



***DRAFT QUANTIFICATION  
PROTOCOL FOR METHANE  
CAPTURE FROM THE ANAEROBIC  
TREATMENT OF INDUSTRIAL  
WASTEWATER***

***OCTOBER 2008***

*Draft Version 1*

---

**Blue Source Canada**

Suite 2210, 777 – 8<sup>th</sup> Avenue S.W, Calgary, Alberta T2P 3R5, T: 403.262.3026, F:  
403.269.3024

**Disclaimer:**

## Table of Contents

<b>1.0</b>	<b>Project and Methodology Scope and Description .....</b>	<b>1</b>
1.1	Protocol Scope and Description.....	1
1.2	Glossary of New Terms .....	7
<b>2.0</b>	<b>Quantification Development and Justification.....</b>	<b>9</b>
2.1	Identification of Sources and Sinks (SS's) for the Project.....	9
2.2	Identification of Baseline.....	17
2.3	Identification of SS's for the Baseline.....	17
2.4	Selection of Relevant Project and Baseline SS's.....	25
2.5	Quantification of Reductions, Removals and Reversals of Relevant SS's .....	30
2.5.1	Quantification Approaches .....	30
2.5.2	Contingent Data Approaches .....	48
2.6	Management of Data Quality.....	48
2.6.1	Record Keeping .....	48
2.6.1	Quality Assurance/Quality Control (QA/QC) .....	48
<b>APPENDIX A</b>	<b>.....</b>	<b>56</b>
<b>APPENDIX B</b>	<b>.....</b>	<b>61</b>
<b>APPENDIX C</b>	<b>.....</b>	<b>63</b>
<b>APPENDIX D:</b>	<b>.....</b>	<b>69</b>

## List of Figures

FIGURE 1.1	Process Flow Diagram for Project Condition	4
FIGURE 1.2	Process Flow Diagram for Baseline Condition	5
FIGURE 2.1	Project Element Life Cycle Chart	10
FIGURE 2.2	Baseline Element Life Cycle Chart	18

## List of Tables

TABLE 2.1	Project SS's	11
TABLE 2.2	Baseline SS's	19
TABLE 2.3	Comparison of SS's	26
TABLE 2.4	Quantification Procedures	31
TABLE 2.5	Contingent Data Collection Procedures	48

## 1.0 Project and Methodology Scope and Description

This quantification protocol is written for those familiar with wastewater treatment processes for industrial wastewater streams containing significant quantities of biodegradable organic matter and with the operation of anaerobic digesters and biogas utilization systems. Some familiarity with, or general understanding of the operation of these projects is expected.

The opportunity for generating carbon offsets with this protocol arises primarily from the capture and destruction of biogas, containing methane, that would have been emitted from wastewater treatment facilities where the baseline practice was the anaerobic treatment of wastewater and venting of produced methane to the atmosphere. There is also the opportunity for indirect greenhouse gas (GHG) emission reductions from the use of biogas produced by the wastewater treatment processes to displace electricity or thermal energy derived from fossil fuels or to displace natural gas in gas transmission systems.

### 1.1 Protocol Scope and Description

This protocol is applicable to projects that involve the capture and destruction of methane produced from anaerobic wastewater treatment processes and prevent the venting of biogas to the atmosphere. These systems could be installed as retrofits or modifications to existing wastewater treatment operations or implemented at new Greenfield facilities as the best available control technology. The most common baseline configuration would be the use of an uncovered deep anaerobic wastewater lagoon where biogas was vented to the atmosphere; however, other facilities may already operate more sophisticated anaerobic digester systems to treat raw wastewater effluents or sludges with high organic loadings but do not utilize the produced biogas. This protocol is also applicable to projects that implement new equipment to utilize the produced biogas, where previously all biogas captured from the anaerobic wastewater treatment systems was flared without energy recovery. The baseline scenario in this case assumes the use of an open flare with 95% methane destruction efficiency.<sup>1</sup> The feedstock to the anaerobic digestion system may be untreated industrial wastewater or sludge produced from other wastewater treatment processes at the project site.

This protocol is intended to be applied to anaerobic wastewater treatment systems used in the food processing industry, and as such may not be suitable for all other types of wastewater treatment systems. In addition, project proponents implementing other types of anaerobic digesters to produce biogas from agricultural residues, source separated organic materials or energy crops, should refer to the Alberta Offset System *Quantification Protocol for the Anaerobic Decomposition of agricultural Materials*.

---

<sup>1</sup> This assumption is consistent with the GE AES Methodology for Waste Water Treatment Methane Capture and Destruction Projects Version 1.0 – August 22, 2007

The decomposition of organic matter, contained in wastewater effluents as suspended or dissolved solids and or in more concentrated sludges, under clearly anaerobic (oxygen-free) conditions produces biogas consisting primarily of methane and carbon dioxide. Biogas composition will vary depending on the composition of wastewater treated, but typically consists of 50-80% methane and 20-50% carbon dioxide, with trace amounts of hydrogen sulphide and other volatile organic compounds. The degradable organic matter contained in wastewater effluents is usually measured in terms of chemical oxygen demand (COD) or biological oxygen demand (BOD). For consistency with the Intercontinental Panel on Climate Change (IPCC) and Clean Development Mechanism Methodology ACM0014 approaches, this protocol uses COD.

Typically, the implementation of methane capture projects at anaerobic wastewater treatment facilities includes the establishment of several supporting units including biogas conditioning units, piping, blowers, flares and thermal/ electrical energy generation systems. This equipment would be installed in addition to other wastewater treatment equipment used to remove other contaminants present in the effluent and to ensure all wastewater discharged to a sanitary sewer system or surface water body meets applicable regional limits.

Wastewater is collected from different operations within the source facility and directed to a pre-treatment area for screening, grit removal, dissolved air flotation or other physical or chemical adjustments before it is treated in the anaerobic digester where anaerobic microbes consume the majority of organic matter and produce combustible biogas in the process. The wastewater then undergoes one or more aerobic treatment processes (bioreactors, clarifiers etc.) to remove the remaining organic solids to within acceptable limits. After the aerobic process the wastewater stream undergoes coagulation and flocculation to precipitate out inorganic compounds (e.g. phosphorous) and to settle out particles so that they can be physically separated using a filter or belt press. The filtered solids may be stored temporarily and then sent for disposal, composting or land application, while the effluent continues to a polishing step for any final chemical adjustments (e.g. pH) before continuing on to a storage lagoon or directly discharged from the site. The biogas produced in the anaerobic treatment unit is flared or conditioned to remove water vapour and other contaminants and then combusted to produce energy. **FIGURE 1.1** offers a process flow diagram for a typical project.

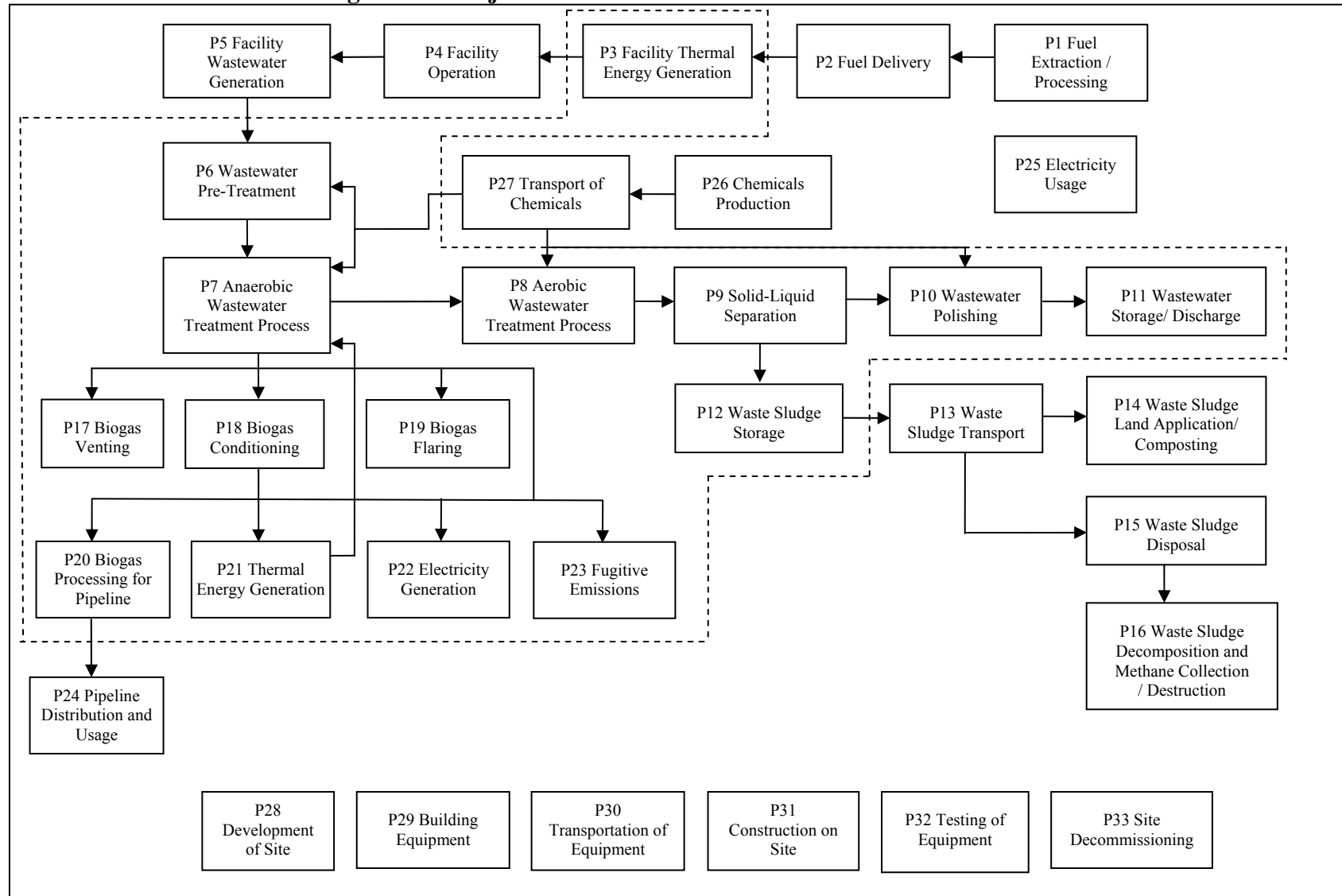
## **Protocol Approach**

To demonstrate that a project is covered by the scope of the protocol, the project developer must demonstrate that the wastewater effluent stream would have been managed differently such that methane would have been emitted to the atmosphere. As evidence, the project developer must demonstrate that this baseline condition, illustrated in **FIGURE 1.2**, was either the previous practise or most likely practise based on conventional industry practices. Further, they must show that under the project activity the chemical oxygen demand of the wastewater effluent has been reduced by the anaerobic treatment process.

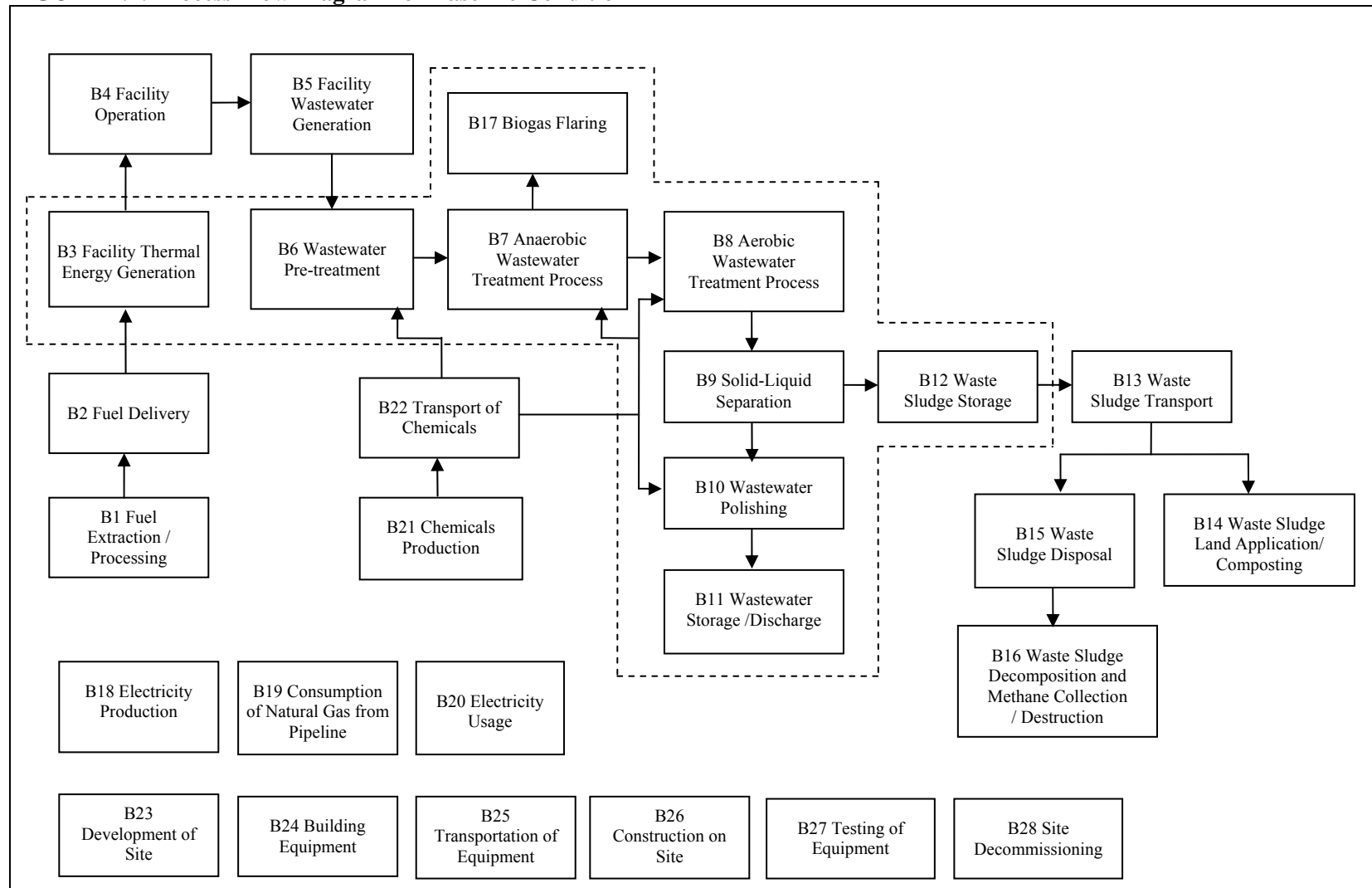
This is accomplished by applying a mass balance on the chemical oxygen demand of the wastewater stream by measuring wastewater flow rates and COD concentrations at the inlets and outlets of the anaerobic treatment units. The quantification of offsets from the utilization of biogas produced from the anaerobic treatment process is accomplished by applying mass and energy balances around the project components that were installed to produce, capture and utilize the biogas. Project proponents would be responsible for metering of relevant energy inputs and outputs to the system.

For those projects that implement systems to utilize biogas produced from existing anaerobic wastewater treatment units, where energy recovery was previously not practiced, proponents must demonstrate that that the project results in increased displacement of energy derived from fossil fuels either on or off-site. For facilities that operated open flares in the baseline, the upgrade to an enclosed combustion device, would also reduce methane emissions by improving the destruction efficiency.

