QUANTIFICATION PROTOCOL FOR SOLUTION GAS CONSERVATION

Public Review Version

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1.0 Project and Methodology Scope and Description

This quantification protocol is written for the solution gas conservation system operator or a solution gas conservation project developer. Some familiarity with, or general understanding of, the operation of a solution gas conservation facility is assumed.

The opportunity for generating carbon offsets with this protocol arises from the direct and indirect reductions of greenhouse gas (GHG) emissions resulting from the conservation of solution gas containing greenhouse gases as part of oil and bitumen extraction processes.

1.1 Protocol Scope and Description

Solution gas is the natural gas produced in association with crude oil and bitumen extraction, consisting mainly of methane (CH_4). Greenhouse gas (GHG) emissions associated with solution gas venting are included in Canada's National GHG Inventory.[1]

Under the baseline condition for projects applying this protocol, the solution gas would be vented to the atmosphere. Oil and gas projects that release solution gas are common in the Province of Alberta - in 2007, 672 million cubic meters (or 4.2%) of all solution gas produced in Alberta was flared or vented.

Conservation of solution gas can generally be achieved in three ways: i) injection into a natural gas pipeline; ii) on-site use as fuel gas; and/or iii) combustion to generate electrical power. Projects applying this protocol will create emission offsets primarily through conservation of solution gas via injection into a natural gas pipeline, which transports the solution gas to a location where it is subsequently combusted by end-users.

Through Alberta Energy Resource Conservation Board's (ERCB) *Directive 060: Upstream Petroleum Industry Flaring, Incinerating and Venting,* certain oil and bitumen extraction sites in Alberta are required to conserve solution gas. The proposed protocol will apply to solution gas conservation that is not required by *Directive 060* or any other regulation.

Protocol Approach:

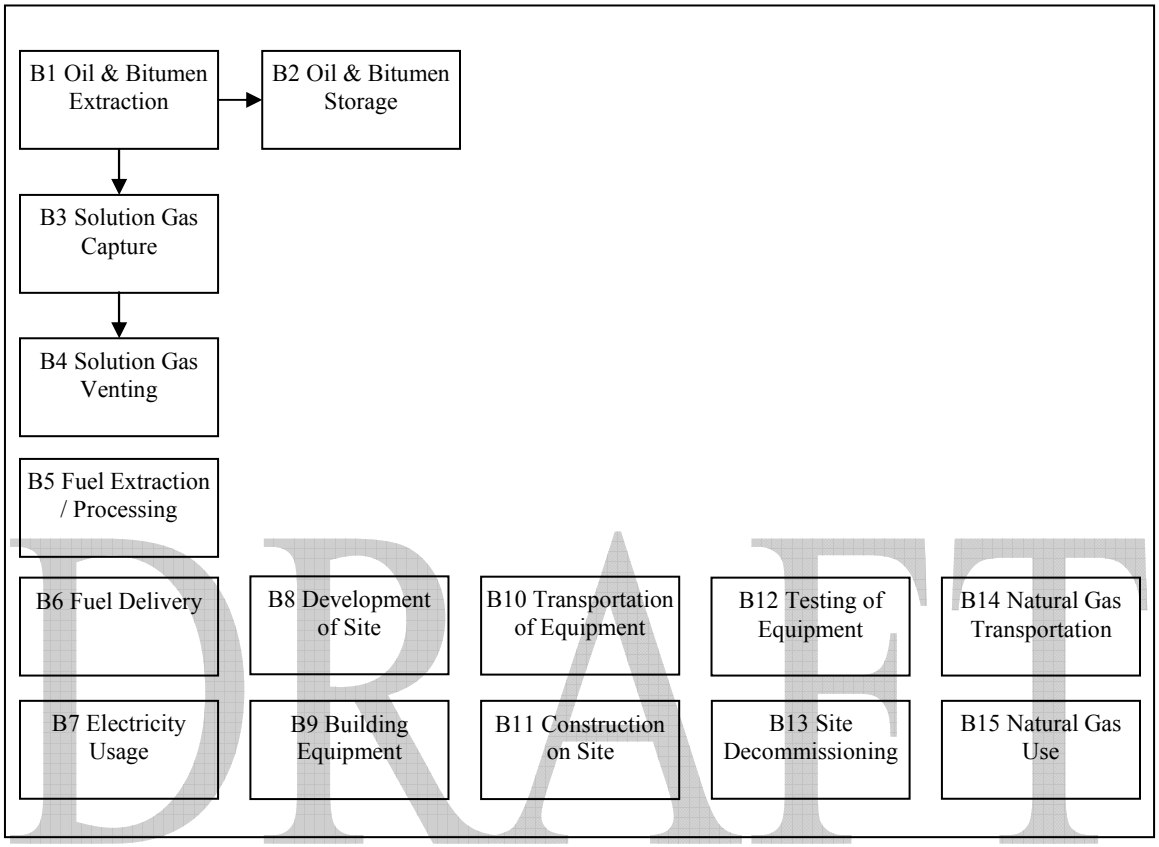
This protocol serves as a generic 'recipe' for project developers to follow in order to meet the measurement, monitoring and GHG quantification requirements for reductions from solution gas conservation activities under controlled conditions.

The baseline condition represents the GHG emissions from the venting of solution gas to the atmosphere due to the extraction of oil or bitumen. Baseline emissions are calculated directly from the concentration and flow of the solution gas being conserved under the

[1] National Inventory Report: Greenhouse Gas Sources and Sinks in Canada, 1990-2006. Oil and Natural Gas (CRF Category 1.B.2)

