end{cases}$$

Where,

$LCE_{LF,m,x}$ = Fraction of methane, for each year *x* after waste disposal in year *m,* assumed to be captured or destroyed by landfill gas collection system at landfill *LF*;
$yr_{LGCS,LF}$ = year of installation (actual if before Project start or planned if after) of landfill gas collection system (LGCS) at landfill *LF*;
m = Year of Project Report period;
2026 = starting year of assuming LGCS is present at landfill *LF* and has collection efficiency of 0.85;
n_{max} = Maximum time it would take for waste disposed at a B.C. landfill to reach 95% decomposition from Table 10: Parameter Constants (years).

Accounting for Leakage

The GHG sources commonly expected to be material to Organics Diversion projects using this Protocol are identified in Table 3: SSRs for Baseline and Project Scenarios for Organics Diversion Projects. The Project Plan must confirm that there are no other GHG sources that are material to the Project.

If the Project has an emission source that is potentially material and not included in Table 3 the Project Proponent must conduct a Leakage assessment as set out in the Regulation section 14(3)(k). Use Equation 19 to convert to tCO_2e.

The primary source of Leakage is the shifting of waste diversion from Unqualified Organic Waste Management Facilities to Qualified Organic Waste Management Facilities, which increases the amount of Eligible Waste sent to Qualified Organic Waste Management Facilities without increasing overall waste diversion rates.

This is addressed in Step 6 of Section 7.3.1: Eligible Waste Quantification of the Protocol, by accounting for the decrease from year *m-1* to year *m*, in the amount of Eligible Waste diverted in Project Instance *PI* to Unqualified Organic Waste Management Facilities.

7.3.4 Project Reductions

In this section, quantification results from sub-sections 7.3.2 to 0 are inputs for quantifying the Project Reduction for a project report period *m*, from all Project Instances *PI*.

Total Baseline Emissions for year *m* are calculated by using Equation 44 and total Project Emissions for year *m* are calculated as shown in Equation 45:

Equation 44: Total Baseline Emissions for year *m*

$$T_{Baseline,m} = \sum_{PI} T_{B8,PI,m}$$

Where,

$T_{B8,PI,m}$ = GHG emissions from anaerobic decomposition of baseline Eligible Waste that would have been disposed at landfills in year *m* in Project Instance *PI* (tonnes of CO_2e).

Equation 45: Total Project Emissions for year *m*

$$T_{Project,m} = \sum_{PI} \{T_{P1,PI,m} + T_{P2,PI,m} + T_{P3C,PI,m} + T_{P4D,PI,m} + T_{P5D,PI,m} + T_{P6D,PI,m} + T_{P7D,PI,m} + T_{P8,PI,m} + T_{P9D,PI,m}\}$$

Where,

$T_{P1,PI,m}$ = GHG emissions from all non-electricity Fuel consumption associated with the transportation of Fuel used at all Project Organic Waste Management Facilities in year *m,* in Project Instance *PI*;

$T_{P2,PI,m}$ = GHG emissions from all Project Organic Waste Management Facilities in year *m* involving the combustion of non-electricity fuel, other than flaring, and involving the use of electricity, in Project Instance *PI*;

$T_{P3C,PI,m}$ = GHG emissions from Aerobic Composting at all Project Organic Waste Management Facilities in year *m*, in Project Instance *PI*;

$T_{P4D,PI,m}$ = GHG emissions from the treatment of digestate at all Project Organic Waste Management Facilities in year *m*, in Project Instance *PI*;

$T_{P5D,PI,m}$ = GHG emissions from digester effluent discharged to an open storage pond from all Project Organic Waste Management Facilities in year *m*, in Project Instance *PI*;

$T_{P6D,PI,m}$ = GHG emissions from venting biogas during upset events from all Project Organic Waste Management Facilities in year *m*, in Project Instance *PI*;

$T_{P7D,PI,m}$ = GHG emissions from flaring biogas and supplementary Fuels from all Project Organic Waste Management Facilities in year *m,* in Project Instance *PI*;

$T_{P8,PI,m}$ = GHG emissions from anaerobic decomposition of Residual Waste disposed at all landfills from all Project Organic Waste Management Facilities in year *m,* in Project Instance *PI*;

$T_{P9D,PI,m}$ = GHG emissions from biogas combustion for energy generation from all Project Organic Waste Management Facilities in year *m,* in Project Instance *PI*.

Total emission reductions due to a project are calculated using Equation 1 and eligible emissions reductions are calculated using Equation 2 if applicable.

7.4 Quantification - Wastewater Treatment and Manure Management

In the following section, provides a calculation method for quantifying the GHG emissions associated with each of the SSRs for LFG projects listed in Table 4.

7.4.1 Project Emissions and Removals

SSR denotes whether the SSR is project (P) or baseline (B) and the number denotes the SSR reference value.

7.4.1.1 Facility Thermal Energy Generation (WT&MM-P1)

Equation 46: Facility Thermal Energy Generation

$$T_{P1,j,m} = \sum_{j,h} \left(EF_{j,h} \times AL_{TEG,h,m} \times CF\right)$$

Where,

$T_{P1,j,m}$ = Total emissions of GHG j (e.g. tonnes of CO_2, tonnes of CH_4, etc.) for period m

$EF_{j,h}$ = Emission factor for GHG j, (e.g. tonnes CO_2 / litre of diesel) for fuel type h

$AL_{TEG,h,m}$ = Activity level of total fuel consumed for type h for thermal energy generation (e.g. litres diesel) in Project Report Period m

CF = Conversion factor to be used when the units of the activity level do not match those of the emission factor. Where both the activity level and emission factor are expressed in the same units, CF would be set to 1

7.4.1.2 Emissions from On-site Mobile and Stationary Support Equipment (WT&MM-P2)

Equation 47: On-site Mobile and Support Equipment

$$T_{P2,j,m} = \sum_{j,h,x} \left(EF_{j,h} \times AL_{h,x,m} \times CF\right)$$

Where,

$T_{P2,j,m}$ = Total emissions from mobile and support equipment of GHG j (e.g. tonnes of CO_2, tonnes of CH_4, etc.) for period m

$EF_{j,h}$ = Emission factor for GHG j for fuel type h (e.g. tonnes of CO_2 / litre)

$AL_{h,x,m}$ = Activity level of total fuel consumed for type h by mobile and support equipment x (e.g. litres diesel) in Project Report Period m

CF = Conversion factor to be used when the units of the activity level do not match those of the emission factor. Where both the activity level and emission factor are expressed in the same units, CF would be set to 1

Determining an Emission Factor

Given the range of reasonable, low uncertainty Fossil Fuel combustion emission factors available for standard fuels (gasoline, diesel, natural gas, etc.), an average emission factor from the latest version of relevant emission factors under General Stationary Combustion of the Greenhouse Gas Emission Reporting Regulation (WCI.020) must be used.

In selecting an appropriate emission factor, the Project Proponent is required to ensure that the factor selected is relevant to the fuel type and equipment type used.

Determining the Activity Level

The total quantity of fuel consumed is determined using typical fuel consumption data per Project Report Period.

7.4.1.3 Transport Emissions to the Facility

7.4.1.3.1 Manure Management

For Manure Management Projects, if off-farm Eligible Waste is transported to the BCS e.g., Centralized Digester, these transportation emissions are calculated using Equation 48.

Equation 48: Transport Emissions (MM-P3)

$$T_{P3,j,m} = \sum_{j,h} EF_{trans,j,h} \times AL_{FC,h,m}$$

Where,

$T_{P3,j,m}$ = Total emissions of GHG j (emissions of CO_2, CH_4, and N_2O are to be assessed) for Project Report Period m

$EF_{trans,j,h}$ = Fuel transportation emission factor for GHG j, (e.g. tonnes CO_2 / litre of diesel) for fuel type h

$AL_{FC,h,m}$ = Quantity of transport fuel combusted (e.g. litres of diesel) for fuel type h in Project Report Period m calculated in Equation 49.

Determining the Emission Factor

For standard mobile combustion fuels (e.g. gasoline, diesel, etc.), an emission factor from the latest Canada National Inventory Report may be used if the emission factor selected is appropriate for the vehicle and fuel type used, and separate emission factors for CO_2, CH_4, and N_2O are available. Where different types of vehicles or fuels are used in fuel transportation, associated emission calculations must be performed separately for each vehicle and fuel type.

Determining the Activity Level

Two approaches to determine the activity level (i.e. quantity of fuel combusted by the transport vehicles) may be used. Where available and appropriate, the most accurate approach of using monitored fuel consumption data for transport vehicles on the actual route(s) affected by the Project is used. For baseline data, to account for any shipment to shipment variability, transport vehicle fuel consumption data for the most recent one-year historic period must be used to determine a baseline transport vehicle fuel consumption value per unit of fuel delivered to the baseline site. This value must be multiplied by total baseline fuel delivered to determine the total fuel combusted by baseline transport vehicles during the quantification period in question.

Alternatively, where detailed transport fuel consumption data are not available, fuel consumption can be estimated using the following equation:

Equation 49: Activity Level Fuel Consumed

$$AL_{FC,h,m} = \sum_{h,x}(FE_x \times D) \times \left(\frac{F_{h,m}}{L_x}\right)$$

Where,

$AL_{FC,h,m}$	= Activity level of total fuel consumed for type h by fuel transport vehicles (e.g. litres diesel) in Project Report Period m
FE_x	= Average fleet fuel economy of fuel transport vehicles x (e.g. litres of diesel / km)
D	= Transport distance per transport vehicle per truck load (km)
$F_{h,m}$	= Total feedstock delivered (e.g. tonnes) for Project Report Period m
L_x	= Fuel cargo load per fuel transport vehicle equipment type x (e.g. tonnes of feedstock / truck load)

FE_x and L_x must be based on the specific types of vehicles transporting fuel in the Project / Baseline Scenario. Where multiple vehicle types are used with differing FE_x and L_x, the calculation must be performed separately for each vehicle equipment type x.

7.4.1.3.2 Wastewater Treatment

Not applicable.

7.4.1.4 Emissions from Waste Treatment and Storage (non-BCS) (WT&MM-P4)

7.4.1.4.1 Manure Management

Equation 50: Emissions from Waste Treatment and Storage

$$T_{P4,CH_4,m} = \sum_{L}\left(EF_{CH_4,L,nBCS_S} \times P_{L,m}\right) \times 0.001$$

Where,

$T_{P4,CH4,m}$	= Total Project Emissions from the waste treatment and storage (tonnes of CH_4) from non-BCS for Project Report Period m
$EF_{CH4,L,nBCSs}$	= Average emission factor for CH_4 emissions from waste treatment and storage (kg CH_4 / head / Project Report Period, i.e., one year) for livestock category L
$P_{L,m}$	= Average population of livestock category L (based on monthly population data) for Project Report Period m calculated using Equation 53
0.001	= conversion factor kg / metric tonnes

Determining an Emission Factor

An emission factor for CH_4 emissions from waste treatment and storage in the non-BCS can be calculated using Equation 51.

Equation 51: Emission Factor for non-BCS

$$EF_{CH_4,L,nBCS_S} = \left(VS_L \times B_{o,L} \times RD_{rp} \times 0.6775\right) \times \left(\sum_{S}\left(MCF_S \times MS_{L,S}\right)\right)$$

Where,

$EF_{CH4,L,nBCSs}$ = Average emission factor for CH_4 emissions from manure treatment and storage for livestock category L (kg CH_4 / head / Project Report Period, i.e., one year)

VS_L = Volatile solids produced by livestock category L on a dry matter basis (kg / head / day) calculated using Equation 52

$B_{0,L}$ = Maximum methane producing capacity for manure for livestock category L (m^3CH_4 / kg) from Table 11: Volatile Solids ($VS_{LU,L}$), Average Mass ($Mass_L$) and Maximum Methane Potential Eligible Livestock ($B_{0,L}$)(m^3 CH_4 / kg VS added)

RD_{rp} = Reporting days in a Project Report Period (days / period) Days with missing data are not eligible to report i.e., days with missing data beyond what is permitted for substitution according to Section 10.1.3.2: Data Substitution Methods (WT&MM) and must be subtracted from the number of reporting days

0.6775 = Density of methane at standard temperature and pressure (kg / scm)

MCF_S = Methane conversion factor for system component S (fraction (0-1)) from Table 12: Methane Conversion Factors (MCF_s) by Manure Management System Component for the appropriate average annual temperature (°C)

$MS_{L,S}$ = Percent of manure from livestock category L that is managed in the non-BCS system component S accounting for the removal of volatile solids through solids separation (fraction 0-1) Default values found in Table 15: Volatile Solids Removed Through Solids Separation (MSL,s) (MSAS,L) (MSL,BCS)

Determining Volatile Solids

The volatile solids produced by livestock category L on a dry matter basis (kg / head / day) calculated using Equation 52.

Equation 52: Volatile Solids on Dry Matter Basis

$$VS_L = VS_{LU,L} \times \frac{Mass_L}{1000}$$

Where,

VS_L = Volatile solids produced by livestock category L on a dry matter basis (kg / animal / day)

$VS_{LU,L}$ = Volatile solid excretion look up for livestock category L (kg / day / 1000 kg) from Table 11: Volatile Solids ($VS_{LU,L}$), Average Mass ($Mass_L$) and Maximum Methane Potential Eligible Livestock ($B_{0,L}$)

$Mass_L$ = Average live mass for livestock category L (kg) from Table 11.

Equation 53: Average Population in Reporting Month

$$P_{L,m} = \frac{\sum_L \left(RD_{rm,p} \times P_{L,p}\right)}{RD_{rp}}$$

Where,

$P_{L,m}$ = Average population of livestock category L (based on monthly population data) for a Project Report Period m (head)

$RD_{rm,p}$ = Reporting days in the reporting month p (days). Days with missing data are not eligible to report i.e., days with missing data beyond what is allowed to be substituted according to Section 10.1.3.2: Data Substitution Methods and must be subtracted from the number of reporting days

$P_{L,p}$ = Monthly average population of livestock category L (head)

RD_{rp}	= Reporting days in the Project Report Period (days) Days with missing data are not eligible to report i.e., days with missing data beyond what is allowed to be substituted according to Section 10.1.3.2 and must be subtracted from the number of reporting days

7.4.1.4.2 Wastewater Treatment Digestion

Not applicable.

7.4.1.5 Emissions from the BCS (metered and venting) (WT&MM-P5)

Methane destruction on-site is calculated using Equation 54.

Equation 54: Biogas Metered Methane Destruction

$$T_{P5,CH4,m} = \sum_{p} \left[CH_{4,metered,p} \times \left(\left(\frac{1}{BCE_x} \right) - BDE_{weighted,p} \right) + CH_{4,vent,p} \right]$$

Where,

$T_{P5,CH4,m}$	= Total Project Emissions from the Biogas Collection System (BCS) for CH_4 for Project Report Period m
$CH_{4,metered,p}$	= Quantity of methane collected in month p (tonnes of CH_4 / month) calculated in Equation 55
BCE_x	= Biogas collection efficiency for BCS type x, the fraction of monthly methane collected by the BCS (fraction (0-1)) must be taken from Table 14: Biogas Collection Efficiency (BCE_x)
$BDE_{weighted,p}$	= Monthly weighted average of all fractional destruction efficiencies of devices used in month p (fraction (0-1)) calculated using Equation 56
$CH_{4,vent,p}$	= the quantity of methane that is vented to the atmosphere due to the BCS in month p (tonnes of CH_4 / month) calculated using Equation 58
p	= Each month in each Project Report Period

Equation 55: Biogas Metered

$$CH_{4,metered,p} = F_p \times C_{CH_4} \times 0.6775 \times 0.001$$

$CH_{4,metered,p}$	= Quantity of methane collected in month p (tonnes of CH_4 / month)
F_p	= Volume of biogas from the digester in month p (scm / month). If device does not internally adjust for stp, Project Proponent must calculate using Equation 57
C_{CH4}	= Methane concentration in the biogas (Fraction (0-1))
0.6775	= Density of methane (kg / scm)
0.001	= Conversion factor (kg / tonnes)

Default values from Table 7 must be used for each biogas destruction device (BDE_x). When a device is not listed in Table 7, a default value of 0.9 must be used or the Project Proponent must undergo direct testing of the device to determine its capture efficiency.