**FIGURE 1.1: Process Flow Diagram for Project Condition**



**FIGURE 1.2: Process Flow Diagram for Baseline Condition**



### **Protocol Applicability**

To demonstrate that a project meets the requirements under this protocol, the project developer must provide evidence that:

1. The project proponent must demonstrate that the baseline anaerobic wastewater treatment system (e.g. an uncovered deep lagoon or sludge pit) would have resulted in sufficiently anaerobic (oxygen-free) conditions to result in the formation of methane. For systems open to the atmosphere the project proponent should demonstrate that the baseline conditions were amenable to methane generation based on the depth of the treatment/storage unit, operational records showing a significant reduction in chemical oxygen demand in the unit, normal operating temperatures in the anaerobic treatment system and in some cases the presence of a grease cap. For systems that are not enclosed or contained the average depth of the anaerobic system must be at least 1 metre deep;
2. For projects where methane production processes are enhanced through the addition of a heating source to create mesophilic or thermophilic conditions that were not previously present in the baseline anaerobic treatment unit, the anaerobic digestion facility must demonstrate reasonable diligence to manage the risk of fugitive emissions in keeping with the guidance provided in **APPENDIX B** as evidenced by an affirmation from the project developer and applicable records;
3. There must not be any applicable regulations that prescribe the project facility to install a biogas capture system to prevent the venting of methane emissions from wastewater treatment operations;
4. In project configurations where sedimentation in the anaerobic treatment unit results in a material reduction in chemical oxygen demand available for anaerobic digestion by microbes (and therefore an over estimate of the baseline methane generation potential of the wastewater), the project proponent must provide records of organic matter (sediments) removed from the anaerobic treatment unit. The project proponent should account for sedimentation COD losses if sediments have been collected and removed from the anaerobic treatment unit at a frequency of once every two years or more often;
5. The quantification of reductions achieved by the project is based on actual measurement and monitoring (except where indicated in this protocol) as indicated by the proper application of this protocol; and,
6. The project must meet the requirements for offset eligibility as specified in the applicable regulation and guidance documents for the Alberta Offset System.

### **Protocol Flexibility**

Flexibility in applying the quantification protocol is provided to project developers in four ways:

1. In cases where the project proponent measures BOD in the wastewater stream (and not the COD), the IPCC conversion factor of 2.4 kg of COD per 1 kg of BOD may be applied to convert from kg of BOD to kg of COD;
2. Projects that do not enhance the anaerobic digestion process (e.g. through addition of a heat source) may use site specific chemical oxygen demand and biogas production data in the project condition to develop monthly methane conversion factors for the baseline provided that two years worth of consistent operation of the anaerobic treatment unit has been attained without any significant modifications to enhance the generation of biogas. Monthly methane conversion factors should be used to account for temperature impacts on the baseline system. Refer to Appendix A for quantification methods.
3. Site specific emission factors may be substituted for the generic emission factors indicated in this protocol document. The methodology for generation of these emission factors must ensure accuracy; and be robust enough to provide uncertainty ranges in the factors;
4. Measurement and data management procedures may be modified by the project developer to account for the available equipment as long as the specified minimum standards for data quantity, frequency and quality are met. Where these standards cannot be met, the project developer must justify why the method used represents a reasonable deviation to the protocol methodology provided.

The project proponent will have to justify their approach in detail to apply any of these flexibility mechanisms.

## 1.2 Glossary of New Terms

### Anaerobic Digestion

The active and naturally occurring biological process where the organic matter, such as that contained in wastewater from certain industrial facilities (e.g. meat and vegetable processing, soft drink production beverage brewing and alcohol distillation) , is degraded under oxygen free conditions by methanogenic bacteria to yield biogas, consisting of primarily methane and carbon dioxide, and a nutrient rich effluent. Biogas may be collected for use in the generation of electricity, heat and / or power, or flared. The unit where anaerobic digestion occurs is generally referred to as an anaerobic digester or an anaerobic wastewater treatment unit. Common digesters include fixed film reactors, complete mix

tank reactors, upflow anaerobic sludge blanket reactors or plug flow reactors.

Biological Oxygen Demand

The amount of oxygen required by aerobic microorganisms to decompose the organic matter in a sample of water, such as that polluted by sewage. The BOD<sub>5</sub> test is a common analysis performed to determine the degree of water pollution from degradable organic compounds in wastewater. BOD<sub>5</sub> test measures the rate of oxygen uptake by microorganisms in a sample of water at a temperature of 20°C and over an elapsed period of five days in the dark

Chemical Oxygen Demand

The amount of oxygen required to chemically oxidize organic compounds in water. The chemical oxygen demand (COD) test is a common water quality test used to indirectly measure the amount of organic compounds in a water sample using a strong oxidizing agent such as potassium dichromate. A high COD value indicates a high concentration of organic matter in the water sample.

Functional Equivalence

The Project and the Baseline should provide the same function and quality of products or services. This type of comparison requires a common metric or unit of measurement (such as the mass of beef processed, m<sup>3</sup> of wastewater generated per month) for comparison between the Project and Baseline activity.

Fugitive Emissions:

Intentional and unintentional releases of GHGs from joints, seals, packing, gaskets, etc. within anaerobic digestion systems, including all processing, piping and treatment equipment.

Land Application:

The beneficial use of stabilized sludge material from the effluent of an anaerobic digester or filter press, applied to cropland based upon crop needs and the composition of the agricultural material, as a source of soil amendment and/or nutrition.

Sludge Pit:

The pit or tank that receives untreated liquid sludge in which anaerobic bacteria decompose the liquid

sludge, thereby decreasing its organic matter content, and emitting biogas. When the pit is dried out and sludge is stable, solids are removed for use.

## 2.0 Quantification Development and Justification

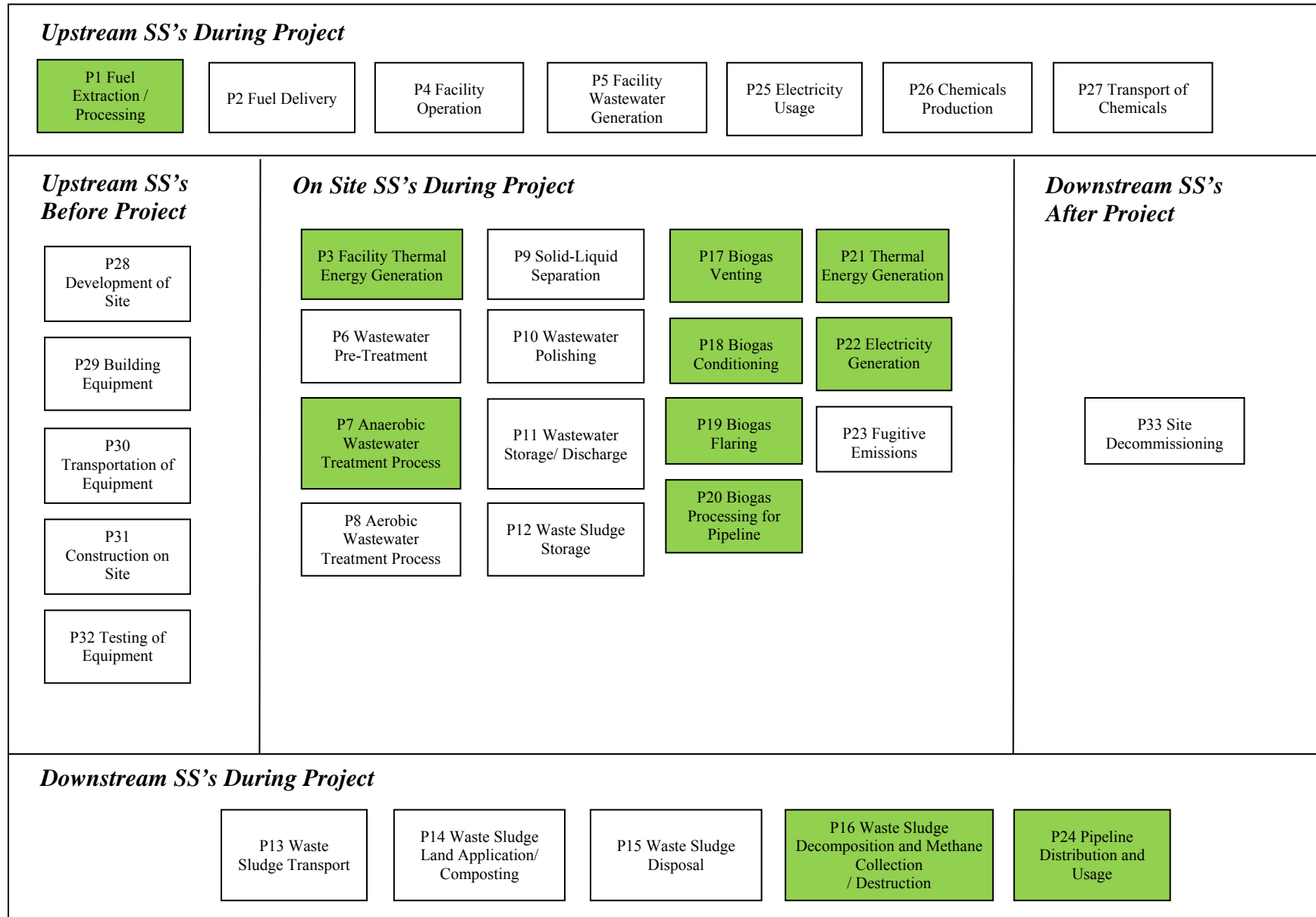
The following sections outline the quantification development and justification.

### 2.1 Identification of Sources and Sinks (SS's) for the Project

SS's were identified for the project by reviewing the relevant process flow diagrams, consulting with stakeholders (i.e. project proponents) and reviewing good practise guidance and other relevant greenhouse gas quantification protocols. This iterative process confirmed that the SS's in the process flow diagrams covered the full scope of eligible project activities under the protocol.

Based on the process flow diagrams provided in **FIGURE 1.1** and **FIGURE 1.2**, the project SS's were organized into life cycle categories in **FIGURE 2.1**. Descriptions of each of the SS's and their classification as controlled, related or affected are provided in **TABLE 2.1**.

**FIGURE 2.1: Project Element Life Cycle Chart**



**TABLE 2.1: Project SS's**

1. SS	2. Description	3. Controlled, Related or Affected
<b>Upstream SS's during Project Operation</b>		
P1 Fuel Extraction / Processing	Each of the fuels used throughout the on-site component of the project will need to be sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the fuels. The total volumes of fuel for each of the on-site SS's are considered under this SS. Volumes and types of fuels are the important characteristics to be tracked.	Related
P2 Fuel Delivery	Each of the fuels used throughout the on-site component of the project will need to be transported to the site. This may include shipments by tanker or by pipeline, resulting in the emissions of greenhouse gases. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fuelling station as the fuel used to take the equipment to the site is captured under other SS's and there are no other delivery emissions as the fuel is already going to the commercial fuelling station. Distance and means of fuel delivery as well as the volumes of fuel delivered are the important characteristics to be tracked.	Related
P4 Facility Operation	The facility that generates the wastewater would have a primary function or product and any number of processes that would require energy inputs and therefore consume fossil fuels as part of the process or unit operation or for material handling. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Related
P5 Facility Wastewater Generation	Wastewater is produced as a by-product of industrial operations in a number ways including from cleaning of process equipment and from the discharge of off-spec materials and by-products using water as a transport medium for the wastes. Greenhouse gas emissions may be associated with these industrial processes and the associated wastewater handling practices, which could include pumping, mixing, equalization and could be powered by fossil fuels either directly or indirectly through a centralized boiler or cogeneration unit. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition. Typical facilities could include meat and vegetable processing facilities, distilleries, breweries and other industries that produce significant loadings of organic matter in wastewater streams.	Related
P25 Electricity Usage	Electricity may be required for operating the wastewater treatment facility (pumps, aeration units, mixers, blowers etc.), the anaerobic treatment unit, the biogas conditioning system and associated equipment. This power may be sourced either from internal generation, connected facilities or the local electricity grid. Metering of electricity may be netted in terms of the power going to and from the grid if the project activity includes the installation of an electricity generator. Quantity and source of power are the important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions.	Related
P26 Chemical Production	The production of chemicals from raw materials upstream of the project site may include several material and energy inputs such as natural gas and diesel. Quantities and types of chemicals used at the facility and their associated GHG intensity per unit would be contemplated to evaluate functional equivalence with the baseline condition.	Related

P27 Transport of Chemicals	Chemicals used at the project facility may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related
<b>Onsite SS's during Project Operation</b>		
P3 Facility Thermal Energy Generation	The facility generating the wastewater may already operate a boiler or other equipment to generate thermal energy for the primary production processes, which are able to utilize the new source of biogas produced by the anaerobic wastewater treatment unit to supplement conventional fossil fuels. The quantity, composition and heating value of biogas produced and combusted for thermal energy generation should be tracked. Additionally if thermal energy (steam or hot water) is distributed to other users, then the quantity of thermal energy (GJ) should be tracked at the point nearest the user to account for any heat losses. If supplemental fossil fuels are consumed for start-up or to provide heat to maintain an appropriate temperature in the anaerobic digester system, the types and quantities of fuels should be tracked. Note that in some project configurations a new standalone cogeneration unit may be installed to use the biogas and export electricity and possibly heat from the site. In such scenarios the project proponent may exclude this SS (if the quantity of fossil fuels used to operate the facility is independent of the systems installed to utilize the biogas) and only include SS P21 Thermal Energy Generation.	Controlled
P6 Wastewater Pre-Treatment	Wastewater may be treated and/or processed prior to being input to the anaerobic treatment system. This could include physical processes such as screening, grit and solids removal, oil-water separation, dissolved air flotation for removal of fats and oils and other processes that adjust the chemical composition of the wastewater. This may involve the use of heavy equipment that operates using diesel or natural gas. Emissions of greenhouse gases are associated with the use of these fossil fuels. Quantities for each of the energy inputs may all need to be tracked to evaluate functional equivalence with the baseline condition.	Controlled
P7 Anaerobic Wastewater Treatment Process	Greenhouse gas emissions may occur that are associated with the operation and maintenance of the anaerobic treatment unit. This may include running any auxiliary equipment or monitoring systems and may include material handling. Thermal energy systems may be required to maintain the desired temperature for the anaerobic digester. This may include boilers or similar equipment, which may require several energy inputs such as natural gas or diesel. Quantities and types for each of the energy inputs would be tracked. The project proponent should ensure that this energy consumption is tracked in accordance with the thermal energy systems used for other primary processes (e.g. food processing), to ensure that the parasitic load is accounted for as well as the use of supplemental fossil fuels that is incremental to baseline activities.	Controlled