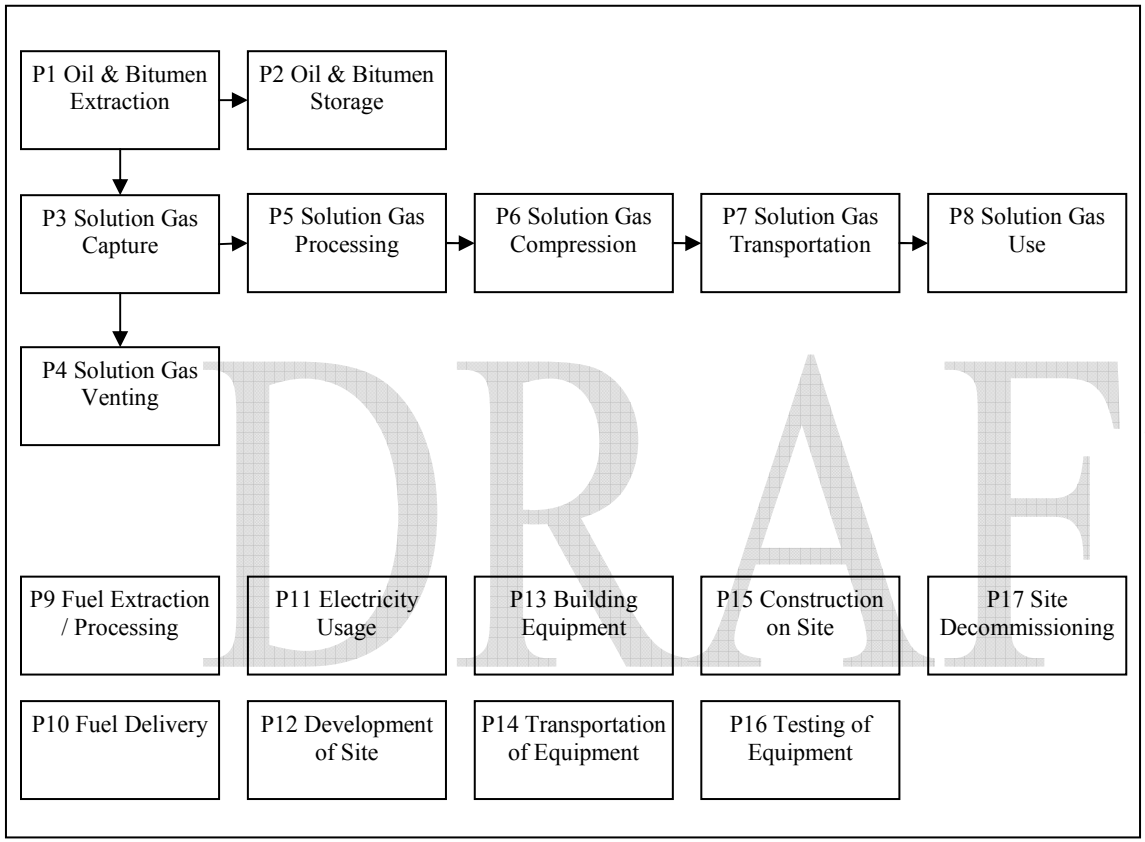
project condition. **FIGURE 1.1** offers a process flow diagram for a typical baseline configuration.

FIGURE 1.1: Process Flow Diagram for Baseline Condition



The project condition is represented by the conservation of the solution gas stream via injection into a natural gas pipeline that would otherwise have been vented to the atmosphere. The project emissions are calculated through direct measurement of the emissions resulting from the project activity. **FIGURE 1.2** offers a process flow diagram for a typical project configuration.

FIGURE 1.2: Process Flow Diagram for Project Condition



Protocol Applicability:

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

1. Prior to the project condition, the solution gas was vented to the atmosphere, and that the solution gas is not vented to the atmosphere under the project condition once it is gathered;

2. The conservation of the solution gas was not required by the Alberta Energy Resource Conservation Board's (ERCB) *Directive 060: Upstream Petroleum Industry Flaring, Incinerating and Venting* at the time the project was commissioned. The regulation may change over the crediting period of the project; however, only those regulations in place at the time the project was commissioned will apply for crediting purposes;

3. In the event that following the commissioning of a solution gas conservation project, the more accurately measured conserved solution gas data indicates that conservation would have been required under *Directive 060*, then no offset credits will be available for the project.

4. Metering of solution gas volumes conserved under the project condition, used to calculate the baseline emissions, takes place as close to the natural gas pipeline injection point or destruction location (i.e. heaters or engines) as is reasonable to address the potential for fugitive emissions - fugitive emissions must be addressed if this is not the case;

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 the following ways:

1. Project developers may use alternative monitoring methodologies other than those described in this protocol. The developer must justify that the chosen methodology is equivalent or more conservative;

2. 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 be sufficiently robust as to ensure reasonable accuracy;

3. Conservation of solution gas may be achieved via on-site use as fuel gas or through combustion to generate electrical power. The project developer may choose to claim those emission offsets resulting from the displacement of fossil fuel used in on-site equipment, such as propane or diesel. In these cases, the volume of fuel displaced should be calculated on an equivalent energy basis and appropriate emission factors should be used;

4. The project developer may choose to simplify the quantification methodology by excluding certain SSR when they are equal to zero, accounted for intrinsically via the location of metering equipment, or when it is conservative to do so.

5. Emission offsets may be generated from those sites where under the baseline condition, flaring, rather than venting of the solution gas occurs, based on the difference between the destruction efficiency of the baseline flare and the destruction efficiency of the conservation activities. Appropriate alterations to the quantification methodology should be made, with suitable justification.

6. The project developer may aggregate offsets from multiple projects to facilitate offset commoditization.

7. The protocol will have the flexibility to adapt to changing solution gas conservation regulation over time.

If applicable, the project developer must indicate and justify why flexibility provisions have been used.

1.2 Glossary of New Terms

Please refer to - http://www.glossary.oilfield.slb.com/MainIndex.cfm?ID=1

Solution Gas: Dissolved gas in well bore or reservoir fluids. The gas will remain in solution until the pressure or temperature conditions change, at which time it may break out of solution to become free gas.

