SPECIFIED GAS EMITTERS REGULATION

QUANTIFICATION PROTOCOL FOR TILLAGE SYSTEM MANAGEMENT

FEBRUARY 2009

Version 1.3

Alberta

ALBERTANS & CLIMATE CHANGE

Disclaimer:

The information provided in this document is intended as guidance only and is subject to revisions as learnings and new information comes forward as part of a commitment to continuous improvement. This document is not a substitute for the law. Please consult the *Specified Gas Emitters Regulation* and the legislation for all purposes of interpreting and applying the law. In the event that there is a difference between this document and the *Specified Gas Emitters Regulation* or legislation, the *Specified Gas Emitters Regulation* or the legislation prevail.

This protocol allows for the incorporation of custom coefficients. In such cases, the following policy framework applies:

1. Government Approved Protocols Only
   - All credits used for compliance must be verified using Alberta Government approved protocols.
   - This includes new protocols and any already approved protocols where **custom coefficients** are being considered.
   - The process for submitting new protocols can be found http://www.carbonoffsetsolutions.ca/.

2. Rigorous Scientific Foundation
   - All protocols will be based on best-available science.
   - Adjustments will be made as appropriate to ensure credits reflect **beyond business as usual** reductions.
   - For carbon sequestration projects, the following adjustments will be made:
     i. Baseline adjustment to account for existing practices.
     ii. Incorporation of an assurance factor to account for potential carbon releases over the project period.
   - Guidance on developing new coefficients/protocols can be found on http://www3.gov.ab.ca/env/climate/.

3. Retroactive Crediting
   - Where custom coefficients have been demonstrated to reflect sound science and have incorporated the appropriate adjustments:
     i. The **new coefficients will be made publically available** as a revised Alberta Government approved protocol.
     ii. All applicable projects are eligible to receive credit for the difference in associated reductions between the originally approved and new quantification protocol, **back to 2002.**

Acknowledgements:

This protocol is largely based on the historical document called *Tillage System Default Coefficient Technical Background Document* dated October 2006. This work was completed under the Soil Management Technical Working Group (SMTWG). Dennis Haak from Agriculture and Agri-Food Canada was the principal author. This work represents the culmination of a multi-stakeholder consultation process and reliance on a number of guidance documents. This document represents an abridged and re-formatted version of this work. Therefore, the background document remains the source of additional detail on any of the technical elements of the protocol. Follow-up work by Dennis Haak has been substantial and very much appreciated.

All Quantification Protocols approved under the *Specified Gas Emitters Regulation* are subject to periodic review as deemed necessary by the Department, and will be re-examined at a minimum of every 5 years from the original publication date to ensure methodologies and science continue to reflect best-available knowledge and best practices. This 5-year review will not impact the credit duration stream of projects that have been initiated under previous versions of the protocol. Any updates to protocols occurring as a result of the 5-year and/or other reviews will apply at the end of the first credit duration period for applicable project extensions.

Any comments, questions, or suggestions regarding the content of this document may be directed to:

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1.0 Project and Methodology Scope and Description

The opportunity for generating carbon offsets with this protocol arises from the direct and indirect reductions of greenhouse gas (GHG) emissions through implementing no-till and reduced till systems on agricultural lands.

1.1 Protocol Scope and Description

This protocol provides a default methodology for quantifying carbon offsets through projects that undertake reduced tillage on agricultural land. Theoretically, this protocol can be applied to all land and all agricultural producers across the country; however, more work will need to be done for soil zones outside the prairies with respect to the assurance factor (see Appendix B). To use this protocol, project developers will not have to prove their baseline at the project start date. This protocol will apply, regardless of historical practices associated with the land or a producer. This approach, termed as the ***adjusted baseline approach,*** accounts for carbon gains from current adoption levels of reduced-till and no-till practices within the given region, adjusted with farm census data from Statistics Canada.

FIGURE 1.1 offers a process flow diagram for a typical project. **FIGURE 1.2** offers a process flow diagram for a typical baseline configuration.

Protocol Approach:
In order to make the default approach feasible and credible, it is necessary to create project coefficients and baseline deductions that are regionally aggregated. In other words, in a given region, all project lands under no-till receive the same emission factor per area regardless of what tillage systems were used in the past. As such this protocol strives to simplify and minimize project administrative costs by not having to collect and analyze historical information for project land parcels.