P8 Aerobic Wastewater Treatment Process	The anaerobic wastewater treatment unit may be followed by an aerobic process (bioreactor, aerobic digester, clarifiers etc.) or an alternating anaerobic-aerobic process to ensure sufficient removal of organic matter from the wastewater stream, beyond the capability of a standalone anaerobic unit. There may be multiple energy and chemical inputs to operate equipment for pumping, mixing, coagulation, flocculation and aeration. Additionally pockets wastewater may have anaerobic conditions either by design or due to poor mixing, creating some additional methane emissions. Quantities and types of fuels and the potential for anaerobic conditions should be tracked to evaluate functional equivalence with the baseline condition.	Controlled
P9 Solid-Liquid Separation	The aggregated particles that have coagulated and been concentrated are generally sent to a filter, press or centrifuge system for de-watering. The resulting solid product is then sent for disposal or land application and the wastewater is usually recycled back to the aerobic treatment process. There may be multiple energy and chemical inputs to operate the solid-liquid separator, pumps and associated equipment. Quantities and types of fuels should be tracked to evaluate functional equivalence with the baseline condition.	Controlled
P10 Wastewater Polishing	The wastewater may undergo some additional chemical adjustments in a polishing step to ensure that the wastewater meets applicable sewer or surface water discharge regulations. Additional chemicals and energy inputs may be required in this step, with associated energy inputs and GHG emissions. Functional equivalence would be evaluated relative to the baseline scenario.	Controlled
P11 Wastewater Storage/ Discharge	After the wastewater has undergone any remaining chemical adjustments in the polishing stage, it will either be stored indefinitely or discharged to the sewer system or another body of water. If any significant quantities of organic material were remaining in the wastewater stream (likely due to upset conditions), there could be some small amount of additional methane produced in the storage pond or downstream of the site. Functional equivalence would also be evaluated relative to the baseline scenario.	Controlled
P12 Waste Sludge Storage	Greenhouse gas emissions may also result if the solid material (sludge) from the solid-liquid separator (filter press) is stored on-site stored for extended periods of time. Further anaerobic decomposition may occur if the material is not fully stabilized resulting in some additional methane emissions. Functional equivalence with the baseline sludge handling practice would be evaluated to determine materiality. If a change in practice from the baseline resulted in incremental quantities of sludge being stored under anaerobic conditions for long periods of time in the project condition, the stability of the sludge material and methane generation potential should be evaluated to evaluate materiality of emissions.	Controlled
P17 Biogas Venting	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 methane capture system 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 would all need to be tracked. For routine venting as part of the system design, the project proponent should refer to the manufacturer's collection efficiency in design documents or other industry common values for the type of methane capture and digester system in place.	Controlled

P18 Biogas Conditioning	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 and other equipment may be required to treat the biogas and remove impurities in order meet the required specifications. This may require several energy inputs such as natural gas and diesel. Quantities and types of each energy input should be tracked.	
P19 Biogas Flaring	Flaring of the biogas may be required during upset conditions or during maintenance to any elements downstream of the anaerobic digester. Emissions of greenhouse gases would be contributed from the combustion of the biogas as well as from any pilot or make-up fuel used in flaring to ensure more complete combustion. Quantities of biogas being flared and the quantities of fossil fuels consumed for flaring would need to be tracked.	Controlled
P20 Biogas Processing for Pipeline	In addition to the biogas conditioning step 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 would be tracked.	Controlled
P21 Thermal Energy Generation	New Boilers or cogeneration systems may be implemented to produce thermal energy from the biogas, which may be used on-site (e.g. heat for the digester or anaerobic treatment unit) or distributed to other heat users. Supplemental fossil fuels may be required for start-up or to supplement system demands when biogas production volumes are low. Emissions of greenhouse gases are associated with the use of these supplemental fossil fuels. Quantities and types for each of the supplemental energy inputs would be tracked accounting for the parasitic load to operate the equipment. Note that this SS may overlap with the SS for P3 Facility Thermal Energy Generation as existing infrastructure may already be in place to utilize biogas and therefore sufficient metering and monitoring systems should be in place to track the quantity of energy supplied from biogas and the quantity of energy from fossil fuels as well as any incremental energy inputs used on-site to heat the anaerobic treatment unit or to distribute thermal energy to off-site users.	Controlled
P22 Electricity Generation	Electricity generation or cogeneration systems may be required to produce electricity for use at the project site or for distribution to the regional grid. The operation of this equipment may require several energy inputs such as natural gas or diesel to supplement the use of biogas. The important quantity to track would be the net electrical output of the system (net of any parasitic loads) and the quantities and types of any supplemental fuels used by the generation unit.	Controlled
P23 Fugitive Emissions	Greenhouse gas emissions may also result from fugitive emissions associated with the operation of the anaerobic digestion facility. These emissions would primarily be methane emissions associated with leaks through valves, connections and equipment seals as many of the facility components operate under pressure. The project proponent should conduct regular operational checks and maintenance activities to minimize the release of fugitive emissions. Functional equivalence would be evaluated based on whether the project system enhanced biogas production with supplemental heat. Refer to Appendix B for further guidance related to the management of fugitive emissions.	Related

<b>Downstream SS's during Project Operation</b>		
P13 Waste Sludge Transport	Sludge produced from wastewater treatment in a primary or secondary settler or other processes may need to be transported to a composting or other anaerobic digestion facility for additional material stabilization, or to a disposal site or to fields for land application. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Controlled
P14 Waste Sludge Land Application/ Composting	The waste sludge may be further cured and stabilized using a composting process (e.g. passive or active windrowing) and then land applied or directly land applied. This process would require the use of heavy equipment and mechanical systems. This equipment would be fuelled by diesel, gas or natural gas, resulting in GHG emissions. Composting and land application may result in additional N <sub>2</sub> O emissions and methane emissions from pockets of anaerobic conditions during composting or land application. Quantities for each of the energy inputs and evaluation of normal practices pre-post project would be contemplated to evaluate functional equivalence between the baseline and project conditions.	Related
P15 Waste Sludge Disposal	The wastewater treatment facility may generate significant amounts of waste sludge requiring disposal if the land applied is not practiced or allowed in the relevant region due to nutrient restrictions. Waste sludge may be disposed of at a disposal site, such as a landfill, by transferring the waste from the transportation container, spreading, burying, processing, otherwise handling the waste using a combination of loaders, conveyors and other mechanized devices. This equipment would be fuelled by diesel, gas or natural gas, resulting in GHG emissions. Other fuels may also be used in some rare cases. Quantities and types for each of the energy inputs would be tracked.	Related
P16 Waste Sludge Decomposition and Methane Collection / Destruction	In the project condition some waste sludge may be sent to landfill in and may result in the production of methane due to anaerobic conditions at the landfill site. A methane collection and destruction system may be in place at the disposal site. The average percentage of methane collected and destructed for landfills in that jurisdiction should be accounted for in a reasonable manner otherwise specific disposal site characteristics and may need to be tracked as well as the characteristics of the specific methane collection and destruction system. The project proponent should track the wet weight of waste sludge sent to landfill and account for any occasions when sediments are removed from the anaerobic digester as the material may have some methane generation potential and be a source of GHG leakage.	Related
P24 Pipeline Distribution and Usage	Biogas may be input to the pipeline system and distributed to customers at another point on the distribution system. This gas will be then consumed by the consumer. The most reasonable fate would be combustion in a controlled manner as this relies on the highest emissions factors for the biogas. The total quantity and energy content of biogas input to the pipeline system would need to be tracked.	Related
<b>Other</b>		

P28 Development of Site	Additional development may be required for implementation of the anaerobic digester at the wastewater treatment facility. This could include civil infrastructure such as access to electricity, gas and water supply, as well as sewer etc. This may also include clearing, grading, building access roads, etc. There will also need to be some building of structures for the facility such as storage areas, storm water drainage, offices, vent stacks, firefighting water storage lagoons, etc., as well as structures to enclose, support and house the equipment. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site such as graders, backhoes, trenching machines, etc.	Related
P29 Building Equipment	Equipment may need to be built either on-site or off-site. This includes all of the components of the storage, handling, processing, combustion, air quality control, system control and safety systems. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabricating and assembly.	Related
P30 Transportation of Equipment	Equipment built off-site and the materials to build equipment on-site, will all need to be delivered to the site. Transportation may be completed by truck, barge and/or train. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
P31 Construction on Site	The process of construction at the site will require a variety of heavy equipment, smaller power tools, cranes and generators. The operation of this equipment will have associated greenhouse gas emission from the use of fossil fuels and electricity.	Related
P32 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using test anaerobic digestion fuels or fossil fuels in order to ensure that the equipment runs properly. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity.	Related
P33 Site Decommissioning	Once the facility is no longer operational, the site may need to be decommissioned. This may involve the disassembly of the equipment, demolition of on-site structures, disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related

## 2.2 Identification of Baseline

The baseline scenario represents the wastewater treatment process GHG emissions that would have occurred from the venting of biogas had the project not installed a methane capture system and the GHG emissions from fossil fuels that would have been consumed had the project activity not installed a biogas utilization system.

The baseline condition is considered as projection based. Under this scenario, the emissions from the anaerobic decomposition of an equivalent quantity of organic matter (expressed as chemical oxygen demand) contained in an industrial wastewater effluent stream that is treated under clearly anaerobic (oxygen-free) conditions would be calculated using existing models covering the activities under the baseline condition. This is accomplished by applying a mass balance on the COD into and out of the baseline anaerobic treatment system and accounting for the effects of temperature and oxygen exposure on the biological process consistent with the approach outlined in the Clean Development Mechanism Consolidated Methodology ACM0014 for Anaerobic Wastewater Treatment Projects. The GHG emissions from fossil fuels consumed in the baseline and replaced with renewable energy output from the biogas utilization system would be accounted for using direct measurement of the biogas energy output in the project activity and displacement of the most likely or most conservative fossil fuel type.

The baseline scenario for projects that previously flared biogas without energy recovery in an open flare assumes a methane destruction efficiency of 95%. The displacement of fossil fuel derived energy sources with energy produced from biogas in the project condition would be accounted for using metered biogas production volumes and/or combustion system energy output data.

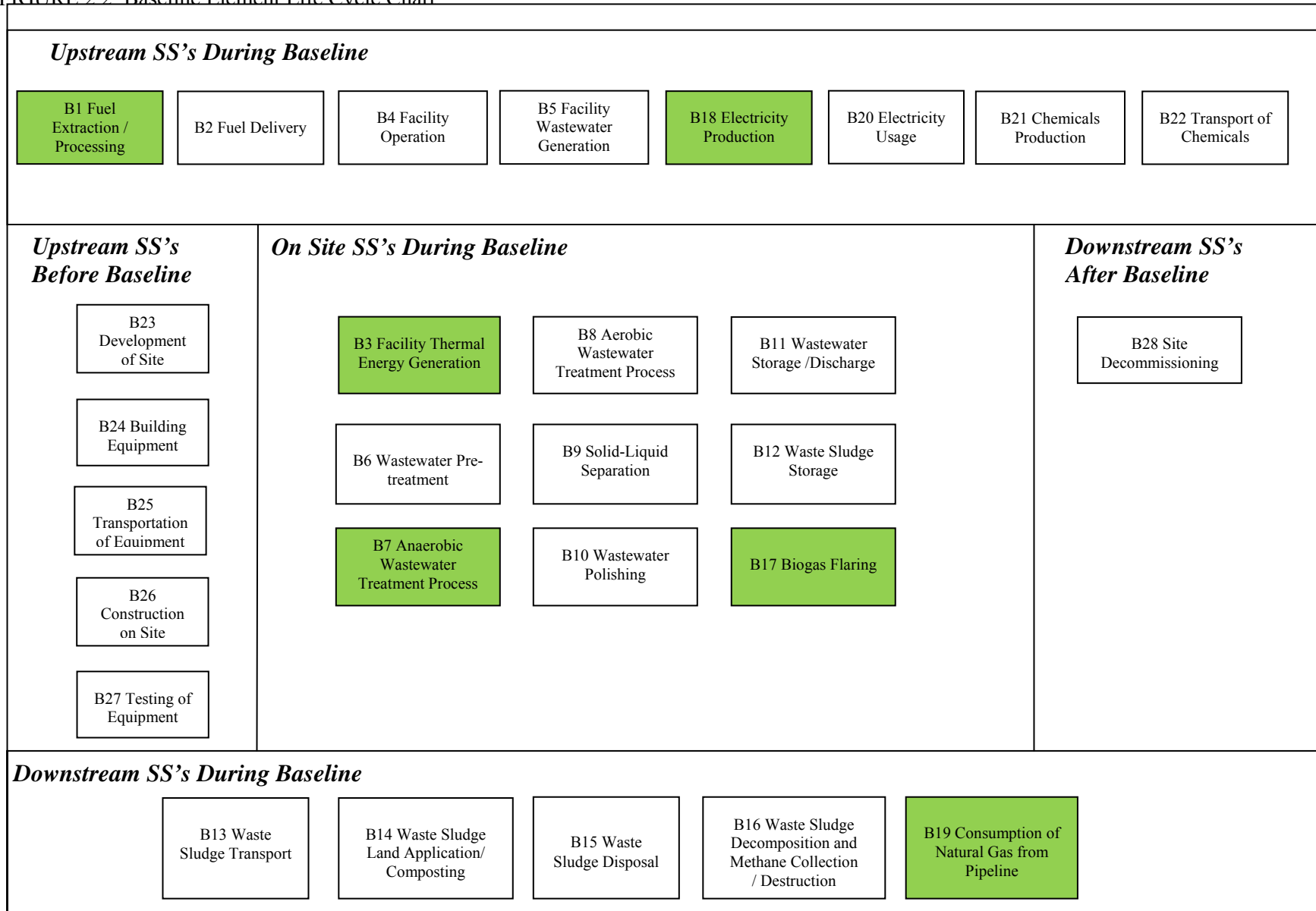
This dynamic approach accounts for the market forces, weather and energy demand and operational parameters without adding multiple streams of material management. There are suitable models that can provide reasonable certainty.

The baseline condition is defined including the relevant SS's and processes as shown in **FIGURE 1.2**. More detail on each of these SS's is provided in Section 2.3, below.

## 2.3 Identification of SS's for the Baseline

Based on the process flow diagrams provided in **FIGURE 1.2**, the project SS's were organized into life cycle categories in **FIGURE 2.2**. Descriptions of each of the SS's and their classification as either 'controlled', 'related' or 'affected' is provided in **TABLE 2.2**

FIGURE 2.2: Baseline Element Life Cycle Chart



**TABLE 2.2: Baseline SS's**

1. SS	2. Description	3. Controlled, Related or Affected
<i>Upstream SS's during Baseline Operation</i>		
B1 Fuel Extraction / Processing	Each of the fuels used at the facility in the baseline will need to be sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the fuels. The total volumes of fuel for each of the on-site SS's are aggregated under this SS to account for GHG emissions associated with their extraction and processing at upstream oil and gas facilities. Volumes and types of fuels are the important characteristics to be tracked.	Related
B2 Fuel Delivery	Each of the fuels used at the facility in the baseline will need to be transported to the site. This may include shipments by tanker or by pipeline, resulting in the emissions of greenhouse gases. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fuelling station as the fuel used to take the equipment to the site is captured under other SS's and there are no other delivery emissions as the fuel is already going to the commercial fuelling station. Distance and means of fuel delivery as well as the volumes of fuel delivered are the important characteristics to be tracked.	Related
B4 Facility Operation	The facility that generates the wastewater would have a primary function or product and any number of processes that would require energy inputs and therefore consume fossil fuels as part of process or unit operation and for material handling. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Related
B5 Facility Wastewater Generation	Wastewater is produced as a by-product of industrial operations in a number ways including from cleaning of process equipment and from the discharge of off-spec materials and by-products using water as a transport medium for the wastes. Greenhouse gas emissions may be associated with these industrial processes and the associated wastewater handling practices, which could include heating, pumping, mixing, sterilization and equalization and could be powered by fossil fuels either directly or indirectly through a centralized boiler or cogeneration unit. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition. Typical facilities could include meat and vegetable processing facilities, distilleries, breweries and other industries that produce significant loadings of organic matter in wastewater streams.	Related
B18 Electricity Production	Electricity will be produced at off-site grid connected generation facilities in the baseline to cover the electricity that is now being generated from the biogas output by the project anaerobic digestion facility. This electricity would have been produced at an emissions intensity as deemed appropriate by the Program Authority. The net quantity of electricity output by the facility in the project condition will need to be tracked in the project condition to quantify this SS.	Related
B20 Electricity Usage	Electricity may be required for operating a variety of equipment at the processing facility and at	

	the wastewater treatment facilities in the baseline. This power may be sourced either from internal generation, connected facilities or the local electricity grid. Metering of electricity should be sufficient to track the use of electricity sourced from on and off-site electricity generation systems. For project configurations where electricity is generated from biogas produced from anaerobic digestion at the project condition, the net electricity output from the generator would displace an equivalent quantity of electricity on or off-site that would have been derived from fossil fuels and this would be accounted for under the SS B17 Electricity Production and not under this SS. Quantity and source of power used at the project site are the important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions.	
B21 Chemical Production	The production of chemicals from raw materials upstream of the project site may include several material and energy inputs such as natural gas and diesel. Quantities and types of chemicals used at the facility and their associated GHG intensity per unit would be contemplated to evaluate functional equivalence with the baseline condition.	Related
B22 Transport of Chemicals	Chemicals used at the project facility may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related
<b>Onsite SS's during Project Operation</b>		
B3 Facility Thermal Energy Generation	The facility may have operated a boiler or other equipment to generate thermal energy for the primary production process by combusting fossil fuels. These fuels may be displaced by thermal energy produced from biogas captured in the project condition. The quantities and types of fuels combusted for thermal energy generation should be tracked in addition to the quantity of thermal energy produced from biogas in the project condition. Appropriate metering systems should be in place to account for any incremental parasitic heating requirements of the project activity such that they may be subtracted from the total quantity of thermal energy displacing the baseline fossil fuel. The project proponent should track the quantity, composition and energy content of biogas consumed on-site to supplement the thermal energy demands of the facility.	Controlled
B6 Wastewater Pre-Treatment	Wastewater may be treated and/or processed prior to being input to the anaerobic treatment system. This could include physical processes such as screening, grit and solids removal, oil-water separation, dissolved air flotation for removal of fats and oils and other processes that adjust the chemical composition of the wastewater. This may involve the use of heavy equipment that operates using diesel or natural gas. Emissions of greenhouse gases are associated with the use of these fossil fuels. Quantities for each of the energy inputs may all need to be tracked to evaluate functional equivalence with the project condition.	Controlled
B7 Anaerobic Wastewater Treatment Process	Greenhouse gas emissions may occur that are associated with the operation of the baseline anaerobic treatment unit. The primary source of GHG emissions would be from the venting of	Controlled