Equation 56: Weighted Biogas Destruction Efficiencies

$$BDE_{weighted,p} = \frac{\sum_x \left(F_{x,p} \times BDE_x \right)}{\sum_x F_{x,p}}$$

Where,

$BDE_{weighted,p}$ = Monthly weighted average of all fractional destruction efficiencies of devices used in month p (fraction (0-1))
$F_{x,p}$ = Volume of biogas in month p sent to biogas destruction device x in standard cubic meters (scm)
BDE_x = Biogas destruction efficiency of device x from Table 7. Biogas flow to an inoperable device must be counted as a separate device with a biogas destruction efficiency (BDE_x) of zero when calculating the fractional monthly weighted average destruction efficiency
$F_{x,p}$ = Volume of biogas in month p sent to biogas destruction device x in standard cubic meters (scm)

Biogas flow must be calculated under standard conditions. Biogas metering equipment that does not internally correct gas flow volumes to standard conditions must apply Equation 57 to volume of biogas prior to calculating metered methane destruction.

Equation 57: Flow Meter Correction

$$F_{corrected,ti} = F_{vol,ti} \times \frac{288.705}{T_{meas,ti}} \times \frac{P_{meas,ti}}{1.00}$$

Where,
$F_{corrected,ti}$ = Corrected volume of biogas for time interval ti adjusted to standard temperature and pressure
288.705 = °Kelvin standard temperature (scm) (°15.5 celsius)
$F_{vol,ti}$ = Volumetric flow of biogas measured for time interval ti *(*m^3)
$T_{meas,ti}$ = Measured temperature of the biogas for time interval ti (°Kelvin)
$P_{meas,ti}$ = Measured pressure of the biogas for the time interval ti (atm)

Equation 58: Biogas Venting Emissions

$$CH_{4,vent,p} = \sum_k \left(\left(F_{pw,k} \times t_k + MaxS_{BCS} \right) \times C_{CH4} \right) \times 0.6775 \times 0.001$$

Where,
$CH_{4,vent,p}$ = the quantity of methane that is vented to the atmosphere due to the BCS in month p (tonnes of CH_4 / month)
$F_{pw,k}$ = The average daily biogas production from the digester for the 7 days preceding the venting event k (scm /day)
t_k = The number of days for each uncontrolled venting event *k* from the BCS system (can be a fraction) (days)
$MaxS_{BCS}$ = Maximum storage of biogas of the BCS system (scm)
C_{CH4} = Methane concentration in the biogas (fraction (0-1))
0.6775 = Density of methane at standard temperature and pressure (kg / scm)
0.001 = Conversion factor kg / tonnes

7.4.1.6 Emissions from Waste Treatment Effluent and Discharge (WT&MM-P6)

7.4.1.6.1 Manure Management

Equation 59: Emissions from BCS Effluent (MM-P6)

$$T_{P6,CH4,m} = \sum_{n}\left(\left(\sum_{L} VS_L \times P_{L,m} \times B_{0,L} \times MS_{L,BCS} \times 0.3\right) \times RD_{rp} \times 0.6775 \times MCF_{ep} \times 0.001\right)$$

$T_{P5,CH4,m}$	= Total Project Emissions from the effluent manure storage units for CH_4 for Project Report Period m
VS_L	= Volatile solids produced by livestock category L on a dry matter basis calculated using Equation 52
$P_{L,m}$	= Population of livestock category L for Project Report Period m calculated using Equation 53
$B_{0,L}$	= Maximum methane producing capacity for livestock category L from VS of dry matter from Table 3 (m^3 CH_4 / kg VS added)
$MS_{L,BCS}$	= Manure separated or fraction of manure from livestock category L that is managed by the BCS (fraction between 0-1) considering removal of volatile solids through solids separation (fraction 0-1)
0.3	= Default value representing the amount of VS that exists the digester as a percentage of the VS entering the digester
n	= Number of effluent manure storage units
RD_{rp}	= Reporting days in the Project Report Period (days)
MCF_{ep}	= Methane conversion factor of the effluent manure storage units (fraction between 0-1) from Table 12: Methane Conversion Factors (MCF_s) by Manure Management System Component for the appropriate average annual temperature (^oC)
0.6775	= Density of methane (kg / scm)

7.4.1.6.2 Wastewater Treatment

Sources of emissions from the effluent from the BCS is calculated according to Equation 60.

Equation 60: Emissions from Sludge Treatment Effluent and Discharge (WT-P6)

$$T_{P6ww,CH4,m} = \sum PE_{sl,treatment,m} + PE_{ww,discharge,m}$$

Where,

$T_{P6,ww,CH4,m}$	= Total Project Emissions in tonnes of methane from treatment of sludge from Wastewater digestor and discharge of Wastewater in Project Report Period m (tonne of CH_4)
$PE_{sl,treatment,m}$	= Project Emissions in tonnes of the sludge treatment systems affected by the Project in Project Report Period m calculated using Equation 61 (tonne of CH_4)
$PE_{ww,discharge,m}$	= Project Emissions from degradable organic carbon in treated Wastewater discharged into sea/river/lake in Project Report Period m calculated using Equation 63 (tonne of CH_4)

Part 1: Project Emissions Sludge Treatment

The methane emissions associated with the treatment of sludge are calculated using Equation 61.

Equation 61: Sludge Treatment

$$PE_{sl,treatment,m} = \sum_{d} S_{d,PJ,m} \times CF_{sl,treatment,d} \times DOC_{sl} \times UF_{PJ} \times DOC_{f} \times C_{CH4} \times 16/12$$

Where,

$PE_{sl.treatment,m}$	= Project Emissions of the sludge treatment systems affected by the Project in Project Report Period m (tonne of CH_4)
$S_{d,PJ,m}$	= Amount of dry matter in the sludge treated by the sludge treatment system d in the Project Scenario in Project Report Period m (tonnes of dry matter)
d	= Index for Project sludge treatment system
DOC_{sl}	= Degradable organic content of the untreated sludge generated in the reporting period m on a dry matter basis (fraction (0-1). Default values of 0.5 for domestic sludge
$CF_{sl,treatment,d}$	= Correction factor for methane for the Project sludge treatment system d from Table 13: Correction Factor for Methane (CF) ($CF_{sl,treatment,d}$) ($CF_{ww,PJ,discharge}$)($CF_{S,treatment,BL,j}$)($CF_{ww,treatment,BL,x}$)
UF_{PJ}	= Uncertainty factor to account for model uncertainties (1.12)
DOC_{f}	= Fraction of DOC dissimilated to biogas (IPCC default value of 0.5)
C_{CH4}	= Methane concentration in the biogas (fraction (0-1))

If the sludge is composted, the following equation must be applied:

Equation 62: Project Sludge Compost Emissions

$$PE_{sl,treatment,m} = \sum S_{d,PJ,m} \times EF_{composting}$$

Where,

$PE_{sl,treatment,m}$	= Project Emissions in tonnes of the sludge treatment systems affected by the Project in Project Report Period m (tonne of CH_4)
$S_{d,PJ,m}$	= Amount of dry matter in the sludge treated by the sludge treatment system d in the Project Scenario in Project Report Period m (tonne of dry matter)
$EF_{composting}$	= Emission factor for composting organic waste (tonne of CH_4 / tonne of waste treated).

Part 2: Project Emissions Wastewater Discharge

Equation 63: Project Emissions Wastewater Discharge

$$PE_{ww,discharge,m} = Q_{ww,m} \times B_{o,ww} \times UF_{PJ} \times COD_{ww,discharge,PJ,m} \times CF_{ww,PJ,discharge}$$

Where,

$PE_{ww,discharge,m}$	= Methane emissions from degradable organic carbon in treated Wastewater in Project Report Period m using an uncertainty factor of 1.12 and data applicable to the Project Scenario
$Q_{ww,m}$	= Volume of Wastewater discharged in Project Report Period m (m^3)
$B_{0,ww}$	= Methane producing capacity of Wastewater (IPCC value of 0.25 kg CH_4 / kg COD)

UF_{PJ} = Uncertainty factor to account for model uncertainties (1.12)
$COD_{ww,discharge,PJ,m}$ = Chemical Oxygen Demand of the treated Wastewater discharged into the sea, river or lake in the Project Scenario in Project Report Period m (tonnes / m^3)
$CF_{ww,PJ,discharge}$ = Correction factor for methane based on the discharge pathway of the Wastewater in the Project Scenario (e.g. into sea, river or lake) from Table 13: Correction Factor for Methane (CF) ($CF_{sl,treatment,d}$) ($CF_{ww,PJ,discharge}$)($CF_{S,treatment,BL,j}$)($CF_{ww,treatment,BL,x}$)

7.4.1.7 Emissions from Biogas Conditioning (WT&MM-P7)

Equation 64: Emissions Biogas Conditioning Equipment

$$T_{P7,j,m} = \sum_{j} \left(EF_{j,h} \times AL_{CE,h,m} \times CF\right)$$

Where,
$T_{P7,j,m}$ = Total emissions of GHG j (e.g. tonnes of CO_2, tonnes of CH_4, etc.) due to fuel consumption for period m
$EF_{j,h}$ = Emission factor for GHG j, (e.g. tonnes CO_2 / litre of diesel) for fuel type h
$AL_{CE,h,m}$ = Activity level of total fuel consumed for type h for conditioning equipment (e.g. litres diesel) in Project Report Period m
CF = Conversion factor to be used when the units of the activity level do not match those of the emission factor. Where both the activity level and emission factor are expressed in the same units, CF would be set to 1

7.4.1.8 Biogas Upgrading for Pipeline (WT&MM-P8)

Equation 65: Emissions Biogas Upgrading Equipment

$$T_{P8,j,m} = \sum_{j} \left(EF_{j,h} \times AL_{UE,h,m} \times CF\right)$$

Where,
$T_{P8,j,m}$ = Total emissions of GHG j (e.g. tonnes of CO_2, tonnes of CH_4, etc.) due to fuel consumption for period m
$EF_{j,h}$ = Emission factor for GHG j, (e.g. tonnes CO_2 / litre of diesel) for fuel type h
$AL_{UE,h,m}$ = Activity level of total fuel consumed for type h for upgrading equipment (e.g. litres diesel) in Project Report Period m
CF = Conversion factor to be used when the units of the activity level do not match those of the emission factor. Where both the activity level and emission factor are expressed in the same units, CF would be set to 1

Note: if the Project Proponent chooses to claim offsets from the displacement of natural gas, this Source must only be counted once and is equivalent to SSR P3 Processing of Fuel in the B.C. GHG Offset Protocol: Fuel Switch from Higher-GHG Intensive to Lower GHG-Intensive Fuels.

7.4.2 Quantification of Baseline Emissions and Removals

7.4.2.1 Facility Thermal Energy Generation (WT&MM-B1)

See Quantification Methodology for P1 in Section 8.1.1.

7.4.2.2 Emissions from On-site Mobile and Stationary Support Equipment (WT&MM-B2)

See Quantification Methodology for P2 in Section 8.1.2.

7.4.2.3 Emissions from Waste Treatment and Storage (WT-B3)

The quantification of Baseline Emissions from waste treatment and storage are different for manure management and Wastewater treatment.

7.4.2.3.1 Manure Management

This is the primary emissions source in the baseline. To ensure that the Baseline Emissions are not overstated, Project Proponents must calculate methane emissions using Equation 66.

Equation 66: Total Baseline Manure Treatment and Storage Methane Emissions (MM-B3)

$$T_{B3,mm,CH4,m} = MIN\left(CH_{4,BL,mm,model,m}\right), CH_{4,mm,meter,m}$$

Where,

$T_{B3,CH4,m}$ = Total baseline methane emissions from manure treatment and storage systems in Project Report Period m (tonne of CH_4)

$CH_{4,BL,mm,.model,m}$ = Modeled baseline methane emissions from Anaerobic manure storage / treatment systems in Project Report Period m (tonne of CH_4)

$CH_{4,mm,meter,m}$ = Metered project methane emissions from Anaerobic manure storage / treatment systems in Project Report Period m (tonne of CH_4)

Equation 67: Metered Methane Emissions

$$CH_{4,mm,meter,m} = \sum_{p} CH_{4,mm,meter,p}$$

$CH_{4,mm,meter,p}$ = Quantity of methane collected from BCS in month p (tonnes of CH_4 / month) calculated in Equation 55

Modeled emissions are determined based upon the conditions described in the selection of the Baseline Scenario in 5.3.

Equation 68: Modeled Baseline Emissions from Manure Treatment and Storage

$$CH_{4,BL,mm,model,m} = \sum_{L,p} \left(VS_{deg,AS,L,p,r} \times B_{0,L}\right) \times 0.6775 \times 0.001$$

Where,

$CH_{4,BL,mm,model,m}$ = Total modeled baseline methane emissions from Anaerobic manure storage / treatment systems in Project Report Period m (tonne of CH_4)

$VS_{deg,AS,L,p}$ = Volatile solids degraded in Anaerobic manure storage / treatment system on a monthly basis from livestock category L calculated using Equation 69 (kg dry matter)

$B_{0,L}$ = Methane producing capacity of manure for livestock category L (m^3 CH_4 / kg VS added)

0.6775 = Density of methane at standard temperature and pressure (kg / scm)

0.001	= conversion factor (tonnes / kg)

Equation 69: Volatile Solids Degraded

$$VS_{deg,AS,L,p} = VS_{avail,AS,L,p} \times f$$

Where,

$VS_{deg,AS,L,p,r}$	= Volatile solids degraded in Anaerobic manure storage / treatment system on a monthly basis from livestock category L (kg dry matter)
$VS_{avail,AS,L,p}$	= Volatile solids available for degradation from Anaerobic manure storage / treatment system AS by livestock category L calculated using Equation 28 (kg dry matter)
f	= Van't Hoff-Arrhenius factor calculated using Equation 71
p	= Each month in the Project Report Period

Equation 70: Volatile Solids Available for Degradation

$$VS_{avail,AS,L,p} = \left(VS_L \times P_{L,p} \times MS_{AS,L} \times RD_{rm,p} \times 0.8\right) + \left(VS_{avail,AS,L,p-1} - VS_{deg,AS,L,p-1}\right)$$

Where,

$VS_{avail,AS,L,p}$	= Monthly volatile solids available for degradation from Anaerobic manure storage / treatment system AS by livestock category L (kg dry matter)
VS_L	= Volatile solids produced by livestock category L on a dry matter basis (kg dry matter / animal / day) calculated using Equation 52
$P_{L,p}$	= Monthly average population of livestock category L (head)
$MS_{AS,L}$	= Fraction of manure handled in baseline animal manure management system AS taking into account removal of volatile solids through solids separation (fraction 0-1)
$RD_{rm,l}$	= Number of reporting days in the reporting month (days). Days with missing data are not eligible to report i.e., days with missing data beyond what is allowed to be substituted according to Section 10.1.3.2: Data Substitution Methods and must be subtracted from the number of reporting days
$VS_{avail,AS,L,p-1}$	= Volatile solids available for degradation from Anaerobic manure storage / treatment system AS by livestock category L from the previous month (kg)
$VS_{deg,AS,L,p-1}$	= Volatile solids available for degradation from Anaerobic manure storage / treatment system AS by livestock category L from the previous month (kg)

In cases where the retention time of the volatile solids in the Anaerobic storage/treatment system is fewer than or equal to 30 days, then the volatile solids retained in the system from the previous month ($VS_{avail, AS, L, i-1}$ - $VS_{deg,AS,L,i-1}$) must be set to zero.