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

Based on the process flow diagrams provided in **FIGURE 1.2**, the project SS's are 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

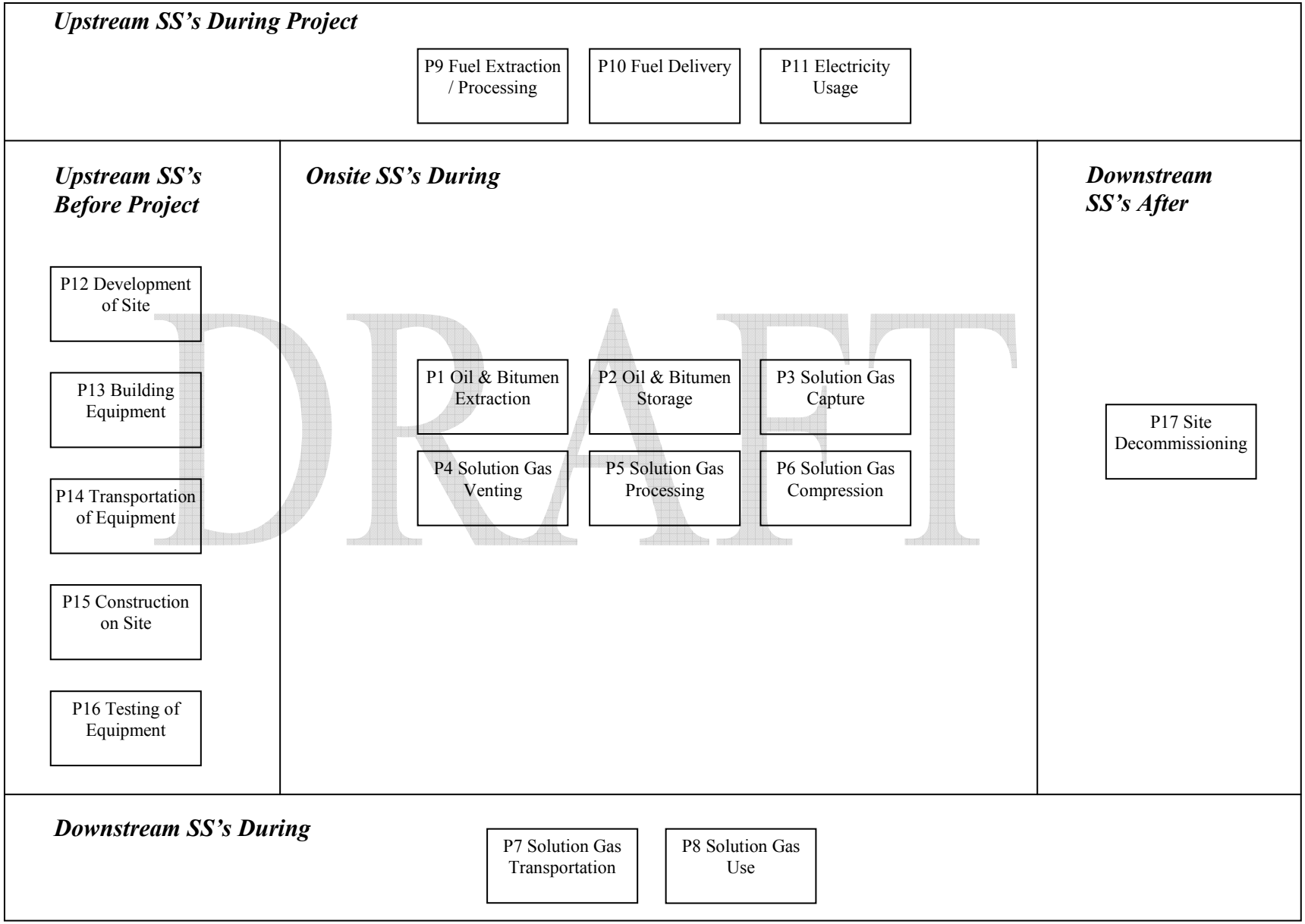


Table 2.1: Project SS's (Sources and Sinks)

1. SS	2. Description	3. Controlled, Related or Affected
Upstream SS's During Project		
P9 Fuel Extraction / Processing	Each of the fuels used throughout the on-site component of the project will need to be sourced and processed. 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
P10 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 truck or pipeline, increasing greenhouse gas emissions. 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.	Related
P11 Electricity Usage	Electricity may be produced off-site. Measurement of the quantity of electricity required by the facility would need to be tracked.	Related
On-Site SS's During Project		
P1 Oil & Bitumen Extraction	Oil and bitumen is extracted from a single or group of adjacent wells. The oil and bitumen is placed into a storage tank to await transportation. The types and quantities of the fuels used to operate the extraction equipment would need to be tracked.	Related
P2 Oil & Bitumen Storage	On-site oil and bitumen storage tanks may be heated via combustion of a fossil fuel such as propane, or solution gas. Quantities and types for each of the energy inputs may need to be tracked.	Controlled
P3 Solution Gas Capture	The compressor and dehydration systems may be fuelled by fossil fuels; these additional GHG emissions are incremental to the project. Quantities and types for each of the energy inputs may need to be tracked.	Controlled
P4 Solution Gas Venting	Non-routine venting of solution gas may occur under the project condition during compressor maintenance or other scenarios. The quantity and characteristics of the vented solution gas would need to be tracked.	Controlled
P5 Solution Gas Processing	A processing system may be required to refine the solution gas prior to injection into a natural gas pipeline. The processing equipment may be fuelled by fossil fuels. The additional GHG emissions are incremental to the project. Quantities and types for each of the energy inputs may need to be tracked.	Controlled
P6 Solution Gas Compression	The compressor system may be fuelled by fossil fuels and these additional GHG emissions are incremental to the project. Quantities and types for each of the energy inputs may need to be tracked.	Controlled
Downstream SS's During Project		

P7 Solution Gas Transportation	Compressed solution gas may be shipped via natural gas pipeline for use in a variety of applications. Fugitive emissions may occur from equipment used to transport the solution gas in the natural gas pipeline. The quantity of fugitive emissions would need to be tracked.	Related
P8 Solution Gas Use	Once injected into the pipeline, the ultimate fate of the solution gas is assumed to be combustion during end-use. Because the methane contained in the solution gas is not destroyed with 100% efficiency, the volume of solution gas injected into the pipeline would need to be tracked.	Related
Other		
P12 Development of Site	Development of the site could include clearing, grading, building access roads as well as civil infrastructure such as access to electricity, gas, water supply and water treatment. Building and structures on the site including offices, storage facilities, storm water drainage, and structures to enclose, support and house equipment may need to be developed. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site.	Related
P13 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
P14 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
P15 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
P16 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using 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
P17 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