	<p>biogas to the atmosphere. The quantity of organic matter as chemical oxygen demand into and out of the anaerobic treatment unit should be tracked in the project condition to determine the quantity of COD removed by the anaerobic wastewater treatment unit in the baseline. This quantity of COD would have decayed to produce methane that would have been emitted to the atmosphere had a methane capture system not been installed. The quantity of methane emitted from the anaerobic treatment unit (e.g. and uncovered deep anaerobic lagoon) in the baseline is a function the mass of COD removed in the unit, the temperature of the wastewater, the maximum methane generation potential per unit of COD and the anaerobic conditions of the lagoon (referred to using a methane conversion factor). The project proponent should track the mass of COD in and out of the lagoon and the temperature of the wastewater at the entrance and exit of the anaerobic treatment unit.</p>	
B8 Aerobic Wastewater Treatment Process	<p>The anaerobic wastewater treatment unit may be followed by an aerobic process (bioreactor, aerobic digester, clarifier etc.) or an alternating anaerobic-aerobic process to ensure sufficient removal of organic matter from the wastewater stream, beyond the capability of a standalone anaerobic unit. There may be multiple energy and chemical inputs to operate equipment for pumping, mixing, coagulation, flocculation and aeration. Additionally pockets wastewater may have anaerobic conditions either by design or due to poor mixing, creating some additional methane emissions. Quantities and types of fuels and the potential for anaerobic conditions should be tracked to evaluate functional equivalence with the project condition.</p>	Controlled
B9 Solid-Liquid Separation	<p>The aggregated particles that have coagulated and been concentrated are generally sent to a filter, press or centrifuge system for de-watering. The resulting solid product is then sent for disposal or land application and the wastewater is usually recycled back to the aerobic treatment process. There may be multiple energy and chemical inputs to operate the solid-liquid separator, pumps and associated equipment. Quantities and types of fuels should be tracked to evaluate functional equivalence with the project condition.</p>	Controlled
B10 Wastewater Polishing	<p>The wastewater may undergo some additional chemical adjustments in a polishing step to ensure that the wastewater meets applicable sewer or surface water discharge regulations. Additional chemicals and energy inputs may be required in this step, with associated energy inputs and GHG emissions. Functional equivalence would be evaluated relative to the project scenario.</p>	Controlled
B11 Wastewater Storage/ Discharge	<p>After the wastewater has undergone any remaining chemical adjustments in the polishing stage, it will either be stored indefinitely or discharged to the sewer system or another body of water. If any significant quantities of organic material were remaining in the wastewater stream (likely due to upset conditions), there could be some small amount of additional methane produced in the storage pond or downstream of the site. Functional equivalence would also be evaluated relative to the baseline scenario.</p>	Controlled
B12 Waste Sludge Storage	<p>Greenhouse gas emissions may also result if the solid material (sludge) from the solid-liquid separator (filter press) is stored on-site stored for extended periods of time. Further anaerobic</p>	Controlled

	decomposition may occur if the material is not fully stabilized resulting in some additional methane emissions. Functional equivalence with the sludge handling practice used in the project condition would be evaluated to determine materiality. If a change in practice from the baseline resulted in incremental quantities of sludge being stored under anaerobic conditions for long periods of time in the project condition, the stability of the sludge material and methane generation potential should be evaluated to evaluate materiality of emissions.	
B17 Biogas Flaring	In the baseline scenario a flare may have operated at the site to destroy some or all of the biogas produced from the anaerobic treatment unit. The project proponent would be responsible for tracking the volume of biogas flared, the type of flare unit (open or enclosed) and the flare destruction efficiency (e.g. from manufacturing specifications) as these items would impact the baseline methane emissions.	
<b>Downstream SS's during Baseline Operation</b>		
B13 Waste Sludge Transport	Sludge produced from wastewater treatment in a primary or secondary settler or other processes may need to be transported to a composting or other anaerobic digestion facility for additional material stabilization, or to a disposal site or to fields for land application. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Controlled
B14 Waste Sludge Land Application/ Composting	The waste sludge may be further cured and stabilized using a composting process (e.g. passive or active windrowing) and then land applied or directly land applied. This process would require the use of heavy equipment and mechanical systems. This equipment would be fuelled by diesel, gas or natural gas, resulting in GHG emissions. Composting and land application may result in additional N <sub>2</sub> O emissions and methane emissions from pockets of anaerobic conditions during composting or land application. Quantities for each of the energy inputs and evaluation of normal practices pre-post project would be contemplated to evaluate functional equivalence between the baseline and project conditions.	Related
B15 Waste Sludge Disposal	The wastewater treatment facility may generate significant amounts of waste sludge requiring disposal if the land applied is not practiced or allowed in the relevant region due to nutrient restrictions. Waste sludge may be disposed of at a disposal site, such as a landfill, by transferring the waste from the transportation container, spreading, burying, processing, otherwise handling the waste using a combination of loaders, conveyors and other mechanized devices. This equipment would be fuelled by diesel, gas or natural gas, resulting in GHG emissions. Other fuels may also be used in some rare cases. Quantities and types for each of the energy inputs would be tracked.	Related

<p>B16 Waste Sludge Decomposition and Methane Collection / Destruction</p>	<p>In the project condition some waste sludge may be sent to landfill in and may result in the production of methane due to anaerobic conditions at the landfill site. A methane collection and destruction system may be in place at the disposal site. The average percentage of methane collected and destructed for landfills in that jurisdiction should be accounted for in a reasonable manner otherwise specific disposal site characteristics and may need to be tracked as well as the characteristics of the specific methane collection and destruction system. The project proponent should track the wet weight of waste sludge sent to landfill and account for any occasions when sediments are removed from the anaerobic digester as the material may have some methane generation potential and be a source of GHG leakage.</p>	<p>Related</p>
<p>B19 Consumption of Natural Gas from Pipeline</p>	<p>Biogas may be input to the pipeline system and distributed to customers at another point on the distribution system in the project condition. This gas will be then consumed by the consumer and result in the displacement of natural gas that would normally have been consumed had the biogas not been input into the gas distribution system. The most reasonable fate would be combustion in a controlled manner as this relies on the highest emissions factors for the biogas. The total quantity and energy content of biogas input to the pipeline system would need to be tracked in the project condition to calculate the equivalent quantity of natural gas displaced in the baseline.</p>	<p>Related</p>
<p><b>Others</b></p>		
<p>B23 Development of Site</p>	<p>The site may need to be developed under the baseline condition. This could include civil infrastructure such as access to electricity, gas and water supply, as well as sewer etc. This may also include clearing, grading, building access roads, etc. There will also need to be some building of structures for the facility such as storage areas and offices, etc., as well as structures to enclose, support and house any equipment. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site such as graders, backhoes, trenching machines, etc.</p>	<p>Related</p>
<p>B24 Building Equipment</p>	<p>Equipment may need to be built either on-site or off-site. This can include the baseline components for the storage, handling and processing of the agricultural material. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabricating and assembly.</p>	<p>Related</p>
<p>B25 Transportation of Equipment</p>	<p>Equipment built off-site and the materials to build equipment on-site will all need to be delivered to the site. Transportation may be completed by truck, barge and/or train. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.</p>	<p>Related</p>

B26 Construction on Site	The process of construction at the site will require a variety of heavy equipment, smaller power tools, cranes and generators. The operation of this equipment will have associated greenhouse gas emission from the use of fossil fuels and electricity.	Related
B27 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using test agricultural materials or fossil fuels in order to ensure that the equipment runs properly. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity.	Related
B28 Site Decommissioning	Once the facility is no longer operational, the site may need to be decommissioned. This may involve the disassembly of the equipment, demolition of on-site structures, disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related

## 2.4 Selection of Relevant Project and Baseline SS's

Each of the SS's from the project and baseline conditions were compared and evaluated as to their relevancy using the guidance provided in Annex VI of the "Guide to Quantification Methodologies and Protocols: Draft", dated March 2006 (Environment Canada). The justification for the exclusion or conditions upon which SS's may be excluded is provided in **TABLE 2.3** below. All other SS's listed previously are included.

**TABLE 2.3: Comparison of SS's**

1. Baseline Options	2. Baseline (C, R, A)	2. Project (C, R, A)	4. Include or Exclude from Quantification	5. Justification for Exclusion
<b>Upstream SS's</b>				
P1 Fuel Extraction / Processing	N/A	Related	Include	N/A
B1 Fuel Extraction / Processing	Related	N/A	Include	
P2 Fuel Delivery	N/A	Related	Exclude	Excluded as these SS's are likely lower in the project condition and therefore it is conservative to exclude them.
B2 Fuel Delivery	Related	N/A	Exclude	
P4 Facility Operation	N/A	Related	Exclude	Excluded as in the majority of project configurations the facility operations upstream of the wastewater treatment processes will not be impacted by the project activity and therefore will be functionally equivalent in the baseline and project conditions.
B4 Facility Operation	Related	N/A	Exclude	
P5 Facility Wastewater Generation	N/A	Related	Exclude	Excluded as in the majority of project configurations the facility wastewater generation and collection systems upstream of the wastewater treatment processes will not be impacted by the project activity and therefore will be functionally equivalent in the baseline and project conditions
B5 Facility Wastewater Generation	Related	N/A	Exclude	
B18 Electricity Production	Related	N/A	Include	N/A
P25 Electricity Usage	N/A	Related	Exclude	Excluded as these SS's are not relevant to the project as the emissions from these practises are covered under proposed greenhouse gas regulations.
B20 Electricity Usage	Related	N/A	Exclude	
P26 Chemical Production	N/A	Related	Exclude	Excluded as under the majority of configurations, chemical use in the project condition will be equivalent to the baseline scenario as the addition of a methane capture system would not be expected to materially impact chemical usage.
B21 Chemical Production	Related	N/A	Exclude	
P27 Transport of Chemicals	N/A	Related	Exclude	Excluded as under the majority of configurations, chemical use in the project condition will be equivalent to the baseline scenario as the addition of a methane capture system would not be expected to materially impact chemical usage.
B22 Transport of Chemicals	Related	N/A	Exclude	
<b>Onsite SS's</b>				
P3 Facility Thermal Energy Generation	N/A	Controlled	Include	N/A
B3 Facility Thermal Energy Generation	Controlled	N/A		
P6 Wastewater Pre-Treatment	N/A	Controlled	Exclude	Excluded as in the majority of project configurations the facility wastewater pre-treatment systems upstream of the anaerobic treatment unit will not be
B6 Wastewater Pre-	Controlled	N/A		

Treatment				impacted by the project activity and therefore will be functionally equivalent in the baseline and project conditions
P7 Anaerobic Wastewater Treatment Process	N/A	Controlled	Include	N/A
B7 Anaerobic Wastewater Treatment Process	Controlled	N/A		
P8 Aerobic Wastewater Treatment Process	N/A	Controlled	Exclude	Excluded as in the majority of project configurations the aerobic wastewater treatment systems downstream of the anaerobic treatment unit will not be impacted by the project activity as the removal of COD in the anaerobic unit will remain consistent or potentially improve during the project activity and result in decreased treatment requirements downstream. Therefore the baseline and project conditions will be functionally equivalent.
B8 Aerobic Wastewater Treatment Process	Controlled	N/A		
P9 Solid-Liquid Separation	N/A	Controlled	Exclude	Excluded as in the majority of project configurations the solid-liquid separation unit operation downstream of the anaerobic treatment unit will not be impacted by the project activity and therefore will be functionally equivalent in the baseline and project conditions
B9 Solid-Liquid Separation	Controlled	N/A		
P10 Wastewater Polishing	N/A	Controlled	Exclude	Excluded as in the majority of project configurations the polishing treatment downstream of the anaerobic treatment unit will not be impacted by the project activity and therefore will be functionally equivalent in the baseline and project conditions
B10 Wastewater Polishing	Controlled	N/A		
P11 Wastewater Storage/ Discharge	N/A	Controlled	Exclude	Excluded as in the majority of project configurations the wastewater storage and discharge systems downstream of the anaerobic treatment unit will not be impacted by the project activity and therefore will be functionally equivalent in the baseline and project conditions
B11 Wastewater Storage/ Discharge	Controlled	N/A		
P12 Waste Sludge Storage	N/A	Controlled	Exclude	Excluded as in the majority of project configurations the sludge storage operations downstream of the anaerobic treatment unit will not be impacted by the project activity and therefore will be functionally equivalent in the baseline and project conditions
B12 Waste Sludge Storage	Controlled	N/A		
P17 Biogas Venting	N/A	Controlled	Include	N/A
P18 Biogas Conditioning	N/A	Controlled	Include	N/A
P19 Biogas Flaring	N/A	Controlled	Include	N/A
B17 Biogas Flaring	Controlled	N/A		
P20 Biogas Processing for Pipeline	N/A	Controlled	Include	N/A
P21 Thermal Energy Generation	N/A	Controlled	Include	N/A