When the for the month following the complete drainage and cleaning of solid buildup from the Anaerobic storage/treatment system, the volatile solids retained in the system from the previous month ($VS_{avail, AS, L, i-1}$ - $VS_{deg,AS,L,i-1}$) must be set to zero.

Equation 71: Van't Hoff-Arrhenius Factor

$$f = MIN\left(exp\left[\frac{E(T_2 - T_1)}{RT_1T_2}\right], 0.95\right)$$

Where,

f = Van't Hoff-Arrhenius Factor
E = Activation energy constant (15,175) (cal/mol)
T_1 = Default 303.16 °Kelvin
T_2 = Monthly average ambient temperature (°Kelvin) If T2 < 278.15°K (5 °C) then *f* is 0.104
R = Ideal gas constant 1.987 (cal/Kmol)

7.4.2.3.2 Wastewater Treatment

Equation 72: Total Baseline Wastewater Treatment Emissions (WT-B3)

$$T_{B3,ww,CH4,m} = MIN\left(CH_{4,BL,ww,model,m}\right), CH_{4,ww,meter,m}$$

Where,

$T_{B3,ww,CH4,m}$ = Total baseline methane emissions from Wastewater treatment systems in Project Report Period m (tonne of CH_4)

$CH_{4,BL,ww,model,m}$ = Modeled baseline methane emissions Wastewater treatment systems in reporting period m (tonne of CH_4)

$CH_{4,ww,meter,m}$ = Metered project methane emissions from Wastewater treatment systems in Project Report Period m (tonne of CH_4)

Equation 73: Metered Methane Emissions

$$CH_{4,ww,meter,m} = \sum_{p} CH_{4,ww,meter,p}$$

Where,

$CH_{4,ww,meter,m}$ = Metered project methane emissions from Wastewater treatment systems in reporting period m (tonne of CH_4)

$CH_{4,ww,meter,p}$ = Quantity of methane collected in BCS in month p (tonnes of CH_4 / month) calculated in Equation 55

Equation 74: Wastewater Treatment Baseline Methane Emissions

$$CH_{4,BL,ww,model,m} = \sum_{j}\left(Q_{ww,x,m} \times COD_{inflow,x,m} \times \eta_{COD,BL,x} \times CF_{ww,treatment,BL,x}\right) \times B_{0,ww} \times UF_{BL}$$

Where,

$CH_{4,BL,ww,model,m}$ = Total baseline methane emissions from Wastewater treatment system x in Project Report Period m (tonne CH_4)

$Q_{ww,x,m}$ = Volume of Wastewater treated in baseline Wastewater treatment system x in Project Report Period m (m^3)

$COD_{inflow,x,m}$ = the rate of COD of the Wastewater inflow to the baseline treatment system x in Project Report Period m (tonne / m^3)

$\eta_{COD,BL,x}$ = COD removal efficiency of the baseline treatment system x calculated from tonnes of $COD_{removed}$ / tonne of COD_{input} (Section 10.1.3.3: Establishment of Baseline Parameters)

$CF_{ww,treatment,BL,x}$ = Correction factor for methane for baseline Wastewater treatment systems x

	(CF values from Table 13: Correction Factor for Methane (CF) ($CF_{sl,treatment,d}$) ($CF_{ww,PJ,discharge}$)($CF_{S,treatment,BL,j}$)($CF_{ww,treatment,BL,x}$))
x	= baseline Wastewater treatment system type x
$B_{0,\ ww}$	=methane producing capacity of the Wastewater (0.25 tonnes CH_4 / tonne COD)[18]
UF_{BL}	= uncertainty factor to account for model uncertainties (0.89)

7.4.2.4 B4 Emissions from Waste Treatment Effluent and Discharge

7.4.2.4.1 Manure Management

Not applicable.

7.4.2.4.2 Wastewater Treatment

Equation 75: Emissions from Waste Treatment Effluent and Discharge (WT-B4)

$$T_{B4,ww,CH4,m} = \sum BE_{sl,treatment,m} + BE_{ww,discharge,m}$$

Where,

$T_{B4,\ ww,CH4,m}$	= Total baseline methane emissions from effluent and discharge from Anaerobic Wastewater storage treatment systems in Project Report Period m (tonne CH_4)
$BE_{sl,treatment,m}$	= Baseline Emissions in tonnes of the sludge treatment systems affected by the Project in Project Report Period m calculated using Equation 76 or Equation 77 (tonne CH_4)
$BE_{ww,discharge,m}$	= Baseline methane emissions from degradable organic carbon in treated Wastewater discharged into sea/river/lake in Project Report Period m calculated using Equation 79 (tonne CH_4).

Part 1: Baseline Emissions Sludge Treatment

Equation 76: Sludge Treatment

$$BE_{sl,treatment,m} = \sum_{d} S_{d,BL,m} \times CF_{sl,treatment,BL,j} \times DOC_{s} \times UF_{BL} \times DOC_{F} \times C_{CH4} \times\ 16/12$$

Where,

$BE_{sl,treatment,m}$	= Baseline Emissions in tonnes of the sludge treatment systems affected by the Project in Project Report Period m (tonne of CH_4)
$S_{d,BL,m}$	= Amount of dry matter in the sludge that would have been treated by the sludge treatment system d in the Baseline Scenario (tonne of dry matter). The *ex post* Emissions Reduction calculation must be based on the actual monitored volume of treated sludge ($S_{d,PJ,m}$)
d	= Index for baseline sludge treatment system
DOC_{Sl}	= Degradable organic content of the untreated sludge generated in the reporting period m on a dry matter basis (fraction (0-1). Default values of 0.5 for domestic sludge
$CF_{S,treatment,BL,d}$	= Correction factor for methane for the baseline sludge treatment system d

[18] Projects may use the default value of 0.6 kg CH_4 / kg BOD_5, if the parameter BOD_5 is used to determine the organic content of the Wastewater. In this case, Baseline and Project Emissions calculations must use BOD_5 instead of COD in the equations, and the monitoring of the Project must be based in direct measurements of BOD_5, i.e. the estimation of BOD_5 values based on COD measurements is not allowed.

UF_{BL} = Uncertainty factor to account for model uncertainties (0.89)
DOC_f = Fraction of DOC dissimilated to biogas (IPCC default value of 0.5)
C_{CH4} = Methane concentration in the biogas (Fraction (0-1))

If the baseline Wastewater treatment system is different from the treatment system in the Project Scenario, the sludge generation rate (amount of sludge generated per unit of COD removed) in the baseline may differ significantly from that of the Project Scenario. For example, typically the amount of sludge generated in aerobic Wastewater systems is larger than in Anaerobic systems, for the same COD removal efficiency. Therefore, for these cases, the monitored values of the amount of sludge generated during the Crediting Period will be used to estimate the amount of sludge generated in the baseline.

If the sludge is composted, Equation 77 must be used to calculate its emissions.

Equation 77: Baseline Sludge Compost Emissions

$$BE_{S,treatment,m} = \sum_{d} S_{d,BL,m} \times EF_{composting}$$

Where,

$BE_{s,treatment,m}$ = Baseline Emissions (tonnes) of the sludge treatment systems affected by the Project in Project Report Period m

$S_{d,BL,m}$ = Amount of dry matter in the sludge that would have been treated by the sludge treatment system d in the Baseline Scenario for Project Report Period m calculated using Equation 78(tonne of dry matter). The *ex post* Emissions Reduction calculation must be based on the actual monitored volume of treated sludge.

$EF_{composting}$ = Emission factor for composting organic waste (tonne of CH_4 / tonne of waste treated).

If the baseline Wastewater treatment system is different from the treatment system in the Project Scenario, the sludge generation rate (amount of sludge generated per unit of COD removed) in the baseline may differ significantly from that of the Project Scenario. For example, it is known that the amount of sludge generated in aerobic Wastewater systems is larger than in Anaerobic systems, for the same COD removal efficiency. For these cases, the monitored values of the amount of sludge generated during the Crediting Period will be used to estimate the amount of sludge generated in the baseline, as calculated using Equation 78: Sludge in Dry Matter TreatedEquation 78.

Equation 78: Sludge in Dry Matter Treated

$$S_{d,BL,m} = S_{l,PJ,m} \times \frac{SGR_{BL}}{SGR_{PJ}}$$

Where,

$S_{d,BL,m}$ = Amount of dry matter in the sludge that would have been treated by the sludge treatment system d in the Baseline Scenario (tonne of dry matter). The *ex post* Emissions Reduction calculation must be based on the actual monitored volume of treated sludge

$S_{l,PJ,m}$ = Amount of dry matter in the sludge (treated by the sludge treatment system d in Project Report Period m in the Project Scenario (tonne of dry matter)

SGR_{BL} = Sludge generation ratio of the Wastewater treatment plant in the Baseline Scenario (tonne of dry matter in sludge / tonne COD removed) see Appendix D

SGR_{PJ} = Sludge generation ratio of the Wastewater treatment plant in the Project Scenario (tonne of dry matter in sludge / tonne COD removed). Calculated using the monitored values of COD removal (i.e. $COD_{inflow,d}$ minus $COD_{outflow,d}$) and sludge generation in the Project Scenario

Part 2: Baseline Emissions Discharge

Emissions associated with Wastewater discharge into discharged into sea, river or lake in the Baseline Scenario.

Equation 79: Baseline Emissions Discharge

$$BE_{ww,discharge,y} = Q_{ww,y} \times B_{o,ww} \times UF_{BL} \times COD_{ww,discharge,BL,y} \times CF_{ww,BL,discharge}$$

Where,

$BE_{ww,discharge,m}$ = Baseline methane emissions from degradable organic carbon in treated Wastewater discharged into sea/river/lake in Project Report Period m

$Q_{ww,x,m}$ = Volume of Wastewater treated in baseline Wastewater treatment system x in Project Report Period m (m^3)

$B_{0,ww}$ = Methane producing capacity of Wastewater (IPCC value of 0.25 kg CH_4 / kg COD)

UF_{BL} = Uncertainty factor to account for model uncertainties (0.89)

$COD_{ww,discharge,BL,m}$ =Chemical Oxygen Demand of the treated Wastewater discharged into sea, river or lake in the baseline situation in Project Report Period m (tonne of COD / m^3). If the Baseline Scenario is the discharge of untreated Wastewater, the COD of untreated Wastewater must be used

$CF_{ww,BL,discharge}$= Correction factor based on discharge pathway in the Baseline Scenario (e.g. into sea, river or lake) of the Wastewater (fraction) (CF values as per Table 5)

To determine **$COD_{ww,discharge,BL,m}$**: if the baseline treatment system(s) is different from the treatment system(s) in the Project Scenario, the monitored values of the COD inflow during Crediting Period will be used to calculate the Baseline Emissions *ex post*. The outflow COD of the baseline systems will be estimated using the removal efficiency of the baseline treatment systems.

7.4.3 Accounting for Leakage

Not Applicable.

7.4.4 Project Reductions

Total Project Emissions are calculated as shown in Equation 37 and total Baseline Emissions are calculated by using Equation 38 (except that some terms may not be required where SSRs have been excluded due to Project-Specific circumstances).

Equation 80: Total Project Emissions

(Project Emissions) = T(P1) + T(P2) + T(P3) + T(P4) + T(P5) + T(P6) + T(P7) + T(P8)

Where,

T(P1) = GHG emissions from Project Facility Thermal Energy Generation SSR P1 in tonne CO_2e

T(P2) = GHG emissions from Project On-site Mobile and Stationary Support Equipment SSR P2 in tonne CO_2e

T(P3) = GHG emissions from Project Transport Emissions to the Facility SSR P3 in tonne CO_2e

T(P4) = GHG emissions from Project Waste Treatment and Storage SSR P4 in tonne CO_2e

T(P5) = GHG emissions from Project BCS (metered and venting) SSR P5 in tonne CO_2e

T(P6) = GHG emissions from Project Waste Treatment Effluent Pond SSR P6 in tonne CO_2e

T(P7) = GHG emissions from Project Biogas Conditioning SSR P7 in tonne CO_2e

T(P8) = GHG emissions from Project Biogas Upgrading for the Pipeline SSR P8 in tonne CO_2e

Equation 81: Total Baseline Emissions

(Baseline Emissions) = T(B1) + T(B2) + T(B3) + T(B4)

Where,

T(B1) = GHG emissions from Baseline Facility Thermal Energy Generation SSR B1 in tonne CO_2e

T(B2) = GHG emissions from Baseline Mobile and Stationary Support Equipment SSR B2 in tonne CO_2e

T(B3) = GHG emissions from Baseline Waste Treatment and Storage SSR B3 in tonne CO_2e

T(B4) = GHG emissions from Baseline Waste Treatment Effluent Pond SSR B4 in tonne CO_2e

Total emission reductions due to a project are then calculated using Equation 1 and eligible emissions reductions are calculated using Equation 2 if applicable.

8.0 PROJECT REDUCTION ESTIMATES

In accordance with section 14 (3) (I) of the Regulation, the Project Plan must include an estimate of the expected Project Reduction to be achieved during the Crediting Period. In the Project Plan, the Project Proponent must include the estimated Project Reduction for each Project Report Period, for each Project Instance if applicable. The Project Proponent must explain anticipated variability of the Project Reduction across Project Report Periods.

9.0 DATA COLLECTION & MONITORING

In the Project Plan, the Project Proponent must detail how data will be collected and managed in accordance with ISO 14064-2:06, sections 5.9 and 5.10 over the Crediting Period and record retention period established in section 27 of the Regulation. The data collection and monitoring approach must be validated and followed throughout the Crediting Period.

For Program of Activities Projects, some of the data or parameters may only be available for aspects of the Project included at initial validation. Project Instances added afterwards would be evaluated during the next verification.

Fuel sampling, analysis and measurement must be in accordance with WCI.25 Sampling, Analysis and Measurement Requirements. For electricity Fuel, electricity emission factors must be updated for each Project Report Period. Total electricity consumed must be measured continuously using an electricity meter approved by Measurement Canada.

9.1 DATA COLLECTION & MONITORING – LANDFILL GAS MANAGEMENT

In the Project Plan, the Project Proponents must detail their data monitoring plan in accordance with the following section.

9.1.1 Data and Parameters Available at Validation

The following parameters are known at the start of the Project (these may require updates over the course of the Project Crediting Period).