Protocol Applicability:
This protocol is applicable to annual crops grown throughout Canada. Perennial crops are not within the scope of the protocol. While some perennial row crops may involve tillage (e.g. orchards, small fruits, nuts, nurseries, woodlots, etc.), the coefficients used in this protocol are not applicable since the tillage in these scenarios only involves part of the land area (i.e. the inter-row zone).

It is recognized that farming and cropping systems are complex, often with interdependent practices. GHG emissions are potentially generated by many different specific practices, in addition to the tillage system. However, the reduction coefficients used in this protocol assume that when comparing the project and baseline scenarios for all other aspects of farm operation that there are negligible GHG impacts from the project. This assumption allows for the layering of protocols across a number of project areas. Aspects relating to nitrogen (N) fertilizer application timing and nitrogen application rate are independent of this Tillage Protocol and will be dealt with in a separate protocol dealing with nitrogen management. Protocol linkages will be considered as part of the development process.

To demonstrate that a project meets the requirements under this protocol, the project proponent must supply sufficient evidence to demonstrate that:

1. Farms must be producing annual crops on the applicable land as confirmed by an affirmation from the project developer and farm records;
2. Farms in the project must operate on the applicable land in a no-till or reduced till system as defined in this protocol as confirmed by an affirmation from the project developer and farm records;
3. 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,
4. The project must meet the requirements for offset eligibility as specified in the applicable regulation and guidance documents for the Alberta Offset System.
5. Additional guidance to this protocol can be found at http://environment.alberta.ca/1238.html.