P22 Electricity Generation	N/A	Controlled	Include	N/A
P23 Fugitive Emissions	N/A	Related	Exclude	Excluded as projects that involve enhanced anaerobic digestion processes (e.g. incremental heating to provide mesophilic or thermophilic conditions in the anaerobic digester) applying this protocol must meet the requirements of with Sections 10.2 through 10.4 of the Canadian Standards Association (CSA) Code for Digester Gas and Landfill Gas Installations CAN/CGA-B105-M93 which specifies the relevant leakage and pressure testing requirements providing reasonable assurance that fugitive emissions are immaterial. Refer to Appendix B for further guidance.
<b>Downstream SS's</b>				
P13 Waste Sludge Transport	N/A	Related	Exclude	Excluded as in the majority of project configurations there will be no change in sludge disposal practices and therefore no change in fossil fuel consumption for sludge transportation, making the baseline and project scenarios functionally equivalent.
B13 Waste Sludge Transport	Related	N/A		
P14 Waste Sludge Land Application/ Composting	N/A	Related	Exclude	Excluded as in the majority of project configurations there will be no change in sludge land application or composting practices due to the project implementation of a methane capture system, making the baseline and project scenarios functionally equivalent.
B14 Waste Sludge Land Application/ Composting	Related	N/A		
P15 Waste Sludge Disposal	N/A	Related	Exclude	Excluded due to the relatively small quantity of GHG emissions from fossil fuel consumption to operate heavy equipment to handle the waste sludge at the disposal site (e.g. landfill).
B15 Waste Sludge Disposal	Related	N/A		
P16 Waste Sludge Decomposition and Methane Collection/ Destruction	N/A	Related	Include	Project proponents can exclude this SS from quantification if facility records demonstrate that no sludge or sediment is sent to landfill in the Project condition.
B16 Waste Sludge Decomposition and Methane Collection/ Destruction	Related	N/A	Exclude	Excluded for conservativeness as higher emissions in the baseline would result in larger emission reductions.
P24 Pipeline Distribution and Usage	N/A	Related	Include	N/A
B19 Consumption of Natural Gas from Pipeline	Related	N/A		
<b>Other</b>				
P28 Development of Site	N/A	Related	Exclude	Emissions from site development are not material given the long project life, and the minimal site development typically required.
B23 Development of Site	Related	N/A	Exclude	Emissions from site development are not material for the baseline condition given the minimal site development typically required.
P29 Building Equipment	N/A	Related	Exclude	Emissions from building equipment are not material given the long project

				life, and the minimal building equipment typically required.
B24 Building Equipment	Related	N/A	Exclude	Emissions from building equipment are not material for the baseline condition given the minimal building equipment typically required.
P30 Transportation of Equipment	N/A	Related	Exclude	Emissions from transportation of equipment are not material given the long project life, and the minimal transportation of equipment typically required.
B25 Transportation of Equipment	Related	N/A	Exclude	Emissions from transportation of equipment are not material for the baseline condition given the minimal transportation of equipment typically required.
P31 Construction on Site	N/A	Related	Exclude	Emissions from construction on site are not material given the long project life, and the minimal construction on site typically required.
B26 Construction on Site	Related	N/A	Exclude	Emissions from construction on site are not material for the baseline condition given the minimal construction on site typically required.
P32 Testing of Equipment	N/A	Related	Exclude	Emissions from testing of equipment are not material given the long project life, and the minimal testing of equipment typically required.
B27 Testing of Equipment	Related	N/A	Exclude	Emissions from testing of equipment are not material for the baseline condition given the minimal testing of equipment typically required.
P33 Site Decommissioning	N/A	Related	Exclude	Emissions from decommissioning are not material given the long project life, and the minimal decommissioning typically required.
B28 Site Decommissioning	Related	N/A	Exclude	Emissions from decommissioning are not material for the baseline condition given the minimal decommissioning typically required.

## 2.5 Quantification of Reductions, Removals and Reversals of Relevant SS's

### 2.5.1 Quantification Approaches

Quantification of the reductions, removals and reversals of relevant SS's for each of the greenhouse gases will be completed using the methodologies outlined in **TABLE 2.4**, below. These calculation methodologies serve to complete the following three equations for calculating the emission reductions from the comparison of the baseline and project conditions.

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

$$\begin{aligned} \text{Emissions}_{\text{Baseline}} = & \text{Emissions}_{\text{Fuel Extraction / Processing}} + \text{Emissions}_{\text{Electricity Production}} + \\ & \text{Emissions}_{\text{Thermal Energy Generation}} + \text{Emissions}_{\text{Anaerobic Wastewater Treatment Process}} + \text{Emissions}_{\text{Biogas Flaring}} \\ & + \text{Emissions}_{\text{Consumption of Natural Gas from Pipeline}} \end{aligned}$$

$$\begin{aligned} \text{Emissions}_{\text{Project}} = & \text{Emissions}_{\text{Fuel Extraction / Processing}} + \text{Emissions}_{\text{Facility Thermal Energy Generation}} \\ & + \text{Emissions}_{\text{Anaerobic Wastewater Treatment Process}} + \text{Emissions}_{\text{Biogas Venting}} + \text{Emissions}_{\text{Biogas Conditioning}} \\ & + \text{Emissions}_{\text{Biogas Flaring}} + \text{Emissions}_{\text{Biogas Processing For Pipeline}} + \text{Emissions}_{\text{Thermal Energy Generation}} \\ & + \text{Emissions}_{\text{Electricity Generation}} + \text{Emissions}_{\text{Waste Sludge Decomposition and Methane Collection/ Destruction}} \\ & + \text{Emissions}_{\text{Pipeline Distribution}} \end{aligned}$$

Where:

$\text{Emissions}_{\text{Baseline}}$  = sum of the emissions under the baseline condition.

- $\text{Emissions}_{\text{Fuel Extraction / Processing}}$  (SS B1)
- $\text{Emissions}_{\text{Electricity Production}}$  (SS B18)
- $\text{Emissions}_{\text{Thermal Energy Generation}}$  (SS B3)
- $\text{Emissions}_{\text{Anaerobic Wastewater Treatment Process}}$  (SS B7)
- $\text{Emissions}_{\text{Biogas Flaring}}$  (SS B17)
- $\text{Emissions}_{\text{Consumption of Natural Gas from Pipeline}}$  (SS B19)

$\text{Emissions}_{\text{Project}}$  = sum of the emissions under the project condition.

- $\text{Emissions}_{\text{Fuel Extraction / Processing}}$  (SS P1)
- $\text{Emissions}_{\text{Facility Thermal Energy Generation}}$  (SS P3)
- $\text{Emissions}_{\text{Anaerobic Wastewater Treatment Process}}$  (SS P7)
- $\text{Emissions}_{\text{Biogas Venting}}$  (SS P17)
- $\text{Emissions}_{\text{Biogas Conditioning}}$  (SS P18)
- $\text{Emissions}_{\text{Biogas Flaring}}$  (SS P19)
- $\text{Emissions}_{\text{Biogas Processing For Pipeline}}$  (SS P20)
- $\text{Emissions}_{\text{Thermal Energy Generation}}$  (SS P21)
- $\text{Emissions}_{\text{Electricity Generation}}$  (SS P22)

**Emissions** Waste Sludge Decomposition and Methane Collection/Destruction (SS P16)

**Emissions** Pipeline Distribution (SS P24)

DRAFT

**TABLE 2.4: Quantification Procedures**

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
<b>Project SS's</b>						
P1 Fuel Extraction / Processing	Emissions <sub>Fuel Extraction / Processing</sub> = $\sum (\text{Vol. Fuel}_i * \text{EF Fuel}_{i\text{CO}_2})$ ; $\sum (\text{Vol. Fuel}_i * \text{EF Fuel}_{i\text{CH}_4})$ ; $\sum (\text{Vol. Fuel}_i * \text{EF Fuel}_{i\text{N}_2\text{O}})$					
	Volume of Fuel Consumed for P3, P7, P18, P19, P20, P21, P22, P24	L / m <sup>3</sup> / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO <sub>2</sub> Emissions Factor for Each Type of Fuel / EF Fuel <sub>iCO<sub>2</sub></sub>	kg CO <sub>2</sub> per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH <sub>4</sub> Emissions Factor for Each Type of Fuel / EF Fuel <sub>iCH<sub>4</sub></sub>	kg CH <sub>4</sub> per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N <sub>2</sub> O Emissions Factor for Each Type of Fuel / EF Fuel <sub>iN<sub>2</sub>O</sub>	kg N <sub>2</sub> O per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
P3 Facility Thermal Energy Generation & P18 Biogas Conditioning	Emissions <sub>P3, P18, P19, P20, P21, P22, P24</sub> = (Vol. Biogas <sub>Combusted</sub> * % CH <sub>4</sub> * ρ CH <sub>4</sub> * (1-DE)) ; (Vol. Biogas <sub>Combusted</sub> * % CH <sub>4</sub> * EF Biogas <sub>N<sub>2</sub>O</sub> ); $\sum (\text{Vol. Fuel}_i * \text{EF Fuel}_{i\text{CO}_2})$ ; $\sum (\text{Vol. Fuel}_i * \text{EF Fuel}_{i\text{CH}_4})$ ; $\sum (\text{Vol. Fuel}_i * \text{EF Fuel}_{i\text{N}_2\text{O}})$ ;					
	Emissions <sub>P3, P18, P19, P20, P21, P22, P24</sub>	kg of CO <sub>2</sub> ; CH <sub>4</sub> ; N <sub>2</sub> O	N/A	N/A	N/A	Quantity being calculated in aggregate form as biogas and supplemental fossil fuel use on site is likely aggregated for these SS's.

& P19 Biogas Flaring	Volume of Biogas Combusted for P3, P18, P19, P20, P21, P22/ Vol. Biogas Combusted	$m^3$	Measured	Direct metering of volume of biogas being combusted on and off-site.	Continuous metering.	Direct metering is standard practise. Frequency of metering is highest level possible.
& P20 Biogas Processing for Pipeline	Methane Composition in Biogas / % CH <sub>4</sub>	-	Measured	Direct measurement.	Monthly	Biogas composition should remain relatively stable during steady-state operation for wastewater treatment operations.
& P21 Thermal Energy Distribution	Density of Methane / $\rho$ CH <sub>4</sub>	$kg / m^3$	Constant	0.7157 kg/m <sup>3</sup> at standard temperature and pressure.	Actual value	If this value is used all volumes should be adjusted accordingly to reflect standard temperature and pressure.
& P22 Electricity Generation	Destruction Efficiency of Combustion Device / DE	%	Estimated	95% destruction efficiency for open flares and 98% for all other enclosed combustion devices. Manufacturer's specifications may also be appropriate where available.	Actual value	Default values taken from GE AES <i>Methodology for Waste Water Treatment Methane Capture and Destruction Projects Version 1.0 August 22, 2007</i> .
& P24 Pipeline Distribution and Usage	N <sub>2</sub> O Emissions Factor for Biogas / EF Biogas <sub>N2O</sub>	$kg N_2O$ per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents. In the absence of biogas data, rely on emissions factors for Natural Gas. The generic Environment Canada emission factors (for industrial use of natural gas or electric utilities) may be adequate, but other factors specific to the type of combustion device (US-EPA AP-42 or CAPP) may be more appropriate.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory. US EPA AP-42 values are commonly used by industry

	Volume of Each Type of Fuel Combusted for P3, P18, P19, P20, P21, P22, P24 / Vol Fuel <sub>i</sub>	L / m <sup>3</sup> / other	Measured	Direct metering or reconciliation of volumes of supplemental fuels used for thermal energy generation, biogas conditioning, biogas flaring, biogas processing for input into the pipeline, electricity generation and pipeline distribution and usage. Where direct metering is not possible, reconciliation of the volumes of each fuel in storage (including volumes received) is reasonable.	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO <sub>2</sub> Emissions Factor for Each Type of Fuel / EF Fuel <sub>i</sub> CO <sub>2</sub>	kg CO <sub>2</sub> per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH <sub>4</sub> Emissions Factor for Each Type of Fuel / EF Fuel <sub>i</sub> CH <sub>4</sub>	kg CH <sub>4</sub> per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N <sub>2</sub> O Emissions Factor for Each Type of Fuel / EF Fuel <sub>i</sub> N <sub>2</sub> O	kg N <sub>2</sub> O per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
P7 Anaerobic Wastewater Treatment Process	This SS is accounted for under SS B7 Anaerobic Wastewater Treatment Process.					

P17 Biogas Venting	<p>The equation below for Project Emissions from biogas venting includes a component for upset conditions such as when a tear or major leak occurs in a digester cover and a component to account for methane emissions due to digester collection efficiencies less than 100% efficient.</p> $\text{Emissions}_{\text{Venting}} = [(\text{Max. Storage Vol.}_{\text{Vessel}} + \text{Flow Biogas}_{\text{Vessel}} * \text{Time}_{\text{Venting}}) * \% \text{CH}_4 * \rho \text{CH}_4 + (\text{Vol. Biogas} * ((1-\text{CE})/\text{CE}) * \% \text{CH}_4 * \rho \text{CH}_4)]$					
	Maximum volume of biogas stored in Vessel at Steady State / Max. Storage Vol. $\text{Vessel}$	$\text{m}^3$	Estimated	From facility engineering specifications or engineering estimate based on dimensions. This may represent only the segment of the digester the leak occurred in if the digester is compartmentalized (eg covered lagoon)	Annual	Reference value will remain consistent unless system is re-engineered (i.e. change to maximum storage volume from change in cap).
	Flow Rate of Biogas at Steady State / Flow Biogas $\text{Vessel}$	$\text{m}^3 / \text{hr}$	Measured	Average flow rate of biogas from the digester at steady state for the preceding period.	Weekly	Biogas flow rates are steady state for the previous week should provide a reasonable approximation of the biogas flow rate at time of venting.
	Time that vessel is venting / t	days	Estimated	Number of partial or complete days of venting either measured or estimated from site records of energy production, witness accounts, etc.	Daily	Number of days in a year when venting occurred is an absolute value.
	Methane Composition in Biogas / % $\text{CH}_4$	-	Measured	Direct measurement.	Monthly	Biogas composition should remain relatively stable during steady-state operation.
	Density of Methane / $\rho \text{CH}_4$	$\text{kg} / \text{m}^3$	Constant	0.7157 $\text{kg}/\text{m}^3$ at standard temperature and pressure.	Actual value	If this value is used all volumes should be adjusted accordingly to reflect standard temperature and pressure.

	Total Volume of Biogas Captured from Anaerobic Treatment System / Vol. Biogas	m3	Measured	Direct metering of volume of biogas being combusted.	Continuous metering.	Direct metering is standard practise. Frequency of metering is highest level possible.
	Collection Efficiency for Anaerobic Digester / CE	-	Estimated	Value of 95% for bank-to-bank covered lagoon systems and 98% for enclosed vessel systems (complete mix or fixed film digesters). Alternatively the project proponent may utilize engineering designs for the anaerobic digester and methane capture systems if available.	Annual	Values obtained from <i>US Environmental Protection Agency (EPA) Climate Leaders Draft Offset Protocol for Managing Manure with Biogas Recovery Systems</i> (October 2006) Table II.f. Digester Collection Efficiencies. Represents best practice guidance and a conservative approach to quantification. Venting emissions are not normally practical to measure, therefore estimation is reasonable.
P16 Waste Sludge Decomposition and Methane Collection/ Destruction	$Emissions_{Sludge\ Disposal} = (Mass_{Feedstock\ Landfill} * MCF * DOC * DOC_F * F * 16/12) * (1 - R) * (1 - OX)$					
	Emissions <sub>Sludge Disposal</sub>	kg of CH <sub>4</sub>	N/A	N/A	N/A	Quantity being calculated.
	Mass of Sludge and Sediment Sent to Landfill / Mass <sub>Sludge Landfill</sub>	kg	Measured	Direct measurement of the incremental mass of waste sludge sent to a landfill facility in the project condition or reconciliation of disposal/haulage receipts. If sediments are removed from the anaerobic treatment system and sent to landfill, this mass should be accounted for under this SS.	Measurement of each load of waste prior to its being disposed of onsite or as it is received at the landfill facility.	Measuring the mass of each load prior to its being disposed of onsite or as it is received at the landfill facility represents the industry practise.