Data / Parameter:	Density of CH_4
Unit of measure:	Tonne of CH_4 / scm of CH_4
Description:	Density of CH_4 at standard temperature and pressure
Equations that use this parameter:	Equation 5, 6, 9
Value(s):	0.0006775
Data source(s):	WCI Final Essential Requirements of Mandatory Reporting (Second Update) WCI.253
Additional comments:	-

Data / Parameter:	Discount factor (DF)
Unit of measure:	Unitless
Description:	Discount factor to account for uncertainties associated with the monitoring equipment.
Equations that use this parameter:	Equation 13
Value(s):	0.2

Data source(s):	CAR, 2011
Additional comments:	Project Proponents must account for the uncertainty associated with monthly LFG CH_4 concentration measurements using monitoring approach 2 by applying a 20% discount factor to the total quantity of CH_4 collected and destroyed.

Data / Parameter:	OX
Unit of measure:	Unitless
Description:	Factor for the oxidation of CH_4 by soil bacteria within the cover of the landfill.
Equations that use this parameter:	Equation 8
Value(s):	0.10
Data source(s):	IPCC, 2006
Additional comments:	Equal to 0.10 for all landfills except those that incorporate a synthetic liner throughout the entire area of the final cover system where OX = 0

Data / Parameter:	CH_4 destruction efficiency of destruction device x (DE_X)
Unit of measure:	% Amount of CH_4 destroyed / amount of CH_4 sent to destruction device
Description:	Default CH_4 destruction efficiency for device x
Equations that use this parameter:	Equation 5, 6, 10
Value(s):	Refer to Appendix A for default values.
Data source(s):	CAR, 2019
Additional comments:	Project Proponents must use a default value (Appendix A). The operational activity of the LFG collection system and the destruction devices must be monitored and documented at least hourly to ensure actual LFG destruction.

9.1.2 Data and Parameters Available During Crediting Period

Data / Parameter:	Fuel combustion emission factor ($EF_{FC,j,h}$)
Unit of measure:	Mass GHGs per unit of mass, energy or volume consumed e.g. g CO_2 / litre, g CH_4 / scm
Description:	Fuel combustion emission factor of GHG j based on Fossil Fuel type h
Equations that use this parameter:	Equation 3, 7
Data source(s):	An average emission factor from the latest version of relevant emission factors under General Stationary Combustion of the latest version of the B.C. Methodological Guidance for Quantifying Greenhouse Gas Emissions (Table 1 or 2)

Measurement / estimation approach:	Estimated
Frequency of measurement / estimation:	Annually
QA/QC procedures:	Double-check values when entering data into Project data management system
Additional comments:	-

Data / Parameter:	Emission factor for electricity ($EF_{elec,m}$)
Unit of measure:	Mass GHGs per unit of electricity produced e.g. tonne CO_2e / MWh
Description:	Emission factor for GHG j producing, transmitting, and distributing electricity in Project Report Period m.
Equations that use this parameter:	Equation 4
Data source(s):	For B.C. Transmission Grid emission factors, Project Proponents must use the most recent consumption intensity emission factor for the province of British Columbia from Canada's National Inventory Report (Annex 13 – Table A13-11).
Measurement / estimation approach:	Estimated: Emission factors must be updated for each Project Report Period.
Frequency of measurement / estimation:	Project Report Period
QA/QC procedures:	Double-check values when manually entering into Project data management system
Additional comments:	-

Data / Parameter:	Quantity of Fossil Fuel consumed at each landfill for LFG collection ($AL_{col,k,h,m}$)
Unit of Measure:	Volume e.g. litres, scm
Description:	Quantity of Fossil Fuel consumed at each landfill k for LFG of Fossil Fuel type h, in Project Report Period m.
Equations that use this parameter:	Equation 3
Data source(s):	Project Proponent or energy provider
Measurement / estimation approach:	Measured: Mass or volumetric flow meter to Project / baseline equipment (note, Baseline Scenario values may require adjustment for Project-Specific circumstances). or Estimated: Summation of Fossil Fuel sales invoices where given quantity of purchased Fossil Fuel is used for both the Project and non-Project equipment, the proportion of Fossil Fuel used by the Project must be estimated by considering the expected rates of fuel consumption by Project and non-Project equipment consuming the fuel. The Project Proponent must clearly document how the estimated proportion was determined and that it is conservative (i.e. not under-estimated for the Project, not over-estimated for the baseline). Baseline values may require adjustment for Project-Specific circumstances.

Frequency of measurement / estimation:	Measured: Continuous Estimated: Monthly
QA/QC procedures:	1. Meter calibrated according to manufacturer specifications 2. Automatic system in place to alert system operator to meter malfunction 3. Periodic comparison against Fossil Fuel invoices or Double-check values when manually entering into Project data management system
Additional comments:	If the Fossil Fuel records are not able to be disaggregated from total on-site consumption records, this emissions source may be combined with P1.

Data / Parameter:	Total electricity consumed ($AL_{elec,m}$)
Unit of Measure:	Unit of electricity consumed e.g. MWh
Description:	Total electricity consumed by each landfill k for Project Report Period m
SSRs and equations that use this parameter:	Equation 4
Data source(s):	Electricity meter
Measurement / estimation approach:	Measured directly using electricity meter approved under Measurement Canada
Frequency of measurement / estimation:	Continuous metering
QA/QC procedures:	1. Meter calibrated according to manufacturer specifications Automatic system in place to alert system operator to meter malfunction
Additional comments:	-

Data / Parameter:	Total quantity of supplemental Fossil Fuel delivered to the destruction device x ($SF_{x,m}$)
Unit of measure:	Mass, volume or energy e.g. litres, scm, kg, tonne
Description:	Total quantity of supplemental Fossil Fuel delivered to the destruction device x during the Project Report Period m
Equations that use this parameter:	Equation 5
Data source(s):	Measured: Mass or volumetric flow meter Estimated: Third party supplier(s) sales invoice(s)
Measurement / estimation approach:	Measured: Mass or volumetric flow meter to Project / baseline equipment (note, baseline values may require adjustment for Project-specific circumstances) or Estimated: Summation of Fossil Fuel sales invoices where given quantity of purchased Fossil Fuel is used for both Project and non-Project equipment, the proportion of Fossil Fuel used by the Project must be estimated by considering the expected rates of Fossil Fuel consumption by Project and non-Project equipment consuming the Fossil Fuel. The Project Proponent must clearly document how the

	estimated proportion was determined and that it is conservative (i.e. not under-estimated for Project, not over-estimated for Baseline Scenario). (Baseline values may require adjustment for Project-specific circumstances.)
Frequency of measurement / estimation:	Measured: Continuous Estimated: Monthly or invoice period
QA/QC procedures:	1. Meter calibrated according to manufacturer specifications 2. Automatic system in place to alert system operator to meter malfunction 3. Periodic comparison against Fossil Fuel invoices or Double-check values when manually entering into Project data management system
Additional comments:	Metered prior to delivery to destruction device x and aggregated to total for Project Report Period.

Data / Parameter:	Average CH_4 concentration of the supplemental Fossil Fuel ($C_{CH4,ff,m}$)
Unit of measure:	% CH_4 by average volume (scm CH_4 / scm of Fossil Fuel)
Description:	Proportion of CH_4 in the natural gas in Project Report Period m
Equations that use this parameter:	Equation 5
Data source(s):	Fossil Fuel supplier invoice(s) Fossil Fuel Supplier Records – Project Proponents may also use fuel supplier data where the CH_4 concentration for their Fossil Fuel is published on their website, if those data are representative of the region and Project Report Period.
Measurement / estimation approach:	Measured by Fossil Fuel Supplier
Frequency of measurement / estimation:	Each invoice Or Per Fossil Fuel supplier records
QA/QC procedures:	Double check entry with invoice
Additional comments:	-

Data / Parameter:	The average CH_4 concentration of LFG from a landfill using monitoring approach 2 ($C_{CH4, LFG,ma2,t}$)
Unit of Measure:	% CH_4 by volume (scm / hr CH_4 per scm / hr LFG)
Description:	The average CH_4 concentration of LFG from a landfill using monitoring approach 2 ma2 in time interval t
Equations that use this parameter:	Equation 13
Data source(s):	Calibrated portable CH_4 analyzer – Project Proponent's records
Measurement / estimation approach:	Measurement: a calibrated portable gas analyzer

Frequency of measurement / estimation:	Monthly – minimum
QA/QC procedures:	-
Additional comments	The Project Proponent must collect the following information: • Date, time, and location of CH_4 measurement • CH_4 content of LFG (% by volume) for each measurement • CH_4 measurement instrument type and serial number • Date, time, and results of instrument calibration

Data / Parameter:	The average CH_4 concentration of the LFG ($C_{CH4,LFG,ma3,t}$)
Unit of Measure:	% CH_4 by volume (scm / hr CH_4 per scm / hr LFG)
Description:	The average CH_4 concentration in the LFG at a landfill in time interval t using monitoring approach 3 ma3
Equations that use this parameter:	Equation 14
Data source(s):	Continuous CH_4 analyzer – Project Proponent's records
Measurement / estimation approach:	Measurement – director measurement
Frequency of measurement / estimation:	Measured continuously and recorded every 15 minutes and averaged at least daily
QA/QC procedures:	Continuous CH_4 analyzers must be: • Cleaned and inspected according to manufacturer's specifications, as specified in the Project Plan, with activities and results documented by site personnel. Cleaning and inspection frequency must, at a minimum, follow the manufacturer's specifications. • Field checked for calibration accuracy by a third-party technician that uses either a portable instrument or manufacturer specified guidance, at the end of – but no more than two months prior to or after – the end date of the Project Report Period.[19] • Calibrated by the manufacturer or a certified third-party calibration service per manufacturer's guidance or every five years, whichever is more frequent. If the required calibration or calibration check is not performed and properly documented, no Offset Units may be generated for that Project Report Period. CH_4 analyzer calibrations must be documented to show that the calibration was carried out to the range of conditions (temperature and pressure) corresponding to the range of conditions as measured at the landfill. If the field check on a piece of equipment reveals accuracy outside of a +/- 5% threshold, calibration by the manufacturer or a certified service provider is required for that piece of equipment within 6 months of a failed test.

[19] Instead of performing field checks, the Project Proponent may have equipment calibrated by the manufacturer or a certified calibration service per manufacturer's guidance, at the end of but not more than two months prior to or after the date of the Project Report Period to meet this requirement.

	For the interval between the last successful field check and any calibration event confirming accuracy outside of the +/- 5% threshold, all data from that meter or analyzer must be scaled according to the following procedure. These adjustments must be made for the entire period from the last successful field check until such time as the meter is properly calibrated. 1. For calibrations that indicate under-reporting (lower CH_4 concentration), the metered values must be used without correction. 2. For calibrations that indicate over-reporting (higher CH_4 concentration), the metered values must be adjusted based on the greatest calibration drift recorded at the time of calibration. For example, if a Project conducts field checks quarterly during a year-long Project Report Period, then only three months of data will be subject at any one time to the penalties above. Frequent calibration may minimize the total accrued drift (by zeroing out any error identified) and result in smaller overall deductions. In addition, strong equipment inspection practices that include checking all probes and internal components will minimize the risk of meter and analyzer inaccuracies and the corresponding deductions. To provide flexibility in verification, data monitored up to two months after a field check may be verified. As such, the end date of the Project Report Period must be no more than two months after the latest successful field check. If a portable instrument is used (e.g. portable CH_4 analyzer), the portable instrument must be maintained and calibrated per the manufacturer's specifications, and calibrated at least annually by the manufacturer, by a laboratory approved by the manufacturer, or at an ISO 17025 accredited laboratory. The portable instrument must also be field calibrated to a known sample gas prior to each use. Other pieces of equipment used for QA/QC of monitoring instruments shall be maintained according to the manufacturer's specifications, including calibration where specified.
Additional comments:	CH_4 concentration of the LFG to be measured on a wet/dry basis (must be measured on the same basis as flow, temperature, pressure). The CH_4 analyzer and flow meter should be installed in the same relative placement to any moisture-removing components of the LFG system (there should not be a moisture-removing component separating the measurement of flow and CH_4 fraction). An acceptable variation to this arrangement is the flow meter is placed after a moisture-removing component (dry basis), while the CH_4 analyzer is placed before this component (wet basis). The opposite arrangement is not permissible. No separate monitoring temperature and pressure is necessary when using flow meters that automatically correct for temperature and pressure, expressing LFG volumes in normalized cubic meters

Data / Parameter:	Conservative LFG flow rate to destruction device ($LFG_{x, ma1,t}$)
Unit of measure:	scm of LFG / hr

Description:	A conservative flow rate of LFG from a landfill using monitoring approach 1 ma1 that is fed to destruction device x[20] in time interval t.
Equations that use this parameter:	Equation 12
Data source(s):	Option 1: Default flare manufacture's minimum requirements to Option 2: Establish a constant flow rate using an on-site fan
Measurement / estimation approach:	Option 1: Estimated – one time at the beginning of the Project. Option 2: Estimated based upon fixed blower one time at the beginning of the Project.
Frequency of measurement / estimation:	Option 1: Once at beginning of Project Option 2: Once at beginning of Project and each time fixed blower is adjusted.
QA/QC procedures:	Option 2: The flow rate must be quantifiable at any required time and must be recorded via on-site reading at minimum three times a year. If the flow rate is found to be less than the asserted constant flow rate at any of the on-site readings, the Project Proponent must calculate using the manufacturer's default value for the period of time up to the previous reading that the stated constant flow rate was correct. The manufacturer's default value may only be applied for the time period where the flare was on.
Additional comments:	A single meter may be used for multiple, identical destruction devices. CH_4 destruction in these units will be eligible only if both units are monitored to be operational. Using Option 2, a constant flow rate can normally be secured though utilization of a driving force to overcome barometric pressure fluctuations, as well as resistance and/or head loss caused by flow of gas through the proposed flare system. The value of the constant LFG flow rate shall be less than the actual gas generation occurring within the landfill to avoid excessive extraction of gas from the field and related operational issues.

Data / Parameter:	LFG flow rate to destruction device ($LFG_{x,ma2,t}$) ($LFG_{x,ma3,t}$)
Unit of measure:	scm of LFG / hr
Description:	Flow rate of LFG fed to destruction device x in time interval t. If the flow meter is not
Equations that use this parameter:	Equation 13, 14
Data source(s):	Flow meter output or data sheet
Measurement / estimation approach:	Measured
Frequency of measurement / estimation:	Continuous (minimum 15-minute intervals)
QA/QC procedures:	All gas flow meters[21] must be:

[21] Field checks and calibrations of flow meters must ensure that the meter accurately reads volumetric flow, and has not drifted outside of the prescribed +/-5% accuracy threshold.