FIGURE 1.1: Process Flow Diagram for Project Condition

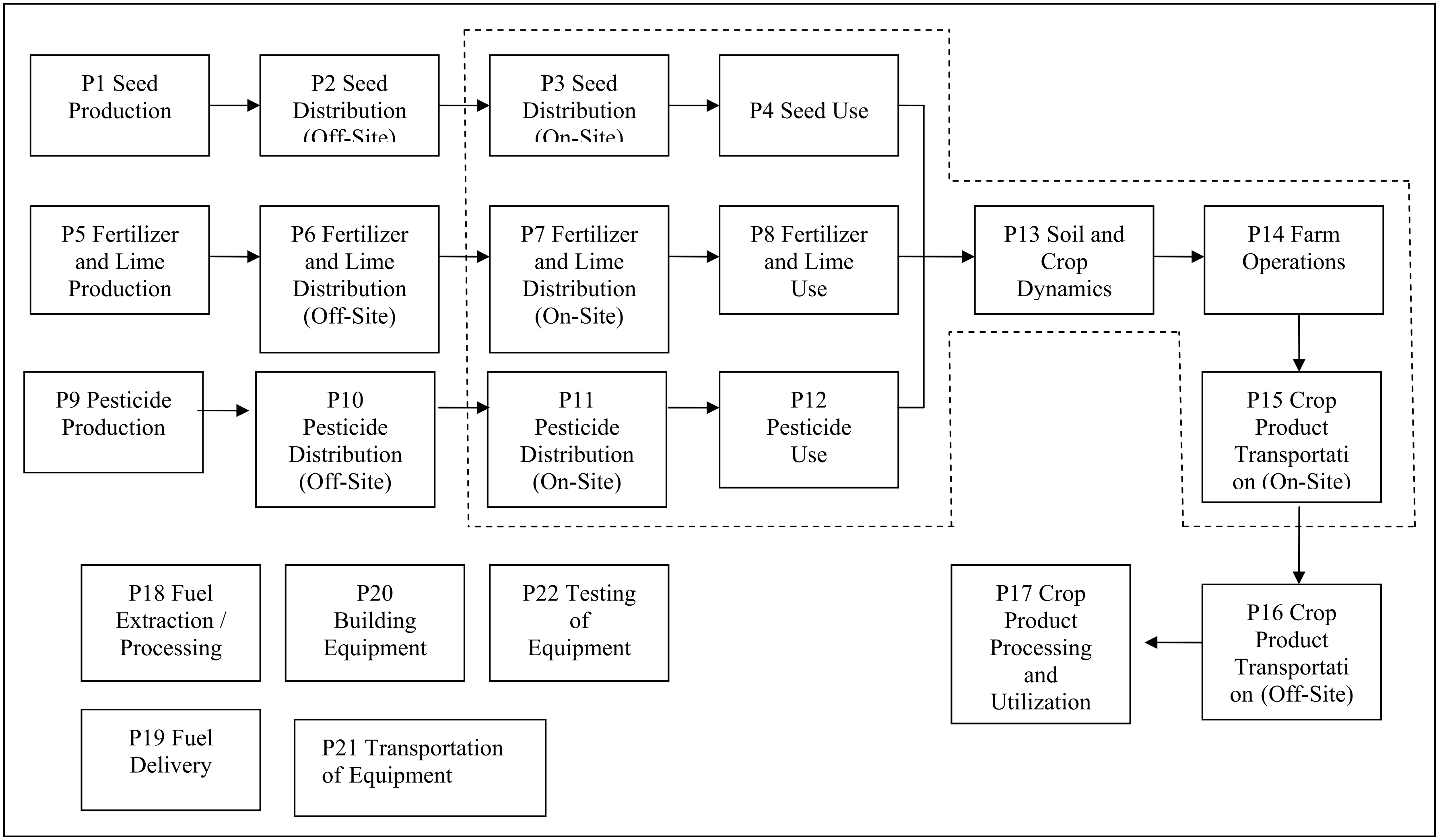
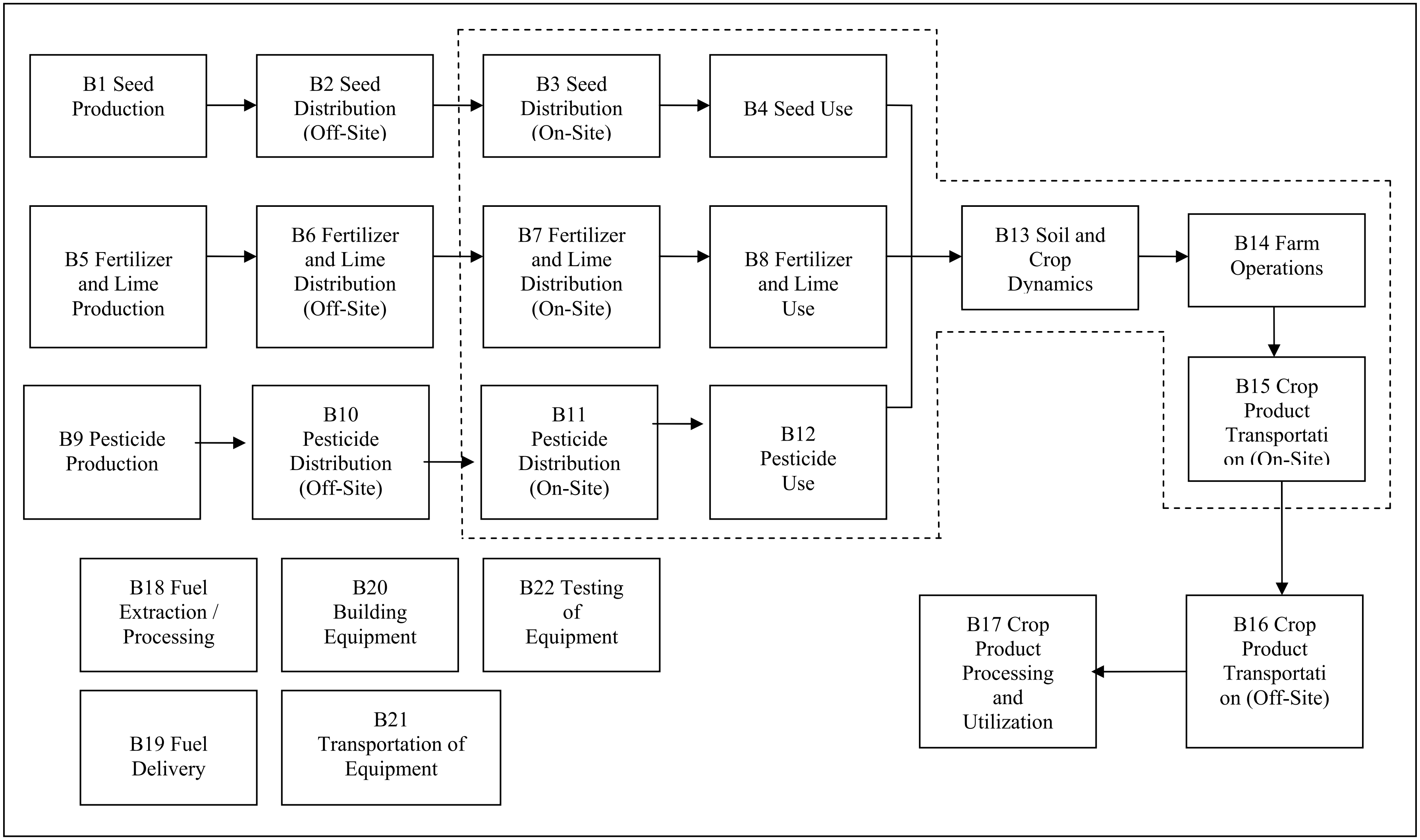


FIGURE 1.2: Process Flow Diagram for Baseline Condition



Protocol Flexibility

Flexibility in applying the quantification protocol is provided to project developers in two ways.