2.1.1 Assessment of the Baseline Scenarios

The baseline emissions represent the emissions that would have occurred from the venting of solution gas from sites that are not under any regulatory requirement to conserve. The table below provides a summary of the different baseline options considered:

1. Baseline Options	2. Description	3. Static/Dynamic	4. Accept or Reject and Justify
1. Historic Benchmark	Assessment of the baseline emissions from site-specific venting of solution gas from oil/bitumen extraction sites over several years prior to the installation of the solution gas capture system.	Static	Reject. The volume of solution gas will change over time depending on the characteristics and volume of extracted oil/bitumen.
2. Performance Standard	Assessment of the typical solution gas conserved from oil/bitumen extraction sites with similar technology employed.	Static	Reject. The volume of solution gas is site-specific. Assigning a baseline to existing solution gas installations would be inaccurate.
3. Comparison based	Assessment of solution gas venting baseline emissions from sites which are not currently required by law or incented by economics to conserve.	Dynamic/Static*	Reject. The volume of solution gas recovered is site-specific.
4. Projection based	Assessment of how much solution gas will be conserved from a particular site using a model and associated assumptions.	Static	Reject. The volume of recovered solution gas is dependent on numerous exogenous factors that make modeling based projections less reliable.
5. Adjusted Baseline	Assessment of site-specific solution gas conservation and adjusting for common industry practices.	Dynamic/Static*	Reject. The volume of solution gas will change over time depending on the characteristics and volume of extracted oil/bitumen.
6. Other: Site Specific	Site-specific measurement of conserved solution gas that enters the pipeline.	Dynamic	Accept. The volume of solution gas conserved is highly site-specific and will vary over time. Site-specific metering of how much solution gas enters the pipeline is the most appropriate way to establish a baseline.

**These baseline approaches may be designed such that they change or stay constant over the registration period; therefore, both designations have been included.*

The only accepted baseline condition is the Site Specific baseline. Under this scenario, the baseline emissions from the project are calculated on the basis of how much solution gas was actually conserved and injected into the gas pipeline rather than being vented.

The metering of the conserved solution gas coupled with periodic gas analyses, is the most robust assessment of the volume of greenhouse gases abated by not venting since it will account for the variability in solution gas volume by time and location. It is also the most simple and accurate method available. While the methodology will remain static, the proposed Site Specific Metering baseline is considered to be dynamic because the value and concentration of solution gas will change over time; therefore, so too will the baseline for each site.

2.2 Identification of Baseline

The baseline condition for projects applying this protocol is defined as the volume of methane that would be released to the atmosphere from the venting of solution gas resulting from the extraction of oil and/or bitumen.

The approach to quantifying the baseline will be calculation based, as there are suitable measurement based data available for the applicable baseline condition that can provide reasonable certainty. The baseline scenario for this protocol is dynamic as the volume of methane would be expected to change materially relative to the location, age and characteristics of the individual oil/bitumen extraction sites. The baseline condition will vary from project to project.

The baseline condition is defined, including the relevant SS's and process, as shown in **FIGURE 1.1** 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 1.1** 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