	Methane Correction Factor / MCF	-	Estimated	Calculated based on IPCC and Environment Canada guidelines, provided in Appendix D.	Annual	Values calculated based on values published by IPCC. Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Degradable Organic Carbon / DOC	-	Estimated	Calculated based on IPCC and Environment Canada guidelines, provided in Appendix D.	Annual	Values calculated based on values published by IPCC. Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Fraction of Degradable Organic Carbon Dissimilated / $DOC_F$	-	Estimated	Calculated based on IPCC and Environment Canada guidelines, provided in Appendix D.	Annual	Values calculated based on values published by IPCC. Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Fraction of $CH_4$ in Landfill Gas Produced At Disposal Site / F	-	Estimated	From IPCC guidelines.	Annual	Reference values adjusted periodically as part of internal IPCC review of its methodologies.

	Fraction of CH <sub>4</sub> Recovered at Landfill / R	-	Estimated	Based on an affirmation from the landfill operator or from landfill gas collection system engineering design efficiency if site-specific data is available to the project developer. If site specific data is not available or if biomass wastes disposed of in multiple landfills within a large area the project developer may use a regional average percentage of landfill methane collected in the region.	Annual	Percentage of methane collected and destroyed at the landfill sites where the materials were previously sent. In cases where biomass is sourced from a large area and diverted from multiple landfills the project developer may use a regional average based on landfill gas capture data from the National GHG Inventory or other relevant sources.
	Oxidation Factor / OX	-	Estimated	From IPCC guidelines.	Annual	Reference values adjusted periodically as part of internal IPCC review of its methodologies.
<b>Baseline SS's</b>						
B1 Fuel Extraction / Processing	$\text{Emissions}_{\text{Fuel Extraction / Processing}} = \sum (\text{Vol. Fuel}_i * \text{EF}_{\text{Fuel}_i \text{CO}_2}) ; \sum (\text{Vol. Fuel}_i * \text{EF}_{\text{Fuel}_i \text{CH}_4}) ; \sum (\text{Vol. Fuel}_i * \text{EF}_{\text{Fuel}_i \text{N}_2\text{O}})$					
	Volume of Fuel Consumed for B3 and B18	L / m <sup>3</sup> / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO <sub>2</sub> Emissions Factor for Each Type of Fuel / EF Fuel <sub>iCO2</sub>	kg CO <sub>2</sub> per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

	CH <sub>4</sub> Emissions Factor for Each Type of Fuel / EF Fuel <sub>i</sub> CH <sub>4</sub>	kg CH <sub>4</sub> per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N <sub>2</sub> O Emissions Factor for Each Type of Fuel / EF Fuel <sub>i</sub> N <sub>2</sub> O	kg N <sub>2</sub> O per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
B18 Electricity Production	Emissions <sub>Electricity</sub> = Electricity * EF <sub>Elec</sub>					
	Emissions <sub>Electricity</sub>	kg of CO <sub>2</sub> e	N/A	N/A	N/A	Quantity being calculated.
	Electricity Sent to Grid or Direct Connected Facilities in Project Condition/ Electricity	kWh	Measured	Direct metering of quantity of renewable electricity delivered to the regional grid or direct connected users net of parasitic loads attributable to the project activity. This quantity of electricity generated in the project condition displaces an equivalent quantity of electricity that would have been produced by other grid connected facilities had the project activity not been implemented.	Continuous metering	Continuous direct metering represents the industry practise and the highest level of detail.
	Emissions Factor for Electricity / EF <sub>Elec</sub>	kg of CO <sub>2</sub> e per kWh	Estimated	From Alberta Environment reference documents.	Annual	Reference values adjusted as appropriate by Alberta Environment.
B3 Facility Thermal Energy Generation	Emissions <sub>Thermal Heat</sub> = $\sum (\text{Vol. Fuel}_i * \text{EF Fuel}_{i\text{CO}_2}) ; \sum (\text{Vol. Fuel}_i * \text{EF Fuel}_{i\text{CH}_4}) ; \sum (\text{Vol. Fuel}_i * \text{EF Fuel}_{i\text{N}_2\text{O}})$					
	Emissions <sub>Thermal Heat</sub>	kg of CO <sub>2</sub> ; CH <sub>4</sub> ; N <sub>2</sub> O	N/A	N/A	N/A	Quantity being calculated.
	Vol. Fuel <sub>i</sub> = Heat Load * % <sub>i</sub> / HHV fuel <sub>i</sub>					

	Volume of Each Type of Fuel / Vol Fuel <sub>i</sub>	L / m <sup>3</sup> / other	Measured	Calculated relative to metered quantity of thermal energy delivered to the end user and converted to an equivalent volume of fuel.	Continuous metering or monthly reconciliation	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	Heat Load Produced under the Project Condition / Heat Load	GJ	Measured	Direct metering of quantity of thermal energy delivered to the end user or total GJ of biogas combusted in the project condition. If biogas is combusted with other fuels, the relative energy input in GJ of each fuel used should be tracked in the project condition and only the biogas component would be credited.	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	Percentage of Each Type of Fuel Offset / % <sub>i</sub>	%	Estimated	Based on recorded fossil fuel consumption in one or more years prior to the implementation of project.	Monthly	Represents most reasonable means of estimation.
	Higher Heating Value of Each Type of Fuel Being Offset by the Project / HHV fuel <sub>i</sub>	GJ per L, m <sup>3</sup> or other unit	Estimated	Reference value.	N/A	Reference value. The use of the higher heating value is conservative and consistent with Environment Canada's National GHG Inventory.
	CO <sub>2</sub> Emissions Factor for Each Type of Fuel / EF Fuel <sub>i</sub> CO <sub>2</sub>	kg CO <sub>2</sub> per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH <sub>4</sub> Emissions Factor for Each Type of Fuel / EF Fuel <sub>i</sub> CH <sub>4</sub>	kg CH <sub>4</sub> per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

	N <sub>2</sub> O Emissions Factor for Each Type of Fuel / EF Fuel <sub>i</sub> N <sub>2</sub> O	kg N <sub>2</sub> O per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
B7 Anaerobic Wastewater Treatment Process	Emissions <sub>Anaerobic Wastewater Treatment</sub> = $\sum (Flow_{IN} * COD_{IN} - Flow_{OUT} * COD_{OUT} - Q_{Sediment} * COD_{Sediment}) * MCF * Bo$					
	Emissions <sub>Anaerobic Wastewater Treatment</sub>	kg of CH <sub>4</sub>	N/A	N/A	N/A	Quantity being calculated.
	Flow Rate of Wastewater into the Anaerobic Treatment Unit in the Project Condition / Flow <sub>IN</sub>	m <sup>3</sup> of wastewater	Measured	Direct measurement of volumetric flow rate of wastewater into the anaerobic treatment unit in the project condition.	Daily	Frequency of metering provides for reasonable diligence as wastewater volumes will be fairly consistent over the course of a year.
	Flow Rate of Wastewater exiting the Anaerobic Treatment Unit in the Project Condition / Flow <sub>IN</sub>	m <sup>3</sup> of wastewater	Measured	Direct measurement of volumetric flow rates of wastewater exiting the anaerobic treatment unit in the project condition.	Daily	Frequency of metering provides for reasonable diligence as wastewater volumes will be fairly consistent over the course of a year.
	Concentration of Chemical Oxygen Demand in the Inlet Wastewater Stream Entering the Anaerobic Treatment Unit in the Project Condition / COD <sub>IN</sub>	Kg COD/ m <sup>3</sup> of wastewater	Measured	Direct measurement of chemical oxygen demand of inlet wastewater to the anaerobic treatment unit in the project activity. Measurement may be performed on site by trained technicians or tested by an external third party laboratory.	Weekly	Frequency of metering provides for reasonable diligence.

<p>Concentration of Chemical Oxygen Demand in the Wastewater Stream Exiting the Anaerobic Treatment Unit in the Project Condition / COD<sub>OUT</sub></p>	<p>Kg COD/ m<sup>3</sup> of wastewater</p>	<p>Measured</p>	<p>Direct measurement of chemical oxygen demand of wastewater exiting the anaerobic treatment unit in the project activity. Measurement may be performed on site by trained technicians or tested by an external third party laboratory.</p>	<p>Weekly</p>	<p>Frequency of metering provides for reasonable diligence.</p>
<p>Quantity of Sediments Removed from the Anaerobic Digester in the Project Condition/ Q<sub>Sediment</sub></p>	<p>m<sup>3</sup> of wastewater</p>	<p>Measured</p>	<p>Direct measurement or reconciliation from disposal or haulage fees.</p>	<p>Each time sediments are removed from the anaerobic digester</p>	<p>Frequency of metering represents the highest level of assurance.</p>
<p>Concentration of Chemical Oxygen Demand in Sediments Removed from the Anaerobic Treatment Unit in the Project Condition / COD<sub>Sediment</sub></p>	<p>Kg COD/ m<sup>3</sup> of wastewater</p>	<p>Measured</p>	<p>Direct measurement of chemical oxygen demand of wastewater and sediments removed from the anaerobic treatment unit in the project activity (e.g. due to decreased volume in the anaerobic treatment unit because of sediment build up or due to upset conditions). Measurement may be performed on site by trained technicians or tested by an external third party laboratory.</p>	<p>Each time sediments are removed from the anaerobic digester</p>	<p>Frequency of metering represents the highest level of assurance.</p>

	Methane Conversion Factor / MCF	-	Calculated	Calculated based on IPCC guidelines as per CDM Methodology ACM0014, further explanation provided in Appendix A.	Monthly	Values calculated based on <i>CDM Consolidated Methodology for Mitigation of Greenhouse Gas Emissions from Treatment of Industrial Wastewater (ACM0014)</i> and values published by IPCC. Reference values adjusted periodically as part of internal IPCC review of its methodologies.
$MCF = f_d * f_T * 0.89$						
	Depth Factor / $f_d$	-	Measured and Estimated.	Reconciliation of the dimensions of the anaerobic treatment unit from system designs or depth measurements under normal operating conditions. Depth of the lagoon or sludge pit is used to calculate the depth factor following CDM guidelines, provided in Appendix A.	Annual	Values calculated based on values published by CDM methodology ACM0014.
	Temperature Factor / $f_T$	-	Calculated	Calculated monthly following CDM methodology ACM0014 and the CCAR Livestock Project Reporting Protocol.	Monthly.	Values calculated based on methodologies published by the CDM and CCAR and values published by IPCC.
	Conservativeness Factor / 0.89	0.89	Estimated	Value from CDM methodology ACM0014.	-	The use of an extra conservative factor from CDM methodology ACM0014 is consistent with best practice guidance.
$f_T = \exp [(15,175*(T_{site} - 303.16)) / (1.987 * (303.16 * T_{site}))]$						

	Temperature at the Project Site / T <sub>site</sub>	Degrees Kelvin	Measured	Reconciliation of monthly average ambient temperatures at the project site. For wastewater streams that exit the processing plant at elevated temperatures the monthly ambient temperatures may be substituted with site measurements of the wastewater temperature of the effluent downstream of the anaerobic treatment system. The use of on-site wastewater temperatures is more accurate than ambient air temperatures.	Monthly reconciliation	If the average monthly temperature is less than 278 K, the value of the temperature factor may be taken as f <sub>T</sub> = 0.104 as per the CCAR Livestock reporting protocol. If the temperature is greater than 303 K the value for f <sub>T</sub> may be taken as one as per ACM0014.  Frequency of reconciliation provides for reasonable diligence. Frequency of metering represents reasonable diligence since process wastewater temperatures are typically consistent.
	Maximum Methane Producing Capacity / Bo	kg CH <sub>4</sub> per kg COD	Estimated	Default value from IPCC guidelines and adjusted for uncertainty, provided in Appendix B.	Annual	IPCC default value. If wastewater does not contain materials akin to simple sugars, a different methane production capacity factor must be obtained from published literature and applied.
B17 Flaring of Biogas	Emissions <sub>Biogas Flaring</sub> = (Vol. Biogas Combusted * % CH <sub>4</sub> * ρ CH <sub>4</sub> * (1-DE)); (Vol. Biogas Combusted * % CH <sub>4</sub> * EF Biogas N <sub>2</sub> O); ∑ (Vol. Fuel <sub>i</sub> * EF Fuel <sub>i</sub> CO <sub>2</sub> ); ∑ (Vol. Fuel <sub>i</sub> * EF Fuel <sub>i</sub> CH <sub>4</sub> ); ∑ (Vol. Fuel <sub>i</sub> * EF Fuel <sub>i</sub> N <sub>2</sub> O);					
	Emissions <sub>Biogas Flaring</sub>	kg of CO <sub>2</sub> ; CH <sub>4</sub> ; N <sub>2</sub> O	N/A	N/A	N/A	Quantity being calculated.
	Volume of Biogas Flared in the Baseline / Vol. Biogas	m <sup>3</sup>	Measured	Direct metering of volume of biogas being combusted in the flare.	Continuous metering.	Direct metering is standard practise. Frequency of metering is highest level possible.
	Methane Composition in Biogas / % CH <sub>4</sub>	-	Measured	Direct measurement.	Monthly	Biogas composition should remain relatively stable during steady-state operation for wastewater treatment operations.

	Density of Methane / $\rho \text{ CH}_4$	kg / m <sup>3</sup>	Constant	0.7157 kg/m <sup>3</sup> at standard temperature and pressure.	Actual value	If this value is used all volumes should be adjusted accordingly to reflect standard temperature and pressure.
	Destruction Efficiency of Combustion Device / DE	%	Estimated	95% destruction efficiency for open flares and 98% for all other enclosed combustion devices. Manufacturer's specifications may also be appropriate where available.	Actual value	Default values taken from GE AES <i>Methodology for Waste Water Treatment Methane Capture and Destruction Projects Version 1.0 August 22, 2007</i> .
	N <sub>2</sub> O Emissions Factor for Biogas / EF Biogas <sub>N<sub>2</sub>O</sub>	kg N <sub>2</sub> O per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents. In the absence of biogas data, rely on emissions factors for Natural Gas. The generic Environment Canada emission factors (for industrial use of natural gas or electric utilities) may be adequate, but other factors specific to the type of combustion device (US-EPA AP-42 or CAPP) may be more appropriate.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory. US EPA AP-42 values are also commonly used by industry.
	Volume of Each Type of Supplemental Fuel Consumed to Operate the Flare / Vol Fuel <sub>i</sub>	L / m <sup>3</sup> / other	Measured	Reconciliation of volume of supplemental fuel used for operation of the flare.	Monthly reconciliation.	Frequency of reconciliation provides for reasonable diligence. If baseline data is unavailable, it is reasonable to exclude the fuel use for flare operation as it is conservative to do so.