1. This protocol applies to a single component of farm operations. As such, this protocol can be combined with other protocols where multiple projects are undertaken to reduce overall greenhouse gas emission from the farming operations in question; and
2. A project operator may define and justify site-specific Soil Organic Carbon (SOC) sequestration and nitrous oxide (N_2O) coefficients adjusted for baseline considerations. These factors may be substituted for the generic emission factors indicated in this protocol document. The methodology must ensure reasonable accuracy and certainty, and be based on available principles-based guidance from Alberta Agriculture and Food. Further, these emission factors must be assessed to ensure that the project developer has properly accounted for any impact on emission factors, assumptions and assurance factor estimates stated in this protocol. These site-specific coefficients would need to be approved by Alberta Environment for use in the Alberta Offset System.

This quantification protocol is written for the farm operator or project developer. Some familiarity with, or general understanding of, the operation of farming practices is expected.

1.2 Glossary of New Terms

Assurance Factor	The assurance factor accounts for the risk and magnitude of carbon sequestration reversal due to tilling events occurring in fields that would otherwise be under reduced and no-till practices. This factor accounts for the average number of tillage events anticipated over a 20 year period. Reversals are contemplated as linear, in keeping with the model for sequestration under reduced and no-till practises. The assurance factor accounts reversal events across the years that the field is credited for the sequestration from reduced and no-till practises. This prevents a liability accruing on the field in years where tillage events occur, as the fields would receive neither a credit nor reversal of a credit in years where the tillage events occurred.
No-Till and Reduced Till	These terms are defined regionally as per **TABLE 1.1**, below.

Table 1.1 Definitions of tillage systems in the Parkland[1] and Dry Prairie protocol areas.

Tillage System	Cropped Land Period [2]	Fallow Period [3]
No Till	Up to two passes with low-disturbance openers (up to 38%) [4, 5] or one pass with a slightly higher disturbance opener (up to 46%) to apply seed, fertilizer or manure [6], discretionary tillage of up to 10% [5] , no cultivation	No cultivations
Reduced Till	Soil disturbance to apply seed, fertilizer, or manure exceeds no till definition and/or one cultivation in fall or spring	One to two cultivations
Full Till	More than one cultivation between harvest and subsequent seeding if no fallow in that period, or, more than three cultivations between harvest to subsequent seeding if fallow	More than two cultivations

Notes:

[1] The Peace River Lowland ecoregion is contained within the Parkland zone.

[2] Cropped land period applies to the management cycle that terminates at harvest, (e.g. harvest to harvest defines the cropped land period). This includes land preparation for seeding which may occur in the previous fall.

[3] Fallow period extends from harvest for one full year to the next fall.

[4] Percentage values associated with openers are based on maximum opener width (e.g. 5 inch openers actually measure 5.5 inches) divided by the shank spacing of the implement.

[5] Additional operations with harrows, packers, or similar non-soil disturbing implements are accepted. Where a second low soil disturbance operation is performed it is normally for injection of fertilizer or manure.

[6] Discretionary tillage of up to 10% means that up to 10% of the surface area of a single agricultural field may be cultivated to address specific management issues. These areas are determined on an annual basis, meaning that specific areas may change from year to year.

2.0 Quantification Development and Justification

The following sections outline the quantification development and justification.

2.1 Identification of Sources and Sinks for the Project

Sources and sinks (SS's) were identified for the project by reviewing the seed protocol document and relevant process flow diagram. This 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**, 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