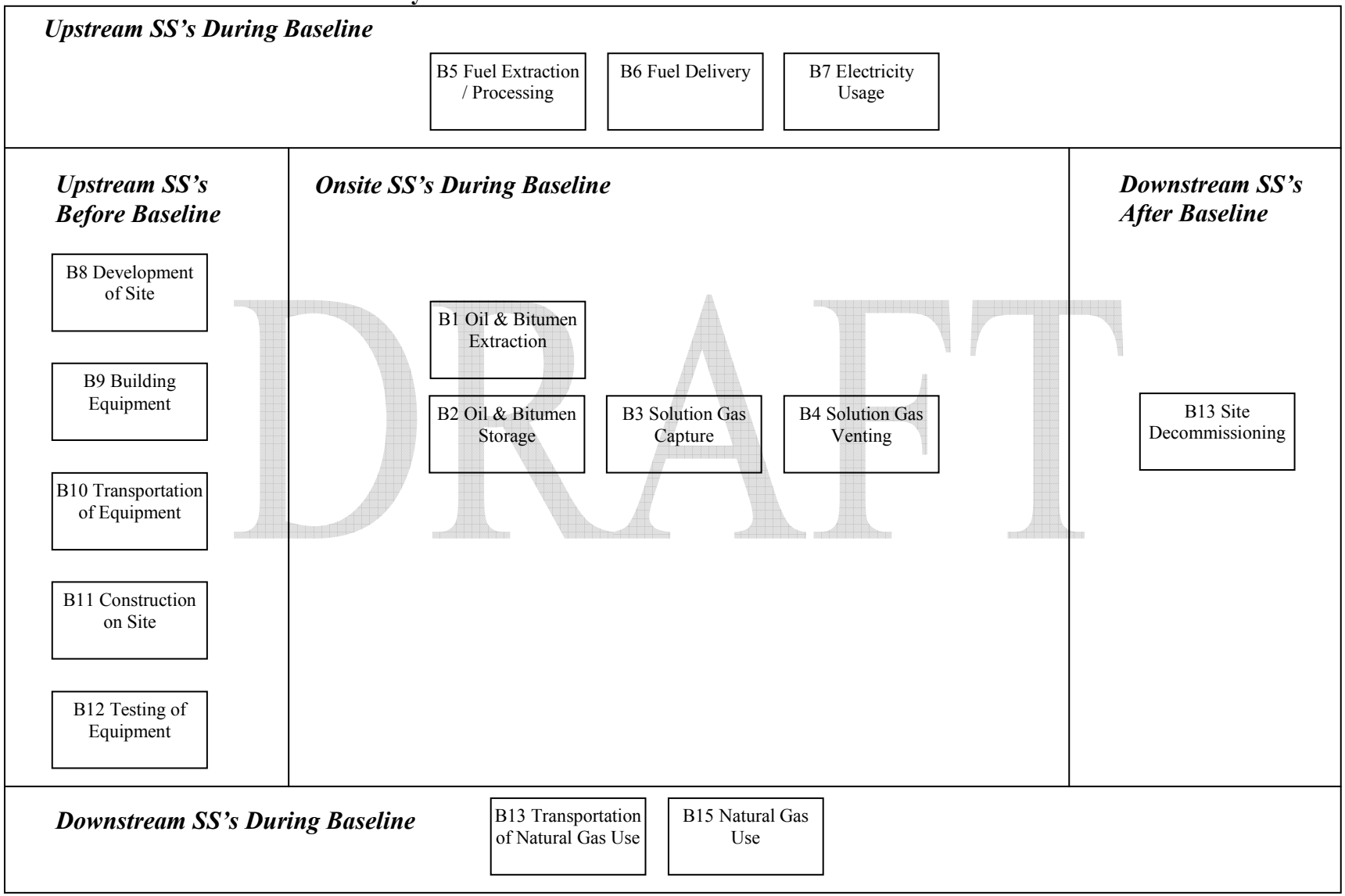


Table 2.2: Baseline SS's

1. SS	2. Description	3. Controlled, Related or Affected
Upstream SS's During Baseline		
B5 Fuel Extraction / Processing	Each of the fuels used throughout the on-site component of the project will need to be sourced and processed. 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
B6 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 truck or pipeline, increasing greenhouse gas emissions. 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.	Related
B7 Electricity Usage	Electricity may be produced off-site. Measurement of the quantity of electricity required by the facility would need to be tracked.	Related
Onsite SS's During Baseline		
B1 Oil & Bitumen Extraction	Oil and bitumen is extracted from a single or group of adjacent wells. The oil and bitumen gas is piped to a storage tank to await transportation. The types and quantities of fuels used in extraction equipment would need to be tracked.	Related
B2 Oil & Bitumen Storage	On-site oil and bitumen storage tanks may be heated via combustion of fossil fuels such as propane, or solution gas. Quantities and types for each of the energy inputs may need to be tracked.	Controlled
B3 Solution Gas Capture	The compressor and dehydration systems may be fuelled by fossil fuels; these additional GHG emissions are incremental to the project. Quantities and types for each of the energy inputs may need to be tracked.	Controlled
B4 Solution Gas Venting	Under the baseline condition, solution gas is released directly to the atmosphere post-capture. The quantity and characteristics of the vented solution gas would need to be tracked.	Controlled
Downstream SS's During Baseline Operation		
B14 Transportation of Natural Gas	Compressed natural gas may be shipped via natural gas pipeline for use in a variety of applications. Fugitive emissions may occur from equipment used to transport the natural gas. The quantity of fugitive emissions would need to be tracked.	Related

1. SS	2. Description	3. Controlled, Related or Affected
B15 Natural Gas Use	Natural gas in pipelines is assumed to be combustion during end-use. Because the methane contained in the solution gas is not destroyed with 100% efficiency, the volume of solution gas injected into the pipeline would need to be tracked.	Related
Other		
B8 Development of Site	Development of the site could include clearing, grading, building access roads as well as civil infrastructure such as access to electricity, gas, water supply and water treatment. Building and structures on the site including offices, storage facilities, storm water drainage, and structures to enclose, support and house equipment may need to be developed. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site.	Related
B9 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
B10 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
B11 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
B12 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using 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
B13 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

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2.4 Selection of Relevant Project and Baseline SS's

The justification for the inclusion, exclusion, or conditions upon which SS's may be excluded is provided in **TABLE 2.3** below.

TABLE 2.3: Comparison of SS's

1. Identified SS	2. Baseline (C, R, A)	3. Project (C, R, A)	4. Include or Exclude from Quantification	5. Justification for Exclusion
Upstream SS's				
P9 Fuel Extraction / Processing	N/A	Related	Include	This SSR may be excluded in the event that no fossil fuels are consumed under the project condition.
B5 Fuel Extraction / Processing	Related	N/A	Include	This SSR may be excluded in the event that no fossil fuels are consumed under the baseline condition. It may also be excluded when conservative to do so.
P10 Fuel Delivery	N/A	Related	Exclude	Excluded as emissions from fuel delivery are not impacted by the implementation of project and as such baseline and project conditions will be functionally equivalent.
B6 Fuel Delivery	Related	N/A		
P11 Electricity Usage	N/A	Related	Exclude	Excluded as these SS's are not relevant to the project as the emissions from these practices are covered under proposed GHG regulations.
B7 Electricity Usage	Related	N/A		
Onsite SS's				
P1 Oil & Bitumen Extraction	N/A	Related	Exclude	Excluded as the extraction of solution gas is functionally equivalent under the baseline and project conditions. These SSR may be included if flexibility mechanisms are used to quantify credit for the displacement of fossil fuels consumed under the baseline scenario; however, the project must always be included under that scenario.
B1 Oil & Bitumen Extraction	Related	N/A		
P2 Oil & Bitumen Storage	N/A	Controlled	Exclude	Excluded as the storage of solution gas is functionally equivalent under the baseline and project conditions. These SSR may be included if flexibility mechanisms are used to quantify credit for the displacement of fossil fuels consumed under the baseline scenario; however, the project emissions must always be included under that scenario.
B2 Oil & Bitumen Storage	Controlled	N/A		
P3 Solution Gas Capture	N/A	Controlled	Exclude	Excluded as the capture of solution gas is functionally

1. Identified SS	2. Baseline (C, R, A)	3. Project (C, R, A)	4. Include or Exclude from Quantification	5. Justification for Exclusion
B3 Solution Gas Capture	Controlled	N/A		equivalent under the baseline and project conditions.
P4 Solution Gas Venting	N/A	Controlled	Include	This SSR may be excluded if the corresponding volume of solution gas is excluded from the quantification of the baseline.
B4 Solution Gas Venting	Controlled	N/A	Include	There are three components that make up the emissions under this SSR: a) the solution gas that is injected into a pipeline; b) the solution gas that is used during processing and c) the solution gas that is used during compression. Parts b) and c) may be excluded if the SSs are identical under the project and baseline conditions, if these values are zero, or if it is conservative to do so.
P5 Solution Gas Processing	N/A	Controlled	Include	N/A
P6 Solution Gas Compression	N/A	Controlled	Include	N/A
Downstream SS's				
P7 Solution Gas Transportation	N/A	Related	Exclude	Excluded as fugitive emissions from the transportation of natural gas and solution gas are functionally equivalent under the baseline and project conditions.
B14 Natural Gas Transportation	Related	N/A		
P8 Solution Gas Use	N/A	Related	Exclude	Excluded as emissions from the use (i.e. combustion) of natural gas and solution gas are functionally equivalent under the baseline and project conditions.
B15 Natural Gas Use	Related	N/A		
Other SS's				
P12 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.
B8 Development of Site	Related	N/A		
P13 Building Equipment	N/A	Related	Exclude	Emissions from building equipment are not material given the long project life and the minimal equipment typically required.
B9 Building Equipment	Related	N/A		
P14 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.
B10 Transportation of Equipment	Related	N/A		