	CO <sub>2</sub> Emissions Factor for Each Type of Fuel / EF Fuel <sub>i CO2</sub>	kg CO <sub>2</sub> per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH <sub>4</sub> Emissions Factor for Each Type of Fuel / EF Fuel <sub>i CH4</sub>	kg CH <sub>4</sub> per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N <sub>2</sub> O Emissions Factor for Each Type of Fuel / EF Fuel <sub>N2O</sub>	kg N <sub>2</sub> O per L / m <sup>3</sup> / other	Estimated	From Environment Canada reference documents. Provided in Appendix A.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
B19 Consumption of Natural Gas from Pipeline	Emissions <sub>Pipeline Gas</sub> = $\sum (\text{Vol. Natural Gas} * \text{EF Fuel}_{i \text{CO}_2}) ; \sum (\text{Vol. Natural Gas} * \text{EF Fuel}_{i \text{CH}_4}) ; \sum (\text{Vol. Natural Gas} * \text{EF Fuel}_{i \text{N}_2\text{O}})$					
	Emissions <sub>Pipeline Gas</sub>	kg of CO <sub>2</sub> ; CH <sub>4</sub> ; N <sub>2</sub> O	N/A	N/A	N/A	Quantity being calculated.
	Vol. Natural Gas = Heat <sub>Biogas</sub> / HHV <sub>Gas</sub>					
	Equivalent Volume of Natural Gas Displaced by Biogas Produced in the Project Activity / Vol. Natural Gas	L, m <sup>3</sup> or other	N/A	Calculated relative to the metered quantity of biogas input into the pipeline on an energy basis and converted to an equivalent volume of natural gas.	Monthly	Quantity being calculated.
	Total Heat Value of Upgraded Biogas Input into Natural Gas Pipeline in the Project Condition / Heat <sub>Biogas</sub>	GJ	Measured	Direct metering of quantity and energy content of biogas input into the pipeline in the project condition.	Continuous metering.	Frequency of metering is highest level possible.
	Higher Heating Value of Natural Gas / HHV <sub>Gas</sub>	GJ per m <sup>3</sup>	Estimated	Reference value for pipeline quality natural gas.	N/A	Reference value. Use of the higher heating value is conservative and is consistent with Environment Canada's National GHG Inventory.

	CO <sub>2</sub> Emissions Factor for Combustion of Each Type of Fuel / EF Fuel <sub>iCO2</sub>	kg CO <sub>2</sub> per m <sup>3</sup>	Estimated	From Environment Canada reference documents. Provided in Appendix A.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH <sub>4</sub> Emissions Factor for Combustion of Each Type of Fuel / EF Fuel <sub>iCH4</sub>	kg CH <sub>4</sub> per m <sup>3</sup>	Estimated	From Environment Canada reference documents. Provided in Appendix A.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N <sub>2</sub> O Emissions Factor for Fuel Including Production and Processing / EF Fuel <sub>N2O</sub>	kg N <sub>2</sub> O per L/ m <sup>3</sup> / other	Estimated	From Environment Canada reference documents. Provided in Appendix A.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

## 2.5.2. Contingent Data Approaches

Contingent means for calculating or estimating the required data for the equations outlined in section 2.5.1 are summarized in **TABLE 2.5**, below.

## 2.6 Management of Data Quality

In general, data quality management must include sufficient data capture such that the mass and energy balances may be easily performed with the need for minimal assumptions and use of contingency procedures. The data should be of sufficient quality to fulfill the quantification requirements and be substantiated by company records for the purpose of verification.

The project proponent shall establish and apply quality management procedures to manage data and information. Written procedures should be established for each measurement task outlining responsibility, timing and record location requirements. The greater the rigour of the management system for the data, the more easily an audit will be to conduct for the project.

### 2.6.1 Record Keeping

Record keeping practises should include:

- a. Electronic recording of values of logged primary parameters for each measurement interval;
- b. Printing of monthly back-up hard copies of all logged data;
- c. Written logs of operations and maintenance of the project system including notation of all shut-downs, start-ups and process adjustments;
- d. Retention of copies of logs and all logged data for a period of 7 years; and
- e. Keeping all records available for review by a verification body.

### 2.6.1 Quality Assurance/Quality Control (QA/QC)

QA/QC can also be applied to add confidence that all measurements and calculations have been made correctly. These include, but are not limited to:

- a Protecting monitoring equipment (sealed meters and data loggers);
- b Protecting records of monitored data (hard copy and electronic storage);
- c Checking data integrity on a regular and periodic basis (manual assessment, comparing redundant metered data, and detection of outstanding data/records);
- d Comparing current estimates with previous estimates as a ‘reality check’;
- e Provide sufficient training to operators to perform maintenance and calibration of monitoring devices;
- f Establish minimum experience and requirements for operators in charge of project and monitoring; and

- g Performing recalculations to make sure no mathematical errors have been made.

**TABLE 2.5: Contingent Data Collection Procedures**

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
<b>Project SS's</b>						
P3 Facility Thermal Energy Generation & P18 Biogas Conditioning & P19 Biogas Flaring & P20 Biogas Processing for Pipeline & P21 Thermal Energy Generation & P22 Electricity Generation	Volume of Biogas Combusted for P3, P18, P19, P20, P21, P22/ Vol. Biogas Combusted  Methane Composition in Biogas / % CH <sub>4</sub>  Volume of Each Type of Fuel Combusted for P3, P18, P19, P20, P21, P22/ Vol Fuel <sub>i</sub>	m <sup>3</sup>  -  L / m <sup>3</sup> / other	Estimated  Estimated  Estimated	Reconciliation of total biogas produced, which would be the summation of biogas combusted for heat generation, electricity generation, input into a gas pipeline, for on-site supplemental energy needs and the remainder that is flared.  Interpolation of previous and following values.  Estimated fossil fuel consumption based on historical fossil fuel consumption per volume of biogas produced over the past 6 months for each SS. Fossil fuel consumption could result from supplemental fuels used for thermal energy generation, biogas conditioning, biogas flaring, biogas processing for input into the pipeline and electricity generation.	Monthly  Annual  Monthly reconciliation.	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.  Biogas composition should remain relatively stable during steady-state operation for wastewater treatment operations.  Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

P17 Biogas Venting	Maximum volume of biogas stored in Vessel at Steady State / Max. Storage Vol. <sub>Vessel</sub>	m <sup>3</sup>	Estimated	From facility engineering specifications.	Annual	Reference value will remain consistent unless system is re-engineered (i.e. change to maximum storage volume from change in cap).
	Flow Rate of Biogas at Steady State / Flow Biogas <sub>Vessel</sub>	m <sup>3</sup> / hr	Estimated	Average flow rate of biogas determined from previous week of operational data divided by the hours operated.	Weekly	Biogas flow rates at steady state for the previous week should provide a reasonable approximation of the biogas flow rate at time of venting.
	Time that vessel is venting / t	days	Estimated	Estimated from operator logs or equipment downtime records	Continuous	Number of days in a year when venting occurred is an absolute value.
	Total Volume of Biogas Captured from Anaerobic Treatment System / Vol. Biogas	m <sup>3</sup>	Estimated	Reconciliation of monthly total biogas production.	Reconciliation of Monthly Totals	Frequency of reconciliation provides for reasonable diligence.
	Methane Composition of Biogas / % CH <sub>4</sub>	-	Estimated	Reconciliation of previous months or years gas analyses.	Annual	Biogas composition should remain relatively stable during steady-state operation. Distribution to the regional natural gas grid should result in predictable compositions due to pipeline quality specifications.
P16 Waste Sludge Decomposition and Methane Collection/ Destruction	Mass of Sludge and Sediment Sent to Landfill / Mass Sludge <sub>Landfill</sub>	kg	Estimated	Reconciliation of disposal/haulage receipts each time waste sludge is sent to a landfill facility in the project condition.	Each time sludge is sent to landfill	Measurement of the mass of each load at the time of pick up or at entry to the landfill facility represents the industry practise.
P24 Pipeline Distribution and Usage	Volume of Biogas Piped from the Site / Vol Biogas <sub>Pipeline</sub>	m <sup>3</sup>	Estimated	Reconciliation of receipts for biogas input into the pipeline from pipeline operator.	Monthly	Frequency of reconciliation provides for reasonable diligence.

	Methane Composition of Biogas / % CH <sub>4</sub>	-	Estimated	Reconciliation of previous months or years gas analyses.	Annual	Biogas composition should remain relatively stable during steady-state operation. Distribution to the regional natural gas grid should result in predictable compositions due to pipeline quality specifications.
	Volume of Each Type of Fuel used to Input Biogas into Pipeline System / Vol Fuel <sub>i</sub>	L / m <sup>3</sup> / other	Estimated	Reconciliation of volumes of fossil fuels used for compression or other biogas processing operations from bills/ receipts. If biogas is used as a fuel then reconciliation of total biogas production versus quantity input into the pipeline may be necessary.	Reconciliation of monthly totals.	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
<b>Baseline SS's</b>						
B18 Electricity Production	Electricity Sent to Grid or Direct Connected Facilities in Project Condition/ Electricity	kWh	Estimated	Reconciliation of quantity of renewable electricity delivered to the regional grid or direct connected users net of parasitic loads attributable to the project activity.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
B3 Facility Thermal Energy Generation	Heat Load Produced under the Project Condition / Heat Load	GJ	Estimated	Estimated from metered volume of biogas combusted, the % methane in biogas and the reference calorific value for pure methane.	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.

B7 Anaerobic Wastewater Treatment Process	Flow Rate of Wastewater into the Anaerobic Treatment Unit in the Project Condition / Flow <sub>IN</sub>	m <sup>3</sup> of wastewater	Estimated	Interpolation of previous and following flow rates. Reconciliation of operating logs may be necessary to confirm that wastewater was produced during the time period that data was missing.	Weekly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Flow Rate of Wastewater exiting the Anaerobic Treatment Unit in the Project Condition / Flow <sub>IN</sub>	m <sup>3</sup> of wastewater	Estimated	Interpolation of previous and following flow rates. Reconciliation of operating logs may be necessary to confirm that wastewater was produced the time period that data was missing.	Weekly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Concentration of Chemical Oxygen Demand in the Inlet Wastewater Stream Entering the Anaerobic Treatment Unit in the Project Condition / COD <sub>IN</sub>	Kg COD/ m <sup>3</sup> of wastewater	Estimated	Interpolation of previous and following COD concentrations in wastewater exiting the anaerobic treatment unit in the project activity.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Concentration of Chemical Oxygen Demand in the Wastewater Stream Exiting the Anaerobic Treatment Unit in the Project Condition / COD <sub>OUT</sub>	Kg COD/ m <sup>3</sup> of wastewater	Estimated	Interpolation of previous and following COD concentrations in wastewater exiting the anaerobic treatment unit in the project activity.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

	Quantity of Sediments Removed from the Anaerobic Digester in the Project Condition/ $Q_{\text{Sediment}}$	$\text{m}^3$ of wastewater	Estimated	Estimated based on operator log books or other records of volume of sediments removed and daily records of inlet wastewater flow rates and volume of wastewater contained in the anaerobic treatment unit or other applicable operating data.	Each time sediments are removed from the anaerobic digester	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Concentration of Chemical Oxygen Demand in Sediments Removed from the Anaerobic Treatment Unit in the Project Condition / COD $_{\text{Sediment}}$	Kg COD/ $\text{m}^3$ of wastewater	Estimated	Reconciliation of chemical oxygen demand of inlet wastewater to the anaerobic treatment unit at the time that sediments were removed from the anaerobic treatment unit in the project activity.	Each time sediments are removed from the anaerobic digester	Represents a conservative approach to quantification since the inlet COD concentrations will be higher than the concentration of COD in partially degraded sediments removed from the lagoon.
B17 Biogas Flaring	Volume of Biogas Flared in the Baseline / Vol. Biogas	$\text{m}^3$	Estimated	Linear interpolation of previous and following values.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Methane Composition in Biogas / % $\text{CH}_4$	-	Estimated	Linear interpolation of previous and following values.	Monthly	Biogas composition should remain relatively stable during steady-state operation for wastewater treatment operations.
	Destruction Efficiency of Combustion Device / DE	%	Estimated	Manufacturer's specifications for flare destruction efficiency or common industry destruction efficiencies for the type of flare used at the site.	Actual value	The use of manufacturer's design information is reasonable and likely conservative for the baseline.

	Volume of Each Type of Supplemental Fuel Consumed to Operate the Flare / Vol Fuel <sub>i</sub>	L / m <sup>3</sup> / other	Estimated	Monthly reconciliation of fuel consumption. Otherwise the project proponent may assume this value to be zero for conservativeness in the baseline.	Monthly reconciliation.	Frequency of reconciliation provides for reasonable diligence.
B19 Consumption of Natural Gas from Pipeline	Total Heat Value of Upgraded Biogas Input into Natural Gas Pipeline in the Project Condition / Heat <sub>Biogas</sub>	GJ	Estimated	Reconciliation of quantity and energy content of biogas input into the pipeline in the project condition based on payments/receipts from gas utility.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

## **APPENDIX A**

### **Calculation Methodology for Baseline Methane Emissions from Anaerobic Wastewater Treatment**

### Parameters Used in Determination of Baseline Methane Generation

This protocol utilizes best practice guidance from IPCC and the Clean Development Mechanism Methodology ACM0014 in the determination of baseline methane emissions from the anaerobic decomposition of organic matter contained in wastewater streams. Since it is not normally practical to measure methane generation from open anaerobic systems prior to the installation of a methane capture system, the best available quantification approach at this time is the use of the IPCC model that incorporates the impacts of temperature and depth of the anaerobic system on the methane production per unit of organic matter destructed in the system.

The slightly modified IPCC approach is based on the mass balance of chemical oxygen demand into and out of the anaerobic treatment unit (e.g. deep lagoon) as shown in Equation 1, taken from Table 2.4.

$$1. \text{CH}_4 \text{ Emissions from Anaerobic Decomposition} = \sum (\text{Flow}_{\text{IN}} * \text{COD}_{\text{IN}} - \text{Flow}_{\text{OUT}} * \text{COD}_{\text{OUT}} - Q_{\text{Sediment}} * \text{COD}_{\text{Sediment}}) * \text{MCF} * \text{Bo}$$

The approach used in CDM Methodology ACM0014 represents the best estimate of baseline emissions from the anaerobic treatment unit by using site specific mass flow rates, temperature conditions, and depths combined with two additional factors for conservativeness which are incorporated into the MCF and Bo values to collectively reduce baseline emissions by 74.76%. The 74.76% overall conservativeness value was obtained by multiplying the 0.89 factor used in the calculation of the MCF (see below) times the ratio of 0.21/0.25 which represents the IPCC recommended (conservative) value for Bo divided by the default IPCC value for Bo as discussed in the following sections.

The following section discusses the relevant parameters and equations used in this protocol.

For each unit of COD removed from the wastewater in the anaerobic treatment unit, a corresponding volume of methane can be produced under conditions favourable for methanogenic bacteria as discussed below.

#### Maximum Methane Generation Potential (Bo)

This factor expresses the maximum methane producing capacity per unit of COD. The IPCC 2006 default value is 0.25 kg CH<sub>4</sub> / kg COD. Taking into account the uncertainty of this estimate, CDM Methodology ACM0014 recommends using a value of 0.21 kg CH<sub>4</sub> / kg COD. If the wastewater contains materials not comparable to simple sugars, a project specific CH<sub>4</sub> generation potential should be measured or obtained from best available science for the specific type of organic materials contained in the wastewater.

In order to account for actual site conditions that impact the maximum methane generation potential a methane conversion factor is used as described below.

Additionally, if the project proponent measures Biological Oxygen Demand (BOD) rather than COD the following IPCC conversion factor can be utilized as shown below.

Conversion from BOD to COD

If BOD is measured at the project site it may be converted to an appropriate COD value by the following IPCC conversion factor as per Equation 2:

$2. \text{ COD (kg COD / m}^3\text{)} = 2.4 \text{ (kg COD/ kg BOD)* BOD (kg BOD / m}^3\text{)}$
--

Methane Conversion Factor

The methane conversion factor represents the extent to which ideal anaerobic conditions are present in the wastewater treatment unit, which is primarily dependent on the depth ( $f_d$ ) of the treatment unit (e.g. lagoon) and the temperature ( $f_T$ ) of the system. Methanogenic bacteria require oxygen free (anaerobic) conditions in order to survive and their rate of consumption of COD is dependent on temperature. Optimum temperatures for anaerobic digestion are generally from 35-40 degrees Celsius or 55-60 degrees Celsius for mesophilic and thermophilic systems, respectively.