	• Cleaned and inspected according to manufacturer's specifications, as specified in the Project Plan, with activities and results documented by site personnel. Cleaning and inspection frequency must, at a minimum, follow the manufacturer's recommendations. • Field checked for calibration accuracy by a third-party technician with the percent drift documented, using either a portable instrument (such as a pitot tube) or manufacturer specified guidance, at the end of – but no more than two months prior to or after – the end date of the Project Report Period.[22] • Calibrated by the manufacturer or a certified third-party calibration service per manufacturer's guidance or every 5 years, whichever is more frequent. If the required calibration or calibration check is not performed and properly documented, no Offset Units may be generated for that Project Report Period. Flow meter calibrations must be documented to show that the meter was calibrated to a range of flow rates corresponding to the flow rates expected at the landfill. If the field check on a piece of equipment reveals accuracy outside of a +/- 5% threshold, calibration by the manufacturer or a certified service provider is required for that piece of equipment within 6 months of a failed test. For the interval between the last successful field check and any calibration event confirming accuracy outside of the +/- 5% threshold, all data from that meter or analyzer must be scaled according to the following procedure. These adjustments must be made for the entire period from the last successful field check until such time as the meter is properly calibrated. 1. For calibrations that indicate under-reporting (lower flow rates, or lower CH_4 concentration), the metered values must be used without correction. 2. For calibrations that indicate over-reporting (higher flow rates, or higher CH_4 concentration), the metered values must be adjusted based on the greatest calibration drift recorded at the time of calibration. To provide flexibility in verification, data monitored up to two months after a field check may be verified. As such, the end date of the Project Report Period must be no more than two months after the latest successful field check. If a portable instrument is used, the portable instrument must be maintained and calibrated per the manufacturer's specifications, and calibrated at least annually by the manufacturer, by a laboratory approved by the manufacturer, or at an ISO 17025 accredited laboratory. The portable instrument must also be field calibrated to a known sample gas prior to each use.
Additional comments:	A single meter may be used for multiple, identical destruction devices. CH_4 destruction in these units will be eligible only if both units are monitored to be operational. Measured continuously by a flowmeter and recorded at least once

	every 15 minutes. Data to be aggregated by time interval *t* (this parameter is calculated in cases where the metered flow must be corrected for temperature and pressure). All flow data collected must be corrected for temperature and pressure at 15°C and 1 atm. The temperature and pressure of the LFG must be measured continuously. Corrected values must be used in all of the equations in this section.

Data / Parameter:	Destruction device operating time ($T_{m,ma1}$)
Unit of measure:	Hours
Description:	Time that the destruction device for a landfill using monitoring approach 1 ma1 is operational in Project Report Period m.
Equations that use this parameter:	Equation 12
Data source(s):	Project Proponent's records of time device is operational
Measurement / estimation approach:	Measured – records time operational using an on / off data logger on destruction device
Frequency of measurement / estimation:	Continuous
QA/QC procedures:	-
Additional comments:	-

Data / Parameter:	Temperature of LFG ($T_{meas,t}$)
Unit of measure:	°Kelvin
Description:	Measured temperature of the LFG for time interval t
Equations that use this parameter:	Equation 15
Data source(s):	Project Proponent
Measurement / estimation approach:	The temperature of the LFG is required to determine the density of the CH_4 combusted. If the LFG flow meter employed measures flow, pressure and temperature and displays or outputs the normalized flow of LFG, then there is no need for separate monitoring of pressure and temperature of the LFG.
Frequency of measurement / estimation:	Must be measured at the same time when CH_4 content in LFG is measured
QA/QC procedures:	All gas flow meters, and continuous CH_4 analyzers must be: 1) Cleaned and inspected on a quarterly basis with maintenance logs outlining maintenance duties according to manufacturer's specifications 2) Field checked by a trained professional for calibration accuracy with the percent drift documented, using either a portable instrument (such as a pitot tube), a permanent fixture or manufacturer specifications, at the end of but no more than two months prior to the end date of the Project Report Period;

[22] Instead of performing field checks, the project developer may instead have equipment calibrated by the manufacturer or a certified calibration service per manufacturer's guidance, at the end of but not more than two months prior to or after the date of the reporting period to meet this requirement.

	Calibrated by the manufacturer or a certified calibration service per manufacturer's specifications or every 5 years, whichever is more frequent
Additional comments:	No separate monitoring of temperature is necessary when using flowmeters that automatically adjust flow volumes for temperature and pressure, expressing LFG volumes in normalized cubic metres.

Data / Parameter:	Pressure of LFG ($P_{meas,t}$)
Unit of measure:	Atm
Description:	Measured pressure of the LFG for the time interval t
Equations that use this parameter:	Equation 15
Data source(s):	Project Proponent
Measurement / estimation approach:	Flow meter
Frequency of measurement / estimation:	Continuous
QA/QC procedures:	All gas flow meters, and continuous CH_4 analyzers must be: 1) Cleaned and inspected on a quarterly basis with maintenance logs outlining maintenance duties according to manufacturer's specifications 2) Field checked by a trained professional for calibration accuracy with the percent drift documented, using either a portable instrument (such as a pitot tube), a permanent fixture or manufacturer specifications, at the end of but no more than two months prior to the end date of the Project Report Period; Calibrated by the manufacturer or a certified calibration service per manufacturer's specifications or every 5 years, whichever is more frequent
Additional comments:	No separate monitoring of pressure is necessary when using flowmeters that automatically measure adjust flow volumes for temperature and pressure, expressing LFG volumes in normalized cubic metres

9.1.3 Data and Parameters Available After Crediting Period

N/A

9.2 DATA COLLECTION & MONITORING – ORGANICS DIVERSION

Mass of various Eligible Waste quantities used in the calculations in the previous sections must be measured directly by weigh scale for every load received at, or produced by, an Organic Waste Management Facility. Record the type of waste contained in every load.

Volumes of digester effluent and biogas must be metered directly.

In an emergency where biogas is vented and biogas flow rate could not be measured directly, the average flow rate for the last seven days with non-zero steady-state flow rate should be used to estimate the flow rate at the time of venting.

Volume fraction of CH_4 in biogas (vented, flared, or combusted for energy generation) must be measured with a continuous analyzer or, alternatively, with monthly measurements by using a direct sampling approach that yields a value with at least 95% confidence. CH_4 content measurement must be carried out close to a location in the system where a biogas flow measurement takes place.

All gas flow meters, and continuous methane analyzers must be:

1) Cleaned and inspected on a quarterly basis with maintenance logs outlining maintenance duties according to manufacturer's specifications
2) Field checked by a trained professional for calibration accuracy with the percent drift documented, using either a portable instrument (such as a pitot tube), a permanent fixture or manufacturer specifications, at the end of but no more than two months prior to the end date of the reporting period; and
3) Calibrated by the manufacturer or by a certified calibration service as per manufacturer's specifications, or every five years, whichever is more frequent.

If using a calibrated portable gas analyzer for CH_4 or CO_2 content measurement, all the following information must also be included for each measurement:

(1) Date, time, and location,
(2) Methane or carbon dioxide content of biogas (% by volume),
(3) Measurement instrument type and serial number,
(4) Date, time, and results of instrument calibration, and
(5) Corrective measures taken if instrument does not meet performance specifications.

9.1 DATA COLLECTION & MONITORING – WASTEWATER TREATMENT AND MANURE MANAGEMENT

In the Project Plan, the Project Proponents must detail their data monitoring plan in accordance with the following section.

9.1.1 Data and Parameters Available at Validation

Data / Parameter:	Emission factor for fuel combustion ($EF_{j,h}$)
Unit of measure:	Mass GHGs per unit of mass, energy or volume consumed e.g. g CO_2 / litre, g CH_4 / m^3
Description:	Fuel combustion emission factor of GHG j based on fuel type h

Equations that use this parameter:	Equation 46, Equation 47, Equation 64, Equation 65
Value(s):	-
Data source(s):	An average emission factor from the latest version of relevant emission factors under General Stationary Combustion of the Greenhouse Gas Emission Reporting Regulation (WCI.020) must be used
Additional comments:	-

Data / Parameter:	Density of methane at standard temperature and pressure
Unit of measure:	Kg / scm
Description:	The mass of methane at standard temperature and pressure. Standard temperature and pressure are defined as 101.325 kPa (1 ATM) at 288.705 °Kelvin (15.5 °Celsius)
Equations that use this parameter:	Equation 51, Equation 55, Equation 58, Equation 59, Equation 62
Value(s):	0.6775
Data source(s):	WCI Final Essential Requirements of Mandatory Reporting (Second Update)
Additional comments:	-

Data / Parameter:	Maximum methane producing capacity for livestock ($B_{0,L}$)
Unit of measure:	m^3 CH_4 / kg of VS
Description:	Provides the maximum amount of methane from each livestock per kg of volatile solids added.
Equations that use this parameter:	Equation 51, Equation 59, Equation 68
Value(s):	Table 3
Data source(s):	Canada National Inventory Report (1990 – 2013) Part 2
Additional comments:	-

Data / Parameter:	Volatile solid excretion look up ($VS_{LU,L}$)
Unit of measure:	kg / day / 1000 kg
Description:	The amount of volatile solids produced by each livestock category L per day per 1000 kg
Equations that use this parameter:	Equation 52
Value(s):	Table 3
Data source(s):	Canada National Inventory Report (1990 – 2013) Part 2 and California Air Resources Board: Compliance Offset Protocol Livestock Projects: Pacific Northwest Average
Additional comments:	-

Data / Parameter:	Methane conversion factor (MCF_S)
Unit of measure:	Fraction (0-1)
Description:	The methane conversion factor indicates the extent to which the CH_4 producing capacity (Bo) is realized in each type of treatment S and discharge pathway and system. For each system component of the manure management system, the methane conversion factor for systems other than the BCS and the effluent manure storage units (MCF_S) must be obtained from Table 4 using the appropriate system type and average annual temperature (°C).
Equations that use this parameter:	Equation 51
Value(s):	Table 4

Data source(s):	IPCC 2006 Methane Conversion Factors by Manure Management System Component/Methane Source ‘S’
Additional comments:	-

Data / Parameter:	Biogas collection efficiency (BCE_x)
Unit of measure:	Fraction (0-1)
Description:	Biogas capture efficiency of the BCS type x; accounts for Fugitive Emissions from the BCS.
Equations that use this parameter:	Equation 54
Value(s):	Table 7
Data source(s):	-
Measurement / estimation approach:	-
Additional comments:	-

Data / Parameter:	Biogas Destruction Efficiency (BDE_x)
Unit of measure:	Fraction (0-1)
Description:	Methane destruction efficiency of destruction device(s)
Equations that use this parameter:	Equation 56
Value(s):	Table 6
Data source(s):	Default values: California Air Resources Board: Compliance Offset Protocol Livestock Projects
Additional comments:	The Project Proponent must monitor the operational activity of each destruction device that receives biogas from the Project and must monitor, collect and maintain documentation of operation at minimum each hourly. No offset units will be issued for any period during which the destruction device is not operational. If for any reason the destruction device or the operational monitoring equipment is inoperable, during the period of inoperability, the destruction efficiency of the device is zero. If a destruction device is furnished with a safety shut-off device that prevents the flow of biogas to the destruction device when the destruction device is not operational does not require hourly monitoring. However, in these situations, the Project Proponent must demonstrate the presence, operability, and use of the safety device are verified.

Data / Parameter:	Maximum Storage of Biogas System ($MaxS_{BCS}$)
Unit of measure:	scm
Description:	Maximum storage of biogas of the BCS system. The total volume of biogas the system is able to contain.
Equations that use this parameter:	Equation 58
Value(s):	Determined through BCS system design
Data source(s):	Project Proponent
Additional comments:	The system design must be the final system that was implemented as the Project.

Data / Parameter:	Fraction of manure handled in baseline animal manure management system ($MS_{AS,L}$)
Unit of measure:	Fraction (0-1)
Description:	The fraction of volatile solids ($MS_{AS,L}$) sent to each Anaerobic storage/treatment systems for each livestock category represents the percent of manure that would be sent to (managed by) the Anaerobic

	manure storage/treatment systems, taking into account any volatile solids removed by solid separation equipment, in the Baseline Scenario. Site-specific data must be used, if available. If site-specific data are unavailable, values from Table 8 can be used to calculate $MS_{AS,L}$.
Equations that use this parameter:	Equation 70
Value(s):	Table 8
Data source(s):	Proponents operating records
Additional comments:	-

Data / Parameter:	COD removal efficiency ($\eta_{COD,BL,x}$)
Unit of measure:	Tonnes of $COD_{removed}$ / tonne of COD_{input}
Description:	The COD removal efficiency is used to calculate the total COD in tonnes that is removed from the system in Project Report Period m by multiplying against the total COD input into the system. In determining Baseline Emissions, historical records of at least one year prior to the post-system installation must be used, if available. See additional comments if unavailable.
Equations that use this parameter:	Equation 74
Value(s):	Determined through measurement.
Data source(s):	Project Proponent measurements
Additional comments:	All the available data in determining the required parameters (COD removal efficiency) must be used to determine the Baseline Emissions in Project Report Period m. **Existing Facilities** For Projects where historical data is unavailable, a pre-project measurement campaign must be implemented in accordance with the procedures described in Appendix D. **Greenfield Wastewater Treatment Facilities** Values may be obtained from a measurement campaign in a comparable existing Wastewater treatment plant, i.e., having similar environmental and technological circumstances for example treating similar type of Wastewater. Average values from the measurement campaign must be used, and the result must be multiplied by 0.89 to account for the uncertainty range (30 per cent to 50 per cent) associated with this approach. The treatment plant and Wastewater source can be considered as similar as the baseline plant, whereby the measurement campaign can be implemented when following conditions can be fulfilled: a) The two sources of Wastewater (Wastewater treated in the selected plant and from the Project) are of the same type, e.g. Municipal Wastewater; b) The selected plant and the baseline plants employ the same treatment technology (e.g. Anaerobic lagoons or activated sludge), and the hydraulic retention times in their biological and physical treatment systems do not vary by more than 20 per cent.

Data / Parameter:	Correction factor for methane ($CF_{ww,treatment,BL,x}$)
Unit of measure:	Fraction (0-1)
Description:	The CF indicates the extent to which the CH_4 producing capacity (Bo) is realized in each type of treatment and discharge pathway and system. Thus, it is an indication of the degree to which the system is Anaerobic.

Equations that use this parameter:	Equation 74
Value(s):	Table 5
Data source(s):	IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories
Additional comments:	-

Data / Parameter:	Methane producing capacity of the Wastewater ($B_{0,ww}$)
Unit of measure:	Kg CH_4 / kg COD
Description:	Provides the maximum amount of methane from Wastewater
Equations that use this parameter:	Equation 63, Equation 74, Equation 79
Value(s):	0.25
Data source(s):	IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories
Additional comments:	-

Data / Parameter:	Uncertainty factor to account for model uncertainties (UF_{PJ})
Unit of measure:	Fraction
Description:	Uncertainty factor to account for model uncertainties
Equations that use this parameter:	Equation 61, Equation 63
Value(s):	1.12
Data source(s):	-
Additional comments:	-

Data / Parameter:	Uncertainty factor to account for model uncertainties (UF_{BL})
Unit of measure:	Fraction
Description:	Uncertainty factor to account for model uncertainties
Equations that use this parameter:	Equation 72, Equation 74, Equation 77
Value(s):	0.89
Data source(s):	IPCC
Additional comments:	-

Data / Parameter:	Emission Factor Composting ($EF_{composting}$)
Unit of Measure:	CH_4/ tonne sludge treated on a dry weight basis
Description:	The methane emissions resulting from composting sludge
Equations that use this parameter:	Equation 62, Equation 75
Data source(s):	Project Proponent IPCC default value is 0.01
Measurement / estimation approach:	Default - IPCC default values (Table 4.1, chapter 4, Volume 5, 2006 IPCC Guidelines for National Greenhouse Gas Inventories)
Frequency of measurement / estimation:	Annual
QA/QC procedures:	-
Additional comments:	-

Data / Parameter:	$COD_{BL,inflow,n}$
Unit of measure:	Tonnes of COD
Description:	COD inflow to baseline treatment system x per volumetric unit of Wastewater e.g. tonnes of COD /m_3 in baseline period n.
Equations that use this parameter:	Equation 82

Value(s):	-
Data source(s):	Project Proponent’s records
Additional comments:	If no historical records are available, Project Proponents may establish baseline parameters using the method described in Appendix D.