1. Identified SS	2. Baseline (C, R, A)	3. Project (C, R, A)	4. Include or Exclude from Quantification	5. Justification for Exclusion
P15 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.
B11 Construction on Site	Related	N/A		
P16 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.
B12 Testing of Equipment	Related	N/A		
P17 Site Decommissioning	N/A	Related	Exclude	Emissions from site decommissioning are not material given the long project life and the minimal site decommissioning typically required.
B13 Site Decommissioning	Related	N/A		

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. A listing of relevant emission factors is provided in **APPENDIX A.** These calculation methodologies serve to complete the following three equations for calculating emission reductions from the comparison of baseline and project conditions.

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

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions}_{\text{Solution Gas Venting}} + \text{Emissions}_{\text{Fuel Extraction / Processing}}$$

$$\text{Emissions}_{\text{Project}} = \text{Emissions}_{\text{Solution Gas Venting}} + \text{Emissions}_{\text{Solution Gas Processing}} + \text{Emissions}_{\text{Solution Gas Compression}} + \text{Emissions}_{\text{Fuel Extraction / Processing}}$$

Where:

Emissions Baseline = sum of the emissions under the baseline condition.

- $\text{Emissions}_{\text{Solution Gas Venting}}$ = emissions under SS B4 Solution Gas Venting
- $\text{Emissions}_{\text{Fuel Extraction / Processing}}$ = emissions under SS B5 Fuel Extraction / Processing

Emissions Project = sum of the emissions under the project condition.

- $\text{Emissions}_{\text{Solution Gas Venting}}$ = emissions under SS P4 Solution Gas Venting
- $\text{Emissions}_{\text{Solution Gas Processing}}$ = emissions under SS P5 Solution Gas Processing
- $\text{Emissions}_{\text{Solution Gas Compression}}$ = emissions under SS P6 Solution Gas Compression
- $\text{Emissions}_{\text{Fuel Extraction / Processing}}$ = emissions under SS P10 Fuel Extraction / Processing

1 **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
Project SS's						
P4 Solution Gas Venting	$Emissions_{Solution\ Gas\ Venting} = Vol._{Solution\ Gas\ Vented} * \%\ CH_4 * \rho_{CH4}$					
	$Emissions_{Solution\ Gas\ Venting}$	kg CH_4	N/A	N/A	N/A	Quantity being calculated.
	Volume of Solution Gas Vented During Non-Routine Procedures / $Vol._{Solution\ Gas\ Vented}$	L/ m^3/ other	Measured	Direct metering of volume of solution gas vented.	Continuous metering	Direct metering is standard practice. Frequency of metering is highest level possible. This volume may be excluded if this volume of gas is excluded from the baseline.
	Methane Composition of Solution Gas / % CH_4	%	Measured	Direct Measurement. Measurement of the concentration may take place anywhere within the project boundary.	Annual sampling	Gas composition should remain relatively stable. Frequency of reconciliation provides for reasonable diligence.
	Density of CH_4 / ρ_{CH4}	kg/m^3	Constant	0.68 kg/m^3 at STP[2]	N/A	Accepted value.
P5 Solution Gas Processing	$Emissions_{Solution\ Gas\ Processing} = \Sigma\ (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2})$; $\Sigma\ (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})$; $\Sigma\ (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$; $Vol._{Solution\ Gas\ Processing} * \%\ CH_4 * EF\ NG_{CO2\ producer}$; $Vol._{Solution\ Gas\ Processing} * \%\ CH_4 * EF\ NG_{CH4\ producer}$; $Vol._{Solution\ Gas\ Processing} * \%\ CH_4 * EF\ NG_{N2O\ producer}$;					
	$Emissions_{Solution\ Gas\ Processing}$	kg of CO_2; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel use on site is likely aggregated for each of

[2] STP (Standard Temperature and Pressure) is defined in this case as 15°C and 101.3 kPa.

1.0 Project/Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
						these SS's.
	Volume of Each Type of Fuel Used / Vol. $Fuel_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation	Both methods are standard practice. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence. This volume may be excluded if the corresponding volume is not included under the baseline.
	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A) – Propane (1.51 kg CO_2/L)	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A) – Propane (0.000027 kg CH_4/L)	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
	N_2O Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A) – Propane (0.000108 kg N_2O/L)	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.

1.0 Project/Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
	Volume of Solution Gas Used for Processing / Vol. $_{\text{Solution Gas Processing}}$	L/ m^3/ other	Measured	Direct metering of volume of solution gas used for processing.	Continuous metering	Direct metering is standard practice. Frequency of metering is highest level possible.
	CO_2 Emissions Factor for Combustion by Producer/ EF $NG_{CO2\ producer}$	kg CO_2 per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A) – 2.389 kg CO_2 / m^3	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
	CH_4 Emissions Factor for Combustion by Producer/ EF $NG_{CH4\ producer}$	kg CH_4 per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A) – 0.0065 kg CH_4 / m^3	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
	N_2O Emissions Factor for Combustion by Producer / EF $NG_{N2O\ producer}$	kg N_2O per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A) - 0.00006 kg N_2O / m^3	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
P6 Solution Gas Compression	Emissions $_{\text{Solution Gas Compression}}$ = Σ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$) ; Σ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; Σ (Vol. Fuel $_i$ * EF Fuel $_{i\ N2O}$); Vol. $_{\text{Solution Gas Compression}}$ * % CH_4 * EF $NG_{CO2\ producer}$; Vol. $_{\text{Solution Gas Compression}}$ * % CH_4 * EF $NG_{CH4\ producer}$; Vol. $_{\text{Solution Gas Compression}}$ * % CH_4 * EF $NG_{N2O\ producer}$;					
	Emissions $_{\text{Solution Gas Compression}}$	kg of CO_2; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel use on site is likely aggregated for each of these SS's.
	Volume of Each Type of Fuel Used / Vol. $Fuel_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation	Both methods are standard practice. Frequency of metering is highest level possible.