As discussed in CDM Methodology ACM0014 the calculation of the methane conversion factor includes a depth factor, a temperature factor and an additional conservativeness factor of 0.89 to account for uncertainty with the approach used, as shown in Equation 3.

$3. \text{ MCF} = f_d * f_T * 0.89$
-------------------------------------

Depth Factor /  $f_d$

The Depth Factor expresses the influence of the depth of the lagoon or sludge pit on methane generation based on the surface oxidation of chemical oxygen demand that occurs due to oxygen contact with the organic matter in the lagoon. According to CDM Methodology ACM0014 the following factors apply:

Depth (m)	Value (%)
> 5	70
1-5	50
< 1	0

Note that meat processing plants may have an extensive grease cap on the surface of anaerobic lagoons that provides a physical barrier between the organic matter (chemical oxygen demand) contained in the wastewater and the oxygen in the air. The presence of a grease cap barrier provides fully anaerobic conditions regardless of depth and enhances the anaerobic digestion process because it acts as an insulating layer and reduces heat losses from the lagoon to keep the lagoon conditions warm for methanogenic bacteria to thrive. For projects where a consistently thick grease cap was present before the implementation of the methane capture system, the Depth Factor is assumed to be 100% as no surface oxidation of the COD will occur (note the 0.89 conservativeness factor is still applied).

#### Monthly Temperature Factor / $f_T$

Consistent with CDM Methodology ACM0014 and the CCAR Livestock Project Reporting Protocol, this protocol utilizes the Van't Hoff Arrhenius Equation to account for the impact of temperature on methanogenic bacteria production of methane.

$$f_T = \exp [(15,175*(T_{\text{site}} - 303.16)) / (1.987 * (303.16 * T_{\text{site}}))]$$

Where:

$f_T$  = Factor expressing the influence of the temperature on the methane generation in each month of the year

E = Activation energy constant (15,175 cal/mol).

$T_{\text{Site}}$  = Average ambient temperature at the project site in each month (K)

303.16 K = Reference Temperature of 30 Degrees Celsius

1.987 = Ideal gas constant (1.987 cal / K mol)

Note that it may be reasonable to substitute wastewater temperatures at the outlet to the anaerobic treatment unit in place of ambient temperatures for  $T_{\text{Site}}$  if the ambient temperatures are not consistent with the temperature of the wastewater in the treatment unit. This is most relevant for projects where wastewater enters an outdoor open anaerobic treatment system at significantly elevated temperatures. The project proponent should be able to provide seasonal temperatures at the outlet from the anaerobic treatment system to account for heat losses.

In project conditions where an enclosed anaerobic treatment unit was already in place in the baseline scenario, but no methane capture was practiced, a default methane conversion factor of 90% may be used consistent with the US Environmental Protection Agency (EPA) Climate Leaders Draft Offset Protocol for Managing Manure with Biogas Recovery Systems (October 2006).

#### Development of a Site Specific Methane Conversion Factor

If the project has not significantly enhanced the anaerobic digestion process (e.g. through the addition of a heat source), then it may be possible to determine a site specific methane conversion factor representative of the baseline condition from collected COD destruction data and biogas production data. The important component would be to ensure that consistent operation of the anaerobic treatment unit has been obtained over the course of several seasons to ensure that temperature impacts are properly accounted for. Provided that biogas production has not been enhanced significantly (as determined from the methane capture system and anaerobic treatment unit design) compared to the baseline condition and that at least two years of consistent operational data is available then monthly average methane conversion factors may be developed by rearranging Equation 1 to solve for the MCF, as shown in Equation 4, below.

$$1. \text{ MCF} = (\text{CH}_4 \text{ Emissions from Anaerobic Decomposition}) / [\sum(\text{Flow}_{\text{IN}} * \text{COD}_{\text{IN}} - \text{Flow}_{\text{OUT}} * \text{COD}_{\text{OUT}} - Q_{\text{Sediment}} * \text{COD}_{\text{Sediment}}) * \text{Bo}]$$

$$4. \text{ MCF} = \text{kg CH}_4 \text{ captured} / [\text{kg COD destroyed} * \text{Bo (kg CH}_4/\text{kg COD)}]$$

## **APPENDIX B**

### **Relevant Emission Factors**

All values interpreted from volume 1 of the technical report: A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H<sub>2</sub>S) Emissions by the Upstream Oil and Gas Industry dated September 2004 completed by Clearstone Engineering Ltd. on behalf of the Canadian Association of Petroleum Producers (CAPP).

**Table A1: Emission Intensity of Fuel Extraction and Production (Diesel, Natural Gas, and Gasoline)**

<b>Diesel</b>		
<b>Production</b>		
Emissions Factor (CO <sub>2</sub> )	0.138	kg CO <sub>2</sub> per Litre
Emissions Factor (CH <sub>4</sub> )	0.0109	kg CH <sub>4</sub> per Litre
Emissions Factor (N <sub>2</sub> O)	0.000004	kg N <sub>2</sub> O per Litre
<b>Natural Gas</b>		
<b>Extraction</b>		
Emissions Factor (CO <sub>2</sub> )	0.043	kg CO <sub>2</sub> per m <sup>3</sup>
Emissions Factor (CH <sub>4</sub> )	0.0023	kg CH <sub>4</sub> per m <sup>3</sup>
Emissions Factor (N <sub>2</sub> O)	0.000004	kg N <sub>2</sub> O per m <sup>3</sup>
<b>Processing</b>		
Emissions Factor (CO <sub>2</sub> )	0.090	kg CO <sub>2</sub> per m <sup>3</sup>
Emissions Factor (CH <sub>4</sub> )	0.0003	kg CH <sub>4</sub> per m <sup>3</sup>
Emissions Factor (N <sub>2</sub> O)	0.000003	kg N <sub>2</sub> O per m <sup>3</sup>
<b>Gasoline</b>		
<b>Production</b>		
Emissions Factor (CO <sub>2</sub> )	0.138	kg CO <sub>2</sub> per Litre
Emissions Factor (CH <sub>4</sub> )	0.0109	kg CH <sub>4</sub> per Litre
Emissions Factor (N <sub>2</sub> O)	0.000004	kg N <sub>2</sub> O per Litre

**Table A2: Emission Intensity of Combustion (Diesel, Natural Gas and Gasoline)**

<b>Diesel</b>		
Emissions Factor (CO <sub>2</sub> )	2.730	kg CO <sub>2</sub> per Litre
Emissions Factor (CH <sub>4</sub> )	0.000133	kg CH <sub>4</sub> per Litre
Emissions Factor (N <sub>2</sub> O)	0.0004	kg N <sub>2</sub> O per Litre
<b>Natural Gas</b>		
<b>Electric Utilities</b>		
Emissions Factor (CO <sub>2</sub> )	1.891	kg CO <sub>2</sub> per m <sup>3</sup>
Emissions Factor (CH <sub>4</sub> )	0.00049	kg CH <sub>4</sub> per m <sup>3</sup>
Emissions Factor (N <sub>2</sub> O)	0.000049	kg N <sub>2</sub> O per m <sup>3</sup>
<b>Gasoline</b>		
<b>Light Duty Gasoline Trucks</b>		
Emissions Factor (CO <sub>2</sub> )	2.360	kg CO <sub>2</sub> per Litre
Emissions Factor (CH <sub>4</sub> )	0.00013	kg CH <sub>4</sub> per Litre
Emissions Factor (N <sub>2</sub> O)	0.000025	kg N <sub>2</sub> O per Litre

## **APPENDIX C**

### **Fugitive Emissions Good Practise Guidance**

## **Fugitive Emissions Good Practise Guidance**

It is crucial to the integrity of the project emission reduction claim that fugitive emissions of methane from the anaerobic decomposition of the organic matter contained in the wastewater do not become a material source of emissions under the project condition. As such the following section provides a review of available guidance and provides recommendations for project proponents.

There are a number of standards that address fugitive emissions from similar systems including the Canadian Standards Association (CSA) Code for Digester Gas and Landfill Gas Installations (CAN/CGA-B105-M93) and the Safety Standards for Agricultural Biogas Installations from the German Federal Organization of Agricultural Cooperative Associations, Central Agency for Safety and Health Protection. These documents are both quite technical. As such, the following guidance has been developed to assist project developers in implementing maintenance and monitoring program that can ensure that fugitive emissions are immaterial.

### ***General Recommendations***

The following general recommendations are provided:

1. Trained, experience and certified personnel, as applicable, should be used to complete monitoring, testing, maintenance and construction/assembly work;
2. Seals that can be made permanent should made so;
3. Seals that are not permanent should remain accessible for testing and monitoring, as applicable; and,
4. Seals that are not accessible should be tested thoroughly upon installation (i.e. underground piping connections).

### ***Step-Wise Approach***

#### **Step #1: Inventory Joints, Seals and Equipment**

An inventory of all joints, seals and equipment should be compiled. This list may be drawn from as-built drawings or from a thorough review of the facility. Labelling of joints may also be considered.

#### **Step #2: Categorize Joints, Seals and Equipment**

Each joint, seal and piece of equipment should be categorized as permanently tight and technically tight based on the following definitions:

##### **Permanently Tight**

Permanently technically tight facility and equipment parts are, e.g., welded equipment with removable components, whereby the necessary detachable connections have only to be operationally released very rarely, and the construction

of which is designed in the same way as the following detachable pipe connections (exception: metallically tightening connections). In addition, connecting pieces for the detachable attachment of pipes, armatures, or blind covers, whereby the necessary detachable connections have only to be operationally released very rarely, and the construction of which is designed in the same way as the following detachable pipe connections (exception: metallically tightening connections) can also be permanently technically tight.

Permanently technically tight pipe connections include non-detachable connections (i.e. welded) and detachable connections, which operationally are very rarely detached (i.e. professional flange connections).

Permanently technically tight connections for the connection of equipment, as far as they are rarely operationally detached, include pipe connections as mentioned above, and NPT-thread (National Pipe Paper Thread, cone type pipe thread) or other conical pipe threads, with sealing, as far as they are not exposed to changing thermal loads.

Beside pure design measures, technical measures combined with organizational measures can also lead to permanently technically tight equipment. This category includes, with appropriate monitoring and maintenance: dynamically loaded seals, e.g., for axle guides of pumps and thermally loaded seals of facility parts

#### Technically Tight

Equipment is technically tight if during a tightness test or tightness monitoring or control no leakage is detectable, e.g., by means of foam generating means or with leakage test or display instruments, whereby rare releases of gases and vapors cannot be excluded. This can include pumps whose technical tightness cannot be ensured permanently (e.g., with a simple sliding ring seal), and detachable connections which are rarely not detached.

### Step #3: Establish Monitoring and Testing Procedures

Select appropriate testing and monitoring procedures for each of the joints, seals and equipment based on manufacturer's specifications, industry practice or applicable standards documents. Relevance, cost effectiveness, access and category should all be included in the analysis. Permanently tight joints, seals and equipment may require less extensive and frequent monitoring as compared to technically tight joints, seals and equipment.

Monitoring and testing frequency should also be established. Recommendations are annual monitoring and testing for permanently tight joints, seals and equipment, and quarterly (at a minimum) for technically tight joints, seals and equipment. In addition, all joints should be checked each time they are maintained, replaced or otherwise disturbed.

A sample data form is provided in the following pages.

### Step #4: Track Compliance with Monitoring and Testing Procedures

Compliance with monitoring and testing procedures should be tracked. Maintenance activity records should correlate with the testing and monitoring procedures.

A sample tracking form is provided in the following pages.





**APPENDIX D:**  
**Parameters for Use in Calculations Based on**  
**Waste Disposal in Landfill by Landfill Type**

**Methane Generation Potential of Waste Materials**

The following calculation methodologies were collected according to the information outlined in the “National Inventory Report – Greenhouse Gas Sources and Sinks in Canada, 1990-2004”, Environment Canada, April 2006.

The methane generation potential of different waste materials disposed of in landfill depends on a number of factors including the composition of the waste and the type of landfill. The methane generation potential is calculated according to the equation below.

$$L_0 = MCF * DOC * DOC_F * F * 16/12 * 1000 \text{ kg CH}_4/\text{t CH}_4$$

- Where:
- $L_0$  = CH<sub>4</sub> generation potential (kg CH<sub>4</sub>/ t waste)
  - MCF = CH<sub>4</sub> correction factor (fraction)
  - DOC = degradable organic carbon (t C/t waste)
  - DOC<sub>F</sub> = fraction DOC dissimilated
  - F = fraction CH<sub>4</sub> in landfill gas
  - 16/12 = stoichiometric factor

The methane correction factor is determined based on the physical characteristics of the landfill that the waste being disposed as shown in Table B.1, below. According to the IPCC Guidelines, the MCF for managed landfill sites has a value of 1.0. The method used to determine the degradable organic carbon is discussed in detail below. The Environment Canada default DOC<sub>F</sub> value of 0.6 was used for all waste types except for wood wastes where a value of 0.5 was used representing the low end of the range of wastes high in lignin as used by Environment Canada. The fraction of CH<sub>4</sub> (F) emitted from a landfill ranges from 0.4 to 0.6 and was assumed to be 0.5.

**TABLE F1: Landfill Type-Based Factors**

Parameter	Mixed-Waste Landfills				Wood Waste Landfills
	Managed	Unmanaged – Deep (>= 5m waste)	Unmanaged – Shallow (< 5m waste)	Uncategorized	
Methane Correction Factor (MCF)	1.0	0.8	0.4	0.6	0.8 <sup>a</sup>
Fraction of degradable organic carbon (DOC)	See below				0.3
Fraction of degradable organic carbon dissimilated (DOC <sub>F</sub> )	0.77				0.5
Fraction of CH <sub>4</sub> in landfill gas (F)	0.5				

- a - the default condition for a wood waste landfill is an unmanaged, deep landfill (Environment Canada, 2006). This parameter may be changed if the emissions are being calculated for an alternate type of wood waste landfill.

### Calculation of DOC

Estimates of the degradable organic carbon (DOC) present in a waste stream can be calculated using the following equation based on the biodegradable portion of the waste:

$$\text{DOC} = (0.4 * A) + (0.17 * B) + (0.15 * C) + (0.3 * D)$$

Where:

A = fraction of MSW that is paper and textiles

B = fraction of MSW that is garden or park waste

C = fraction of MSW that is food waste

D = fraction of MSW that is wood or straw

The fractions A through D can be determined from a waste audit if mixed wastes are utilized in the project activity while source segregated waste streams can be classified according to the above descriptions. Note that the DOC value should only be calculated using the fractions of the waste that would have been destined for landfill in the baseline scenario and other materials used as feedstocks should not be considered when determining the values for the fractions A through D.

If site-specific waste characterization data is not available, default DOC values in the following table were calculated using average Lo values published by Environment Canada (2006) for mixed wastes disposed in landfills for each province. Note that the calculated DOC values are representative of mixed municipal wastes and assume a MCF of 1.0 and a DOC<sub>F</sub> of 0.77, which may not be accurate for all project conditions (e.g. for disposal of biomass in an unmanaged shallow landfill with a MCF equal to 0.4 and the DOC<sub>F</sub> equal to 0.5 would have yielded a different calculated DOC value).

**TABLE F2: Estimates of DOC by Province**

Province	Lo (value after 1990)	DOC (calculated)
British Columbia	108.8	0.21
Alberta	100.0	0.19
Saskatchewan	106.8	0.21
Manitoba	92.4	0.18
Ontario	90.3	0.18
Quebec	127.8	0.25
New Brunswick	117.0	0.23
Prince Edward Island	117.0	0.23
Nova Scotia	89.8	0.17
Newfoundland and Labrador	102.2	0.20
Northwest Territories and Nunavut	117.0	0.23
Yukon	117.0	0.23