Data / Parameter:	$COD_{BL,outflow,n}$
Unit of measure:	Tonnes of COD
Description:	COD output from the baseline treatment system in baseline period n
Equations that use this parameter:	Equation 82
Value(s):	-
Data source(s):	Historical records
Additional comments:	If no historical records are available, Project Proponents may establish baseline parameters using the method described in Appendix D.

Data / Parameter:	Baseline Dry Matter Sludge ($S_{BL,DM,n}$)
Unit of measure:	tonnes of dry matter
Description:	The amount of dry matter in the sludge in baseline period n
Equations that use this parameter:	Equation 84
Value(s):	2.
Data source(s):	Historical records
Additional comments:	If no historical records are available, Project Proponents may establish baseline parameters using the method described in Appendix D.

9.1.2 Data and Parameters Available During Crediting Period

Data / Parameter:	Quantity of fuel consumed for thermal energy ($AL_{TEG,h,m}$)
Unit of Measure:	Volume e.g. litres, m^3
Description:	Activity level of total fuel consumed for type h for thermal energy generation (e.g. litres diesel) in Project Report Period m
Equations that use this parameter:	Equation 46
Data source(s):	Project Proponent or energy provider
Measurement / estimation approach:	Measured: Mass or volumetric flow meter to Project / Baseline equipment (note, baseline values may require adjustment for project-specific circumstances). or Estimated: Summation of fuel sales invoices where given quantity of purchased fuel is used for both Project and non-project equipment, the proportion of fuel used by the Project must be estimated by considering the expected rates of fuel consumption by Project and non-project equipment consuming the fuel. The Project Proponent must clearly document how the estimated proportion was determined and that it is conservative (i.e. not under-estimated for the project, not over-estimated for the baseline). (Note: baseline values may require adjustment for Project-Specific circumstances.)
Frequency of measurement / estimation:	Measured: Continuous Estimated: Monthly
QA/QC procedures:	1. Meter calibrated according to manufacturer specifications 2. Automatic system in place to alert system operator to meter malfunction 3. Periodic comparison against fuel invoices and

	Systematic and documented approach to detercting errors that may result from manual data entry.
Additional comments:	-

Data / Parameter:	Quantity of fuel consumed for mobile and support equipment ($AL_{h,x,m}$)
Unit of Measure:	Volume e.g. litres, m^3
Description:	Activity level of total fuel consumed for type h by mobile and support equipment x (e.g. litres diesel) in Project Report Period m
Equations that use this parameter:	Equation 47
Data source(s):	Project Proponent or energy provider
Measurement / estimation approach:	Measured: Mass or volumetric flow meter to Project / baseline equipment (note, baseline values may require adjustment for Project-Specific circumstances). or Estimated: Summation of fuel sales invoices where given quantity of purchased fuel is used for both the Project and non-project equipment, the proportion of fuel used by the Project must be estimated by considering the expected rates of fuel consumption by Project and non-project equipment consuming the fuel. The Project Proponent must clearly document how the estimated proportion was determined and that it is conservative (i.e. not under-estimated for the Project, not over-estimated for the baseline). (Note: baseline values may require adjustment for Project-Specific circumstances.)
Frequency of measurement / estimation:	Measured: Continuous Estimated: Monthly
QA/QC procedures:	4. Meter calibrated according to manufacturer specifications 5. Automatic system in place to alert system operator to meter malfunction 6. Periodic comparison against fuel invoices and Systematic and documented approach to detercting errors that may result from manual data entry.
Additional comments:	If the fuel records are not able to be disaggregated from total on-site consumption records, this emissions source may be combined with P1.

Data / Parameter:	Average fleet fuel economy (FE_x)
Unit of Measure:	Volume per 100 km e.g. litre / 100 km
Description:	Average fleet fuel economy of fuel transport. The parameter must be based on the specific types of vehicles transporting fuel in the project / baseline. Where multiple vehicle types are used with differing FE_x, the calculation must be performed separately for each vehicle equipment type x.
Equations that use this parameter:	Equation 49
Data source(s):	Third-party supplier(s)
Measurement / estimation approach:	Provided by transport company based on vehicle specifications and fuel consumption records, reflecting typical gross vehicle weight of vehicles used to deliver fuel to Project / baseline Operations
Frequency of measurement / estimation:	Once per vehicle type
QA/QC procedures:	1. Cross-check against other typical fuel economy data for similar vehicles and

	Systematic and documented approach to detercting errors that may result from manual data entry.
Additional comments:	-

Data / Parameter:	Distance of transport vehicle (D)
Unit of Measure:	Km
Description:	Transport distance per transport vehicle per truck load
Equations that use this parameter:	Measure of distance traveled per shipment.
Data source(s):	Project Proponent or supplier
Measurement / estimation approach:	Vehicle odometer(s)
Frequency of measurement / estimation:	Measured: A minimum of three separate odometer readings Estimated: Use known distances or estimate distances traveled based upon shipment frequency
QA/QC procedures:	Once, or updated whenever the transport routes change.
Additional comments:	1. Ensure odometer logs are completed at the beginning and end of a trip and Systematic and documented approach to detercting errors that may result from manual data entry.

Data / Parameter:	Total feedstock delivered ($F_{h,m}$)
Unit of Measure:	Mass or volume .e.g. tonnes, litres, m^3
Description:	Total feedstock delivered for Project Report Period m
Equations that use this parameter:	Equation 47
Data source(s):	Third party supplier(s) sales invoice(s)
Measurement / estimation approach:	Measured: Fuel delivery sales invoices
Frequency of measurement / estimation:	Every shipment
QA/QC procedures:	Systematic and documented approach to detercting errors that may result from manual data entry.
Additional comments:	-

Data / Parameter:	Fuel cargo load per fuel transport vehicle type x (L_x)
Unit of Measure:	Volume per transport vehicle, using the same volumetric units as total fuel delivered. e.g. litre / truck, m^3 / truck, etc.
Description:	Feedstock cargo load per fuel transport vehicle equipment type x. The parameter must be based on the specific types of vehicles transporting feedstock in the Project / baseline. Where multiple vehicle types are used with differing L_x, the calculation must be performed separately for each vehicle equipment type x.
Equations that use this parameter:	Equation 49
Data source(s):	Third party supplier(s)
Measurement / estimation approach:	Estimated: Provided by transport company, reflecting the average fuel cargo load for vehicles used to deliver fuel to Project / baseline Operations.
Frequency of measurement / estimation:	Annually
QA/QC procedures:	1. Cross-check against other typical cargo loading information for similar vehicles and

	Systematic and documented approach to detercting errors that may result from manual data entry.
Additional comments:	-

Data / Parameter:	Population of livetock ($P_{L,p}$)
Unit of Measure:	Natural number (head of livestock)
Description:	Average population of livestock category L (based on monthly population data) for a given Project Report Period m
Equations that use this parameter:	Equation 50
Data source(s):	Project Proponent – operating records
Measurement / estimation approach:	Measurement and stored in software or other Project Proponent data recording techniques.
Frequency of measurement / estimation:	Data monitored and recorded at least monthly.
QA/QC procedures:	Double counts for reconciliation
Additional comments:	-

Data / Parameter:	Percent of manure ($MS_{L,S}$)
Unit of measure:	%
Description:	Percent of manure from livestock category L that is managed in the non-BCS system component S. The fraction of volatile solids sent to systems other than the BCS and effluent manure storage units ($MS_{L,S}$) for each livestock category represents the fraction of manure that was sent to (managed by) these systems, taking into account any volatile solids removed by solid separation equipment. Site-specific data must be used if available. If site-specific data are unavailable, values from Table 8 must be used to calculate $MS_{L,S}$.
Equations that use this parameter:	Equation 51
Data source(s):	Project Proponent's operating records or default values from Table 8
Measurement / estimation approach:	Tracked by Project Proponent.
Frequency of measurement / estimation:	Monthly
QA/QC procedures:	-
Additional comments:	-

Data / Parameter:	$Mass_L$
Unit of measure:	Kg
Description:	Annual average live weight by livestock category L
Equations that use this parameter:	Equation 52, Equation 65
Data source(s):	Operating records or default values Table 3
Measurement / estimation approach:	Tracked by Project Proponent
Frequency of measurement / estimation:	Monthly
QA/QC procedures:	-
Additional comments:	-

Data / Parameter:	Volume of biogas from the digester (F_p)
Unit of Measure:	m^3 / month

Description:	The volume of raw biogas that is produced and measured by the flow meter.
Equations that use this parameter:	Equation 55
Data source(s):	Project Proponent, Measurement Canada
Measurement / estimation approach:	Direct measurement of flow meter
Frequency of measurement / estimation:	The Project Proponent must monitor the total flow of biogas, measured continuously and recorded at least at 15 minute intervals or totalized and recorded at least daily, adjusted for temperature and pressure, prior to delivery to the destruction device(s); the total flow of biogas can come from one meter or summed from multiple meters; the flow of biogas delivered to each destruction device, measured continuously and recorded at least at 15 minute intervals or totalized and recorded at least daily, adjusted for temperature and pressure. A single meter may be used for multiple destruction devices. In this instance, methane destruction in these devices is eligible only if the operational activity of all these devices are independently monitored and the least efficient BDE_x of all destruction devices is used.
QA/QC procedures:	All gas flow meters and continuous methane analyzers must be: 1) Cleaned and inspected on a quarterly basis with maintenance logs outlining maintenance duties according to manufacturer's specifications 2) Field checked by a trained professional for calibration accuracy with the percent drift documented, using either a portable instrument (such as a pitot tube), a permanent fixture or manufacturer specifications, at the end of but no more than two months prior to the end date of the Project Report Period; 3) Calibrated by the manufacturer or a certified calibration service per manufacturer's specifications or every 5 years, whichever is more frequent
Additional comments:	If the field check on a piece of equipment after cleaning reveals accuracy outside of a +/- 5% threshold, the equipment must be calibrated by the manufacturer or a certified service provider. The Project Proponent must maintain documentation of efforts to calibrate the equipment within 30 days of the failed field check or a biogas destruction efficiency of zero must be assigned to all destruction devices monitored by the equipment from date of discovery until calibration. For the interval between the last successful field check and any calibration event confirming accuracy outside the +/- 5% threshold, all data from that meter or analyzer must be scaled according to the following procedure. These adjustments must be made for the entire period from the last successful field check until such time as the meter is properly calibrated. (1) For calibrations that indicate the flow meter was outside the +/- 5% accuracy threshold, the Project Proponent must estimate total emission reductions independently for each meter using: (A) The metered values without correction; and (B) The metered values adjusted based on the greatest calibration drift recorded at the time of calibration. (2) The lower of the two emission reduction estimates must be reported as the scaled emission reduction estimate.

Data / Parameter:	Methane concentration in the biogas (C_{CH4})
Unit of Measure:	Expressed as a fraction

Description:	Proportion of methane collected and metered in BCS
Equations that use this parameter:	**Equation 55,Equation 58,** Equation 61,Equation 64,Equation 74
Data source(s):	Project Proponent
Measurement / estimation approach:	The fraction of methane in the biogas must be measured with a continuous analyzer or, alternatively, with quarterly measurements. Use a direct sampling approach that yields a value with at least 95% confidence. Samples to be taken at least quarterly. Calibrate monitoring instrument in accordance with the manufacturer's specifications. The methane content measurement must be carried out close to a location in the system where a biogas flow measurement takes place.
Frequency of measurement / estimation:	The quarterly methane concentration (C_{CH4}) is used for the entire month in which it is taken and for all subsequent months until a new methane concentration is taken. A weighted average of more frequent samples may also be used.
QA/QC procedures:	All gas flow meters and continuous methane analyzers must be: 4) Cleaned and inspected on a quarterly basis with maintenance logs outlining maintenance duties according to manufacturer's specifications 5) Field checked by a trained professional for calibration accuracy with the percent drift documented, using either a portable instrument (such as a pitot tube), a permanent fixture or manufacturer specifications, at the end of but no more than two months prior to the end date of the Project Report Period; 6) Calibrated by the manufacturer or a certified calibration service per manufacturer's specifications or every 5 years, whichever is more frequent
Additional comments:	If using a calibrated portable gas analyzer for CH_4 content measurement, all of the following information must also be included: 1. Date, time, and location of methane measurement; 2. Methane content of biogas (% by volume) for each measurement; 3. Methane measurement instrument type and serial number; 4. Date, time, and results of instrument calibration; and 5. Corrective measures taken if instrument does not meet performance specifications

Data / Parameter:	Temperature of biogas ($T_{meas,ti}$)
Unit of Measure:	°Kelvin
Description:	Measured temperature of the biogas for time interval ti
Equations that use this parameter:	Equation 56
Data source(s):	Project Proponent
Measurement / estimation approach:	The temperature of the gas is required to determine the density of the methane combusted. If the biogas flow meter employed measures flow, pressure and temperature and displays or outputs the normalized flow of biogas, then there is no need for separate monitoring of pressure and temperature of the biogas
Frequency of measurement / estimation:	Must be measured at the same time when methane content in biogas is measured
QA/QC procedures:	All gas flow meters and continuous methane analyzers must be: 3) Cleaned and inspected on a quarterly basis with maintenance logs outlining maintenance duties according to manufacturer's specifications

	4) Field checked by a trained professional for calibration accuracy with the percent drift documented, using either a portable instrument (such as a pitot tube), a permanent fixture or manufacturer specifications, at the end of but no more than two months prior to the end date of the Project Report Period; 5) Calibrated by the manufacturer or a certified calibration service per manufacturer's specifications or every 5 years, whichever is more frequent
Additional comments:	-

Data / Parameter:	Pressure of biogas ($P_{meas,ti}$)
Unit of Measure:	atm
Description:	Measured pressure of the biogas for the time interval ti
Equations that use this parameter:	Equation 56
Data source(s):	Project Proponent, Measurement Canada
Measurement / estimation approach:	Flow meter
Frequency of measurement / estimation:	Continuous
QA/QC procedures:	All gas flow meters and continuous methane analyzers must be: 3) Cleaned and inspected on a quarterly basis with maintenance logs outlining maintenance duties according to manufacturer's specifications 4) Field checked by a trained professional for calibration accuracy with the percent drift documented, using either a portable instrument (such as a pitot tube), a permanent fixture or manufacturer specifications, at the end of but no more than two months prior to the end date of the Project Report Period; 5) Calibrated by the manufacturer or a certified calibration service per manufacturer's specifications or every 5 years, whichever is more frequent
Additional comments:	-

Data / Parameter:	Volume of biogas ($F_{vol,ti}$)
Unit of Measure:	m^3
Description:	Volumetric flow of biogas measured for time interval ti prior to being corrected for standard temperature and pressure. Standard temperature and pressure are defined as 101.325 kPa (1 ATM) at 288.705 °Kelvin (15.5 °celsius)
Equations that use this parameter:	Equation 56
Data source(s):	Project Proponent, Measurement Canada
Measurement / estimation approach:	Direct measurement of flow meter
Frequency of measurement / estimation:	Continuous
QA/QC procedures:	All gas flow meters and continuous methane analyzers must be: 1) Cleaned and inspected on a quarterly basis with maintenance logs outlining maintenance duties according to manufacturer's specifications 2) Field checked by a trained professional for calibration accuracy with the percent drift documented, using either a portable instrument (such as a pitot tube), a permanent fixture or manufacturer specifications, at the end of but no more than two months prior to the end date of the Project Report Period;