1.0 Project/Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
						Frequency of reconciliation provides for reasonable diligence. This volume may be excluded if the corresponding volume is not included under the baseline.
	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A) – Propane (1.51 kg CO_2/L)	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A) – Propane (0.000027 kg CH_4/L)	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
	N_2O Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A) – Propane (0.000108 kg N_2O/L)	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
	Volume of Solution Gas Used for Compression / Vol. $_{Solution\ Gas\ Compression}$	L/ m^3/ other	Measured	Direct metering of volume of solution gas used for compression.	Continuous metering	Direct metering is standard practice. Frequency of metering is highest level possible.
	CO_2 Emissions Factor for	kg CO_2	Estimate	From Environment	Annual	Reference values

1.0 Project/Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
	Combustion by Producer/ EF $NG_{CO2\ producer}$	per L / m^3 / other		Canada reference documents. (Appendix A) – 2.389 kg CO_2 / m^3		adjusted annually as part of Environment Canada's emissions inventory.
	CH_4 Emissions Factor for Combustion by Producer/ EF $NG_{CH4\ producer}$	kg CH_4 per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A) – 0.0065 kg CH_4 / m^3	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
	N_2O Emissions Factor for Combustion by Producer / EF $NG_{N2O\ producer}$	kg N_2O per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A) - 0.00006 kg N_2O / m^3	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
P9 Fuel Extraction / Processing	$Emissions_{Fuel\ Extraction\ /\ Processing} = \Sigma (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2}) ; \Sigma (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4}) ; \Sigma (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O}) ;$					
	$Emissions_{Fuel\ Extraction\ /\ Processing}$	kg of CO_2; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel use on site is likely aggregated for each of these SS's.
	Volume of Each Type of Fossil Fuel Combusted (other than solution gas) / $Vol.\ Fuel_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation	Both methods are standard practice. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence. This SS only applies to fossil fuels other than solution gas.

1.0 Project/Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
	CO_2 Emissions Factor for Fuel Including Production and Processing / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A)	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
	CH_4 Emissions Factor for Fuel Including Production and Processing / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A)	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
	N_2O Emissions Factor for Fuel Including Production and Processing / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A)	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
Baseline SS's						
B4 Solution Gas Venting	Emissions $_{Solution\ Gas\ Venting}$ = (Vol. $_{Solution\ Gas\ Injected}$ + Vol. $_{Solution\ Gas\ Processing}$ + Vol. $_{Solution\ Gas\ Compression}$) * % CH_4 * ρ_{CH4}					
	Emissions $_{Solution\ Gas\ Venting}$	kg CH_4	N/A	N/A	N/A	Quantity being calculated.
	Volume of Solution Gas Injected into Pipeline / Vol. $_{Solution\ Gas\ Injected}$	L/ m^3/ other	Measured	Direct metering of volume of solution gas injected into natural gas pipeline under project condition.	Continuous metering	Direct metering is standard practice. Frequency of metering is highest level possible.
	Volume of Solution Gas Used for Processing / Vol. $_{Solution\ Gas\ Processing}$	L/ m^3/ other	Measured	Direct metering of volume of solution gas used for processing solution gas under project condition.	Continuous metering	Direct metering is standard practice. Frequency of metering is highest level possible. This volume may excluded as it is conservative to do so; if this volume

1.0 Project/Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
						is included, SS P5 must be included.
	Volume of Solution Gas Used for Compression / Vol. $_{\text{Solution Gas Compression}}$	L/ m^3/ other	Measured	Direct metering of volume of solution gas used for heating under project condition.	Continuous metering	Direct metering is standard practice. Frequency of metering is highest level possible. This volume may excluded as it is conservative to do so; if this volume is included, SS P6 must be included.
	Methane Composition of Solution Gas / % CH_4	%	Measured	Direct measurement of the concentration may take place anywhere within the project boundary.	Annual sampling	Gas composition should remain relatively stable during steady-state operation. Frequency of reconciliation provides for reasonable diligence.
	Density of CH_4 / ρ_{CH4}	kg/m^3	Constant	0.68 kg/m^3 at STP[3]	N/A	Accepted value.
B5 Fuel Extraction / Processing	Emissions $_{\text{Fuel Extraction / Processing}}$ = Σ (Vol. Fuel $_i$ * EF Fuel $_{i\,CO2}$) ; Σ (Vol. Fuel $_i$ * EF Fuel $_{i\,CH4}$) ; Σ (Vol. Fuel $_i$ * EF Fuel $_{i\,N2O}$) ;					
	Emissions $_{\text{Fuel Extraction / Processing}}$	kg of CO_2; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel use on site is likely aggregated for each of these SS's.
	Volume of Each Type of Fossil Fuel Combusted (other than solution gas) / Vol. Fuel $_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage	Continuous metering or monthly	Both methods are standard practice. Frequency of

[3] STP (Standard Temperature and Pressure) is defined in this case as 15°C and 101.3 kPa.

1.0 Project/Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
				(including volumes received).	reconciliation	metering is highest level possible. Frequency of reconciliation provides for reasonable diligence. This SS only applies to fossil fuels other than solution gas.
	CO_2 Emissions Factor for Fuel Including Production and Processing / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A)	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
	CH_4 Emissions Factor for Fuel Including Production and Processing / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A)	Annual	Reference values adjusted annually as part of Environment Canada's emissions inventory.
	N_2O Emissions Factor for Fuel Including Production and Processing / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimate	From Environment Canada reference documents. (Appendix A)	Annual	Reference values adjusted annually as part of Environment 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.

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
Project SS's						
P4 Solution Gas Venting	Volume of Solution Gas Vented During Non-Routine Procedures / Vol. Solution Gas Vented	L / m^3/ other	Estimated	Obtained from required reporting records as per ERCB Directive 007	Monthly	Provides reasonable estimate of the parameter, when more accurate and precise method cannot be used.
P5 Solution Gas Processing	Volume of Each Type of Fuel Used / Vol. Fuel $_i$	L / m^3 / other	Estimate	Reconciliation of volume of fuel used or purchased within a given time period.	Monthly	Provides reasonable estimate of the parameter, when more accurate and precise method cannot be used.
P6 Solution Gas Compression	Volume of Each Type of Fuel Used / Vol. Fuel $_i$	L / m^3 / other	Estimate	Reconciliation of volume of fuel used or purchased within a given time period.	Monthly	Provides reasonable estimate of the parameter, when more accurate and precise method cannot be used.
P10 Fuel Extraction / Processing	Volume of Each Type of Fuel Combusted (excluding solution gas) for P5 and P6 / Vol. Fuel $_i$	L / m^3 / other	Estimate	Reconciliation of volume of fuel purchased within a given time period.	Monthly	Provides reasonable estimate of the parameter, when more accurate and precise method cannot be used.
Baseline SS's						
B4 Solution Gas Venting	Methane Composition of Solution Gas / % CH_4	%	Estimated	Interpolation of previous and following measurements taken or 90%, whichever is lower.	Annually	Solution gas composition should remain relatively stable during steady-state operation. Interpolating gas composition provides a reasonable estimate when the more accurate and precise method cannot be used.
	Volume of Solution Gas Injected into Pipeline / Vol.	L/ m^3/ other	Estimated	Obtained from required reporting records as per ERCB Directive	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

	Solution Gas Injected			007; or, Reconciliation of volume of solution gas injected within given time period based on average flow rates.		
	Volume of Solution Gas Used for Extraction / Vol. Solution Gas Extraction	L/ m^3/ other	Measured	Obtained from required reporting records as per ERCB Directive 007; or, Reconciliation of volume of solution gas injected within given time period based on average flow rates.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Volume of Solution Gas Used for Heating / Vol. Solution Gas Storage	L/ m^3/ other	Measured	Obtained from required reporting records as per ERCB Directive 007; or, Reconciliation of volume of solution gas injected within given time period based on average flow rates.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
B5 Fuel Extraction / Processing	Volume of Each Type of Fuel Combusted (excluding solution gas) / Vol. Fuel $_i$	L / m^3 / other	Estimate	Reconciliation of volume of fuel purchased within a given time period.	Monthly	Provides reasonable estimate of the parameter, when more accurate and precise method cannot be used.

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 rigor 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 storage of primary data;
b. Printing of monthly back-up hard copies of all logged data;
c. Written logs of operations and maintenance of the project system 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;
e. Keeping all records available for review by a verification body.

2.6.2 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.

APPENDIX A:

Relevant Emission Factors

Table A1: Emission Intensity of Fuel Extraction and Production (Diesel, Natural Gas, and Gasoline)[4]

Diesel		
Production		
Emissions Factor (CO_2)	0.138	kg CO_2 per Litre
Emissions Factor (CH_4)	0.0109	kg CH_4 per Litre
Emissions Factor (N_2O)	0.000004	kg N_2O per Litre
Natural Gas		
Extraction		
Emissions Factor (CO_2)	0.043	kg CO_2 per m^3
Emissions Factor (CH_4)	0.0023	kg CH_4 per m^3
Emissions Factor (N_2O)	0.000004	kg N_2O per m^3
Processing		
Emissions Factor (CO_2)	0.090	kg CO_2 per m^3
Emissions Factor (CH_4)	0.0003	kg CH_4 per m^3
Emissions Factor (N_2O)	0.000003	kg N_2O per m^3
Gasoline		
Production		
Emissions Factor (CO_2)	0.138	kg CO_2 per Litre
Emissions Factor (CH_4)	0.0109	kg CH_4 per Litre
Emissions Factor (N_2O)	0.000004	kg N_2O per Litre

Table A2: Emission Factors for Natural Gas and NGL's[5]

Source	Emission Factors		
	CO_2	**CH_4**	**N_2O**
	g/m^3	**g/m^3**	**g/m^3**
Natural Gas			
Electric Utilities	1891	0.49	0.049
Industrial	1891	0.037	0.033
Producer Consumption	2389	6.5	0.06
Pipelines	1891	1.9	0.05
Cement	1891	0.037	0.034
Manufacturing Industries	1891	0.037	0.033
Residential, Construction, Commercial/Institutional, Agriculture	1891	0.037	0.035
	g/L	**g/L**	**g/L**
Propane			
Residential	1510	0.027	0.108
All Other Uses	1510	0.024	0.108
Ethane	976	N/A	N/A
Butane	1730	0.024	0.108

[4] Source: Quantification Protocol for Acid Gas Injection, v.1, May 2008. Alberta Environment.
[5] Source: Annex 12, Table A12-1 of the National Inventory Report: Greenhouse Gas Sources and Sinks in Canada, 1990 – 2006.

Table A3: Emission Factors for Refined Petroleum Products[6]

Source	Emission Factors (g/L)		
	CO_2	CH_4	N_2O
Light Fuel Oil			
Electric Utilities	2830	0.18	0.031
Industrial	2830	0.006	0.031
Producer Consumption	2830	0.006	0.031
Residential	2830	0.026	0.006
Forestry, Construction, Public Administration, and Commercial/Institutional	2830	0.026	0.031
Heavy Fuel Oil			
Electric Utilities	3080	0.034	0.064
Industrial	3080	0.12	0.064
Producer Consumption	3080	0.12	0.064
Residential, Forestry, Construction, Public Administration, and Commercial/Institutional	3080	0.057	0.064
Kerosene			
Electric Utilities	2550	0.006	0.031
Industrial	2550	0.006	0.031
Producer Consumption	2550	0.006	0.031
Residential	2550	0.026	0.006
Forestry, Construction, Public Administration, and Commercial/ Institutional	2550	0.026	0.031
Diesel	2730	0.133	0.4

[6] Source: Annex 12, Table A12-2 of the National Inventory Report: Greenhouse Gas Sources and Sinks in Canada, 1990 – 2006.