	3) Calibrated by the manufacturer or a certified calibration service per manufacturer's specifications or every 5 years, whichever is more frequent
Additional comments:	-

Data / Parameter:	Days Venting (t_k)
Unit of Measure:	Days
Description:	The number of days for each uncontrolled venting event k from the BCS system (can be a fraction) days
Equations that use this parameter:	Equation 58
Data source(s):	Project Proponent
Measurement / estimation approach:	Monitored and recorded from the time of discovery. The number of days for each uncontrolled venting (tk) must date back to the last field check date without any uncontrolled venting events
Frequency of measurement / estimation:	Daily
QA/QC procedures:	-
Additional comments:	-

Data / Parameter:	Amount of dry matter in the sludge ($S_{d,PJ,m}$)
Unit of Measure:	tonnes of dry matter
Description:	Amount of dry matter in the sludge treated by the sludge treatment system d in the Project Scenario in Project Report Period m
Equations that use this parameter:	Equation 61, Equation 62
Data source(s):	Project Proponent
Measurement / estimation approach:	Measure the total quantity of sludge on a wet basis. The volume (m3) and density or direct weighing may be used to determine the sludge amount (wet basis). Representative samples are taken to determine the moisture content to calculate the total sludge amount on dry basis.
Frequency of measurement / estimation:	Monitoring of 100 per cent of the sludge amount through continuous or batch measurements and moisture content through representative sampling to ensure the 90/10 confidence/precision level.
QA/QC procedures:	-
Additional comments:	-

Data / Parameter:	Fraction of Volatile Solids to the BCS ($MS_{L,BCS}$)
Unit of Measure:	(fraction between 0-1)
Description:	The fraction of volatile solids sent to the BCS for each livestock category L. This represents the fraction of manure that was sent to (managed by) the BCS, taking into account any volatile solids removed by solid separation equipment. Site-specific data must be used, if the data are available. If site-specific data are unavailable, then values from Table 8 must be used to calculate $MS_{L,BCS}$
Equations that use this parameter:	Equation 59
Data source(s):	Project Proponent's operating records or default values from Table 8.
Measurement / estimation approach:	Tracked by proponent.
Frequency of measurement / estimation:	Checked each Project Report Period.
QA/QC procedures:	-
Additional comments:	-

Data / Parameter:	Quantity of fuel consumed for biogas conditioning equipment ($AL_{CE,h,m}$)
Unit of Measure:	Volume e.g. litres, m^3
Description:	Activity level of total fuel consumed for type h for thermal energy generation (e.g. litres diesel) in Project Report Period m
Equations that use this parameter:	Equation 64
Data source(s):	Direct measurements of fuel combusted, e.g. using flow meters, weigh scales, etc.
Measurement / estimation approach:	Measured: Mass or volumetric flow meter to Project / baseline equipment (note, baseline values may require adjustment for Project-Specific circumstances). or Estimated: Summation of fuel sales invoices where given quantity of purchased fuel is used for both Project and non-project equipment, the proportion of fuel used by the Project must be estimated by considering the expected rates of fuel consumption by Project and non-project equipment consuming the fuel. The Project Proponent must clearly document how the estimated proportion was determined and that it is conservative (i.e. not under-estimated for the Project, not over-estimated for the baseline). (Note: baseline values may require adjustment for Project-Specific circumstances.)
Frequency of measurement / estimation:	Measured: Continuous Estimated: Monthly
QA/QC procedures:	1. Meter calibrated according to manufacturer specifications 2. Automatic system in place to alert system operator to meter malfunction 3. Periodic comparison against fuel invoices and Systematic and documented approach to deterciting errors that may result from manual data entry.
Additional comments:	-

Data / Parameter:	Quantity of fuel consumed for biogas upgrading equipment ($AL_{UE,h,m}$)
Unit of Measure:	Volume e.g. litres, m^3
Description:	Activity level of total fuel consumed for type h for thermal energy generation (e.g. litres diesel) in Project Report Period m
Equations that use this parameter:	Equation 61
Data source(s):	Direct measurements of fuel combusted, e.g. using flow meters, weigh scales, etc.
Measurement / estimation approach:	Measured: Mass or volumetric flow meter to Project / baseline equipment (note, baseline values may require adjustment for Project-Specific circumstances). or Estimated: Summation of fuel sales invoices where given quantity of purchased fuel is used for both Project and non-project equipment, the proportion of fuel used by the Project must be estimated by considering the expected rates of fuel consumption by Project and non-project equipment consuming the fuel. The Project Proponent must clearly document how the estimated proportion was determined and that it is conservative (i.e. not under-estimated for the Project, not over-estimated for the baseline). (Note: baseline values may require adjustment for Project-Specific circumstances.)

Frequency of measurement / estimation:	Measured: Continuous Estimated: Monthly
QA/QC procedures:	1. Meter calibrated according to manufacturer specifications 2. Automatic system in place to alert system operator to meter malfunction 3. Periodic comparison against fuel invoices and Systematic and documented approach to detecting errors that may result from manual data entry.
Additional comments:	-

Data / Parameter:	Volatile solids available ($VS_{avail,AS,L,p}$)
Unit of Measure:	Kg
Description:	Volatile solids available for degradation from Anaerobic manure storage (treatment system AS by livestock category L
Equations that use this parameter:	Equation 63
Data source(s):	Project Proponent
Measurement / estimation approach:	Calculated value from operating records
Frequency of measurement / estimation:	Monthly
QA/QC procedures:	-
Additional comments:	-

Data / Parameter:	Ambient monthly temperature (T_2)
Unit of Measure:	°Kelvin
Description:	Average monthly temperature at location of the Operation
Equations that use this parameter:	Equation 66
Data source(s):	Project Proponent
Measurement / estimation approach:	Temperature records obtained from weather service. It must be obtained from the closest weather station, with available data, located in the same air basin, if applicable.
Frequency of measurement / estimation:	Continuous summed to monthly averages
QA/QC procedures:	-
Additional comments:	-

Data / Parameter:	Volume of baseline Wastewater ($Q_{ww,x,m}$)
Unit of Measure:	Volumetric e.g. m^3 litres
Description:	Volume of Wastewater treated in baseline Wastewater treatment system x in Project Report Period m
Equations that use this parameter:	Equation 66
Data source(s):	Project Proponent
Measurement / estimation approach:	Measurements are undertaken using flow meters
Frequency of measurement / estimation:	Monitored continuously (at least hourly measurements are undertaken, if less, confidence/precision level of 90/10 must be attained)
QA/QC procedures:	
Additional comments:	-

Data / Parameter:	Chemical Oxygen Demand ($COD_{inflow,x,m}$)
Unit of Measure:	Tonnes of COD /m^3
Description:	The Chemical Oxygen Demand of the Wastewater before and after the treatment system affected by the Project
Equations that use this parameter:	Equation 74
Data source(s):	Project Proponent
Measurement / estimation approach:	Measure the COD according to national or international standards. COD is measured through representative sampling
Frequency of measurement / estimation:	Average value may be used through sampling with the confidence/precision level 90/10. In determining Baseline Emissions using Equation 31, historical records of at least one year prior to the post-system installation must be used. 1. For Wastewater treatment plant that has been operating for at least three years and if one year of historical data are not available, the following procedures must be followed: (a) All the available data in determining the required parameters (COD removal efficiency, specific energy consumption and specific sludge production) must be used to determine the Baseline Emissions in Project Report Period m; (b) A pre-project measurement campaign must be implemented to determine the required parameters (COD removal efficiency, specific energy consumption and specific sludge production). The measurement campaign must be implemented in the baseline Wastewater systems for at least 10 days. The measurements must be undertaken during a period that is representative for the typical operation conditions of the systems and ambient conditions of the site (temperature, etc). Average values from the measurement campaign must be used and the result must be multiplied by 0.89 to account for the uncertainty range (30 per cent to 50 per cent). The parameters from the measurement campaign are used to calculate the Baseline Emission in Project Report Period m; The Baseline Emissions in Project Report Period m is taken as the minimum between the result of (a) and (b). If the baseline treatment system is different from the treatment system in the Project Scenario, the monitored values of the COD inflow during Crediting Period will be used to calculate the Baseline Emissions *ex post*.
QA/QC procedures:	-
Additional comments:	-

Data / Parameter:	$COD_{ww,discharge,PJ,m}$
Unit of Measure:	tonnes COD / m^3
Description:	The chemical oxygen demand of the Wastewater after the treatment system affected by the project activity
Equations that use this parameter:	Equation 63
Data source(s):	Project Proponent
Measurement / estimation approach:	Measure the COD according to national standards. COD is measured through representative sampling.

Frequency of measurement / estimation:	Samples and measurements shall ensure a 90/10 confidence/precision level
QA/QC procedures:	-
Additional comments:	-

9.1.3 Data and Parameters Available After Crediting Period

n/a

10.0 REFERENCE MATERIALS

10.1.1 Landfill Gas Management

10.1.1.1 Supplementary Guidance

Destruction Efficiencies for Combustion Devices (DE_x)
Project Proponent must use the appropriate default CH_4 destruction efficiencies provided in Table 7. The values presented in Table 7 apply to all project types.

Table 7: Default Destruction Efficiencies for Combustion Devices

Destruction Device	Destruction Efficiency (DE)
Open Flare	0.96
Enclosed Flare	0.995
Lean-burn Internal Combustion Engine	0.936
Rich-burn Internal Combustion Engine	0.995
Boiler	0.98
Micro turbine or large gas turbine	0.995
Upgrade and use of gas as CNG/LNG	0.95
Upgrade and injection into natural gas transmission and distribution pipeline	0.98*
Offsite use of gas under direct-use agreement	Per corresponding destruction device factor (not pipeline)

* The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories gives a standard value for the fraction of carbon oxidized for gas destroyed of 99.5% (Reference Manual, Table 1.6, page 1.29). It also gives a value for emissions from processing, transmission and distribution of gas which would be a very conservative estimate for losses in the pipeline and for leakage at the end user (Reference Manual, Table 1.58, page 1.121).

These emissions are given as 118,000kgCH_4/PJ on the basis of gas consumption, which is 0.6%. Leakage in the residential and commercial sectors is stated to be 0 to 87,000kgCH_4/PJ, which equates to 0.4%, and in industrial plants and power station the losses are 0 to 175,000kg/CH_4/PJ, which is 0.8%.

These leakage estimates are compounded and multiplied. The methane destruction efficiency for landfill gas injected into the natural gas transmission and distribution system can now be calculated as the product of these three efficiency factors, giving a total efficiency of (99.5% * 99.4% * 99.6%) 98.5% for residential and commercial sector users, and (99.5% * 99.4% * 99.2%) 98.1% for industrial plants and power stations

10.1.1.2 Data Substitution Guidelines[23]

This section provides guidance on calculating mission reductions when data integrity has been compromised due to missing data points. No data substitution is permissible for equipment such as thermocouples, which monitor the proper functioning of destruction devices. Rather, the methodologies presented below are to be used only for the CH_4 concentration and flow metering parameters.

The expectation is that Projects will have continuous, uninterrupted data for the entire verification period. However, it is recognized that unexpected events or occurrences may result in brief data gaps.

The following data substitution methodology may be used only for flow and CH_4 concentration at gaps that are discrete, limited, non-chronic, and due to unforeseen circumstances. Data substitution may only be applied to CH_4 concentration or flow readings, but not both simultaneously. If data is missing or both parameters, no reductions can be credited.

Further, substitution may only occur when two other monitored parameters corroborate proper functioning of the destruction device and system Operation within normal ranges. These two parameters must be demonstrated as follows:

1. Proper functioning can be evidenced by thermocouple readings for flares, energy output engines, etc.
2. For CH_4 concentration substitution, flow rates during the data gap must be consistent with normal operation.
3. For flow substitution, CH_4 concentration rates during the data gap must be consistent with normal operations.

If corroborating parameters fail to demonstrate any of these requirements, no substitution may be employed. If the requirements above can be met, the following substitution methodology may be applied:

Table 8: Missing Data Methodology

Duration of Missing Data	Methodological Procedure
Less than six hours	Use the arithmetic mean of the four hours immediately before and following the outage.
Six to 24 hours	Use the 90% lower or upper confidence limit of the 24 hours prior to and after the outage, whichever results in greater conservativeness.
One to seven days	Use the 95% lower or upper confidence limit of the 72 hours prior to and after the outage, whichever results in greater conservativeness.
Greater than one week	No data may be substituted, and no credits may be generated

The lower confidence limit must be used for both CH_4 concentration and flow readings for landfill Projects, as this will provide the greatest conservativeness.

[23] Reproduced from U.S. Landfill Project Protocol v5.0 - https://www.climateactionreserve.org/wp-content/uploads/2019/07/U.S._Landfill_Project_Protocol_V5.0.pdf

For weekly measured CH_4 concentration, the lower of the measurement before and the measurement after must be used. This substitution must only be used to substitute for one consecutive missing weekly measurement.

10.1.2 Organics Diversion

10.1.2.1 Landfill Parameters

The landfill-specific decay rates k_{LF} for organic waste decomposition at B.C. landfills are shown in the table below.

Table 9: Landfill Decay Rate k_{LF} for Organic Waste[24]

Landfill Name	k_{LF} (years^{-1})	Landfill Name	k_{LF} (years^{-1})
Alberni Valley	0.11	Heffley Creek	0.05
Armstrong	0.05	Knockholt	0.05
Bailey	0.11	Lower Nicola	0.05
Bessborough	0.05	McKelvey Creek	0.09
Cache Creek	0.05	Mini's Pit	0.11
Campbell Mtn	0.05	Mission Flats	0.05
Campbell River	0.11	Nanaimo	0.11
Central	0.09	Ootischenia	0.09
Central Subregion	0.05	Prince Rupert	0.12
Columbia Regional	0.05	Salmon Arm	0.09
Comox Valley	0.11	Sechelt	0.11
Ecowaste	0.11	Squamish	0.12
Foothills	0.09	Terrace	0.11
Ft. Nelson	0.05	Thornhill	0.11
Ft. St. John	0.05	Vancouver	0.11
Gibraltar	0.09	Vernon	0.05
Glenmore	0.05	Westside	0.05
Hartland	0.09		

24 Taken from: https://www2.gov.bc.ca/gov/content/environment/waste-management/food-and-organic-waste/organic-waste-diversion/cleanbc-organic-infrastructure-and-collection-program

10.1.2.2 Parameter Constants Used in Equations

Table 10: Parameter Constants

Parameter	Description	*Value*	*Units*
$TDOC$	Default fraction of total degradable organic carbon in organic waste	0.15	n/a
DOC	Default fraction of organic waste that decomposes under anaerobic conditions	0.7	n/a
F_{CH_4}	Default fraction of methane in gas produced at a landfill	0.5	n/a
OX	Default factor for the oxidation of methane by cover soil bacteria	0.1	n/a
r_{maxCH_4}	Maximum fraction of methane assumed to be generated at a landfill out of the theoretical maximum methane generation $A \times TDOC$	0.95	n/a
n_{max}	Maximum number of years it would take for organic waste disposed at a B.C. landfill to reach 95% decomposition	60	years
MCF_{LF}	Default methane correction factor for a landfill	1.0	n/a
MCF_{eff}	Default methane correction factor for digester effluent	0.3	n/a
$B_{0,eff}$	Maximum methane producing capacity of digester effluent per tonne chemical oxygen demand	0.25	tonne CH_4 / tonne COD
ρ_{CH_4}	Density of CH_4 at standard temperature and pressure (15^{o}C and 1 atm)	0.678	kg/m^3 CH_4
e	Mathematical constant that is the base of the natural logarithm, rounded to five decimal places	2.71828	n/a

10.1.3 Wastewater Treatment and Manure Management

10.1.3.1 Supplementary Guidance

Table 11: Volatile Solids ($VS_{LU,L}$), Average Mass ($Mass_L$) and Maximum Methane Potential Eligible Livestock ($B_{0,L}$)

Eligible Livestock Category (L)	**Volatile Solids Table (kg /day / 1,000 kg mass)**	**Average Mass (kg)**	**$B_{0,L}$ (m^3 CH_4 / kg VS added)**
Dairy Cows (Milkers)	11.11*	634**	0.24**
Heifer	8.44*	462**	0.19**
Heifer Grazing	15.02*	462**	0.19**
Cows Grazing	8.09*	634**	0.24**
Calves	7.70*	186**	0.17*
Swine	3.77*	61**	0.48**

*Values adapted from California Environmental Protection Agency: Air Resources Board Compliance Offset Protocol Livestock Projects Capturing and Destroying Methane from Manure Management Systems

**Source: National Inventory Report 1990–2013 Greenhouse Gas Sources and Sinks in Canada Part 2

Table 12: Methane Conversion Factors (MCF_S) by Manure Management System Component (IPCC, 2006)

<table>
<tr><th rowspan="3" colspan="2">System[a]</th><th colspan="19">MCFs by average annual temperature (°C)</th><th rowspan="3">Source and comments</th></tr>
<tr><th colspan="5">Cool</th><th colspan="11">Temperate</th><th colspan="3">Warm</th></tr>
<tr><th>≤ 10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th><th>17</th><th>18</th><th>19</th><th>20</th><th>21</th><th>22</th><th>23</th><th>24</th><th>25</th><th>26</th><th>27</th><th>≥ 28</th></tr>
<tr><td colspan="2">Pasture/Range/Paddock</td><td colspan="5">1.0%</td><td colspan="11">1.5%</td><td colspan="3">2.0%</td><td>Judgement of IPCC Expert Group in combination with Hashimoto and Steed (1994).</td></tr>
<tr><td colspan="2">Daily spread</td><td colspan="5">0.1%</td><td colspan="11">0.5%</td><td colspan="3">1.0%</td><td>Hashimoto and Steed (1993).</td></tr>
<tr><td colspan="2">Solid storage</td><td colspan="5">2.0%</td><td colspan="11">4.0%</td><td colspan="3">5.0%</td><td>Judgement of IPCC Expert Group in combination with Amon et al. (2001), which shows emissions of approximately 2% in winter and 4% in summer. Warm climate is based on judgement of IPCC Expert Group and Amon et al. (1998).</td></tr>
<tr><td colspan="2">Dry lot</td><td colspan="5">1.0%</td><td colspan="11">1.5%</td><td colspan="3">2.0%</td><td>Judgement of IPCC Expert Group in combination with Hashimoto and Steed (1994).</td></tr>
<tr><td rowspan="2">Liquid/Slurry</td><td>With natural crust cover</td><td>10%</td><td>11%</td><td>13%</td><td>14%</td><td>15%</td><td>17%</td><td>18%</td><td>20%</td><td>22%</td><td>24%</td><td>26%</td><td>29%</td><td>31%</td><td>34%</td><td>37%</td><td>41%</td><td>44%</td><td>48%</td><td>50%</td><td>Judgement of IPCC Expert Group in combination with Mangino et al. (2001) and Sommer (2000). The estimated reduction due to the crust cover (40%) is an annual average value based on a limited data set and can be highly variable dependent on temperature, rainfall, and composition.
When slurry tanks are used as fed-batch storage/digesters, MCF should be calculated according to Formula 1.</td></tr>
<tr><td>Without natural crust cover</td><td>17%</td><td>19%</td><td>20%</td><td>22%</td><td>25%</td><td>27%</td><td>29%</td><td>32%</td><td>35%</td><td>39%</td><td>42%</td><td>46%</td><td>50%</td><td>55%</td><td>60%</td><td>65%</td><td>71%</td><td>78%</td><td>80%</td><td>Judgement of IPCC Expert Group in combination with Mangino et al. (2001). When slurry tanks are used as fed-batch storage/digesters, MCF should be calculated according to Formula 1.</td></tr>
</table>

System[a]		MCFs by average annual temperature (°C)																			Source and comments
		Cool					Temperate											Warm			
		≤ 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	≥ 28	
Uncovered anaerobic lagoon		66%	68%	70%	71%	73%	74%	75%	76%	77%	77%	78%	78%	78%	79%	79%	79%	79%	80%	80%	Judgement of IPCC Expert Group in combination with Mangino *et al.* (2001). Uncovered lagoon MCFs vary based on several factors, including temperature, retention time, and loss of volatile solids from the system (through removal of lagoon effluent and/or solids).
Pit storage below animal confinements	< 1 month	3%					3%											30%			Judgement of IPCC Expert Group in combination with Moller *et al.* (2004) and Zeeman (1994). Note that the ambient temperature, not the stable temperature is to be used for determining the climatic conditions. When pits used as fed-batch storage/digesters, MCF should be calculated according to Formula 1.
	> 1 month	17%	19%	20%	22%	25%	27%	29%	32%	35%	39%	42%	46%	50%	55%	60%	65%	71%	78%	80%	Judgement of IPCC Expert Group in combination with Mangino *et al.* (2001). Note that the ambient temperature, not the stable temperature is to be used for determining the climatic conditions. When pits used as fed-batch storage/digesters, MCF should be calculated according to Formula 1.

System[a]		MCFs by average annual temperature (°C)																			Source and comments
		Cool					Temperate											Warm			
		≤ 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	≥ 28	
Anaerobic digester		0-100%					0-100%											0-100%			Should be subdivided in different categories, considering amount of recovery of the biogas, flaring of the biogas and storage after digestion. Calculation with Formula 1.
Burned for fuel		10%					10%											10%			Judgement of IPCC Expert Group in combination with Safley *et al.* (1992).
Cattle and Swine deep bedding	< 1 month	3%					3%											30%			Judgement of IPCC Expert Group in combination with Moller *et al.* (2004). Expect emissions to be similar, and possibly greater, than pit storage, depending on organic content and moisture content.
Cattle and Swine deep bedding (cont.)	> 1 month	17%	19%	20%	22%	25%	27%	29%	32%	35%	39%	42%	46%	50%	55%	60%	65%	71%	78%	80%	Judgement of IPCC Expert Group in combination with Mangino *et al.* (2001).
Composting - In-vessel[b]		0.5%					0.5%											0.5%			Judgement of IPCC Expert Group and Amon *et al.* (1998). MCFs are less than half of solid storage. Not temperature dependant.
Composting - Static pile[b]		0.5%					0.5%											0.5%			Judgement of IPCC Expert Group and Amon *et al.* (1998). MCFs are less than half of solid storage. Not temperature dependant.
Composting - Intensive windrow[b]		0.5%					1.0%											1.5%			Judgement of IPCC Expert Group and Amon *et al.* (1998). MCFs are slightly less than solid storage. Less temperature dependant.
Composting – Passive windrow[b]		0.5%					1.0%											1.5%			Judgement of IPCC Expert Group and Amon *et al.* (1998). MCFs are slightly less than solid storage. Less temperature dependant.

Source: IPCC

Table 13: Correction Factor for Methane (CF) ($CF_{sl,treatment,d}$) ($CF_{ww,PJ,discharge}$)($CF_{S,treatment,BL,j}$)($CF_{ww,treatment,BL,x}$)

Type of Wastewater treatment and discharge pathway or system	CF value
Discharge of Wastewater to sea, river or lake	0.1
Land Application	0.1
Aerobic treatment, well managed	0.0
Aerobic treatment, poorly managed or overloaded	0.3
Anaerobic digester for sludge without methane recovery	0.8
Anaerobic reactor without methane recovery	0.8
Anaerobic mustow waste handling system (depth less than 2 metres)	0.2
Anaerobic deep waste handling system (depth more than 2 metres)	0.8
Septic system	0.5

The CF indicates the extent to which the CH_4 producing capacity (Bo) is realized in each type of treatment and discharge pathway and system.
Source: California Environmental Protection Agency: Air Resources Board Compliance Offset Protocol Livestock Projects Capturing and Destroying Methane from Manure Management Systems

Table 14: Biogas Collection Efficiency (BCE_x)

BCS Type	Cover Type	Biogas Capture Efficiency
Covered Lagoon	Bank-to-bank, impermeable	0.95
	Partial area (modular) Impermeable	0.95 x % covered area
Complete mix, plug flow, or fixed film	Enclosed Vessel*	0.98

***** If a BCS cover design that does not meet the definition of Enclosed Vessel, the Project Proponent must offer verifiable evidence of the biogas capture efficiency of their BCS or use the covered lagoon default value.
Source: California Environmental Protection Agency: Air Resources Board Compliance Offset Protocol Livestock Projects Capturing and Destroying Methane from Manure Management Systems

Table 15: Volatile Solids Removed Through Solids Separation ($MS_{L,s}$) ($MS_{AS,L}$) ($MS_{L,BCS}$)

Type of Solid Separation	Volatile Solids Removed (fraction)
Gravity	0.45
Mechanical:	
Stationary screen	0.17
Vibrating screen	0.15
Screw press	0.25
Centrifuge	0.50
Roller drum	0.25
Belt press/screen	0.50

Source: California Environmental Protection Agency: Air Resources Board Compliance Offset Protocol Livestock Projects Capturing and Destroying Methane from Manure Management Systems

Table 16: Baseline Default Assumptions for Greenfield Manure Management Projects

Baseline Assumption	>200 Mature Dairy Cows	< 200 Mature Dairy Cows
Anaerobic manure storage system	Flush system into an Manure Management Anaerobic Lagoon with >30 day retention time	Flush system into an Manure Management Anaerobic Lagoon with >30 day retention time
Non-Anaerobic manure storage systems(s)	Solids storage	Solids storage
MS_L	90% lagoon 10% solids storage	50% lagoon 50% solids storage
Lagoon cleaning schedule	Annually (September)	Annually (September)

Source: California Environmental Protection Agency: Air Resources Board Compliance Offset Protocol Livestock Projects Capturing and Destroying Methane from Manure Management Systems

10.1.3.2 Data Substitution Methods

Volumetric Flow of Biogas and Methane Concentration

The data substitution method is required for all circumstances where Projects encounters a failure in the reporting of Project volumetric flow of the biogas (F_p) or methane concentration data (C_{CH4}). However, data substitution must not be used for equipment that monitors operation of destruction devices and a BDE of 0% must be used for all periods where the operation of the destruction device is not assured.

Table 17: Volumetric Flow and Methane Concentration Data Substitution Methods

Duration of Missing Data	Methodological Procedure
> 24 hours of either or both parameters	Use the arithmetic mean of the 24 hours immediately before and following the outage.
1 – 7 days of either parameter	Use the 95% lower or upper confidence limit of the 72 hours prior to and after the outage, whichever results in greater conservativeness.
Within 1 quarter of methane concentration data	Use the highest or lowest value for the other three quarters of methane concentration data, whichever results in greater conservativeness. This may only be applied once per Project Report Period.
< 1 week of one or both parameter or any time with more than one parameter.	Take a zero BDE for the device(s) in question with missing data and use the 99% lower or upper confidence limit of all available valid data for the Project Report Period, whichever results in greater conservativeness. If less than 25% of the data for the Project Report Period is available, then the single highest or lowest data point must be used.

Wastewater Treatment Projects

A complete record of all measured parameters used in the GHG emissions calculations is required. Therefore, whenever a quality-assured value of a required parameter is unavailable (e.g., if a meter malfunctions during unit operation or if a required sample is not taken), a substitute data value for the missing parameter must be used in the calculations, according to the following requirements:

Table 18: COD, BOD_5 or Wastewater Flow Data Substitution Methods

Missing Data Situation	Methodological Procedure
Missing weekly value(s) of COD or BOD_5 or Wastewater flow entering an Anaerobic Wastewater treatment process	The substitute data value must be the arithmetic average of the quality-assured values of those parameters for the week immediately preceding and the week immediately following the missing data incident.
No quality-assured data for a particular parameter are available prior to the missing data incident,	The substitute data value must be the first quality-assured value obtained after the missing data period. If, for a particular parameter, the “after” value is not obtained by the end of the reporting year, you may use the last quality-assured value obtained “before” the missing data period for the missing data substitution. You must document and keep records of the procedures you use for all such estimates.

10.1.3.3 Establishment of Baseline Parameters

To complete the calculations, the following baseline parameters need to be established:

Equation 82: COD Removal Efficiency in the Baseline

$$\eta_{COD,BL,x} = \frac{(COD_{BL,inflow,n} - COD_{BL,outflow,n})}{COD_{BL,inflow,n}}$$

$\eta_{COD,BL,x}$ = COD removed from baseline treatment system x in baseline period n
$COD_{BL,inflow,n}$ = COD input to baseline treatment system x per volumetric unit of Wastewater e.g. tonnes of COD /m_3 in baseline period n
$COD_{BL,outflow,n}$ = COD output from baseline treatment system x per volumetric unit of Wastewater e.g. tonnes of COD / m_3 in baseline period n

Equation 83: Total COD Removed

$$COD_{BL,TR,n} = Q_{ww,n} \times COD_{BL,inflow,n} \times \eta_{COD,BL,x}$$

$COD_{BL,TR,n}$ = Total amount of COD removed from treatment system x (tonnes of COD), in baseline period n
$COD_{BL,inflow,n}$ = COD input to baseline treatment system x per volumetric unit of Wastewater e.g. tonnes of COD /m_3 in baseline period n
$Q_{ww,n}$ = Volume of Wastewater treated in baseline Wastewater treatment system x in Project Report Period m, (m^3)
$\eta_{COD,BL,n,x}$ = COD removal efficiency of COD in baseline treatment system x per volumetric unit of Wastewater e.g. tonnes of COD / m^3, in baseline period n

Calculating Baseline Sludge Generation Ratio

Sludge generation ratio of the Wastewater treatment plant in the Baseline Scenario

Equation 84: Baseline Sludge Generation Ratio

$$SGR_{BL} = \frac{S_{BL,DM,n}}{COD_{BL,TL,n}}$$

SGR_{BL} = Baseline sludge generation ratio (tonne of dry matter in sludge / tonne COD removed)
$S_{BL,DM,n}$ = The amount of dry matter in the sludge (tonnes of dry matter sludge) in baseline period n
$COD_{BL,TL,n}$ = COD removed from baseline treatment system x (tonnes of COD) in baseline period n

Pre-project Data Measurement Campaign
When historical records are not available, Project Proponents may develop Baseline Scenario parameters using the method described below.

The following parameters may be determined using the pre-project Data Measurement Campaign

- COD removal efficiency,
- specific energy consumption and
- specific sludge production

The campaign must take measurements for 10 days at minimum and must be taken during a period that is representative for typical operating conditions of the systems including ambient conditions. The values from the campaign are used to generate an arithmetic mean. To account for inherent uncertainty of a shortened baseline data collection period, the arithmetic mean must be multiplied by 0.89.