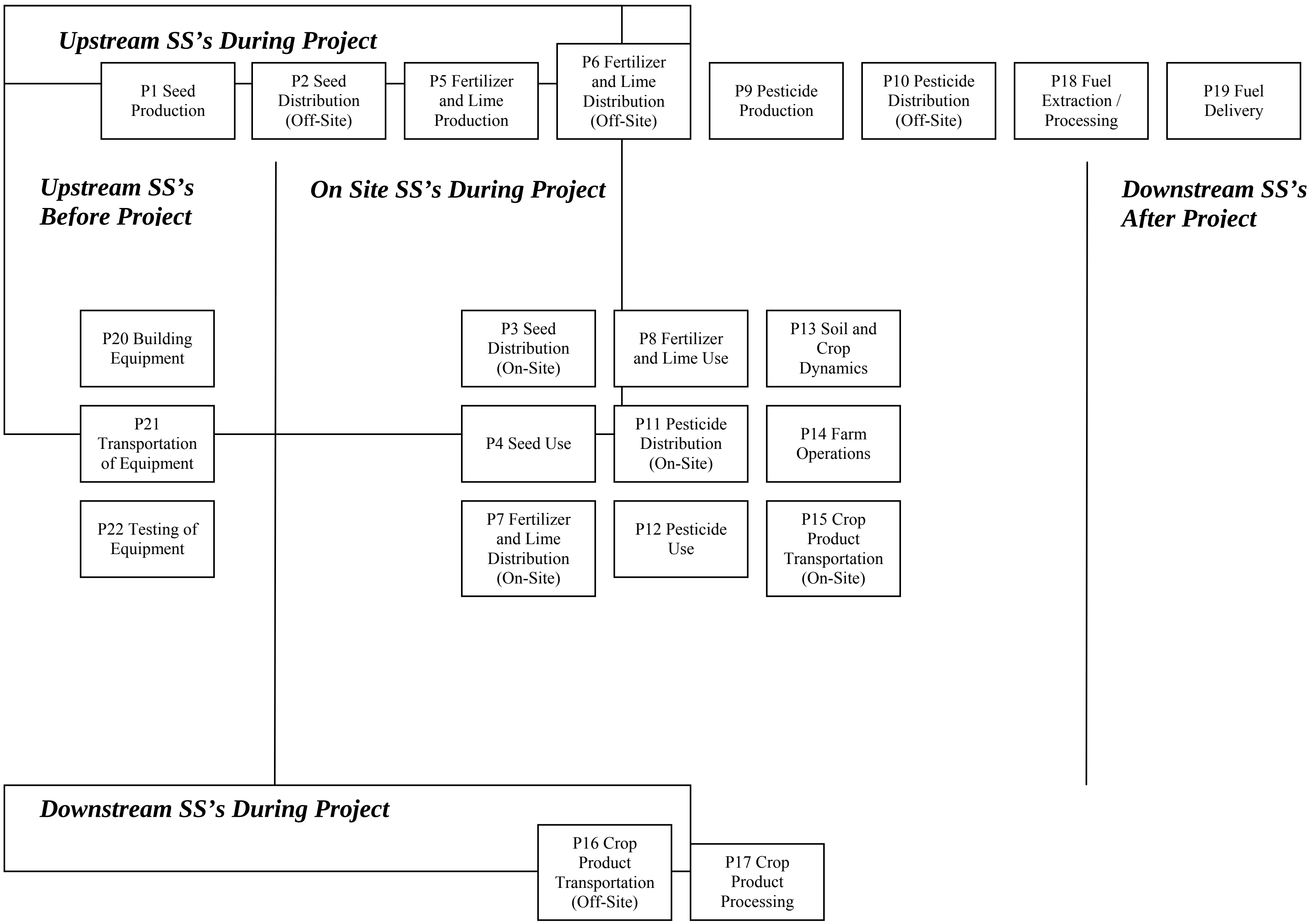


TABLE 2.1: Project SS's

1. SS	2. Description	3. Controlled, Related or Affected
Upstream SS's during Project Operation		
P1 Seed Production	Seed production may include several energy inputs such as natural gas, diesel and electricity. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
P2 Seed Transportation (Off-Site)	Seeds 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
P5 Fertilizer and Lime Production	Fertilizer and lime production may include several material and energy inputs such as natural gas, diesel and electricity. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
P6 Fertilizer and Lime Distribution (Off-Site)	Fertilizer and lime 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
P9 Pesticide Production	Pesticide production may include several material and energy inputs such as natural gas, diesel and electricity. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
P10 Pesticide Distribution (Off-Site	Pesticide 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
P18 Fuel Extraction and Processing	Each of the fuels used throughout the on-site component of the project will need to 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
P19 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 is no other delivery.	Related

Onsite SS's during Project Operation		
P3 Seed Distribution (On-Site)	Seed would need to be transported from storage to the field. 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
P4 Seed Use	Emissions associated with the use of the seeds. Inputs of embedded energy and materials would need to be tracked to ensure equivalency with the baseline condition.	Controlled
P7 Fertilizer and Lime Distribution (On-Site)	Fertilizer and lime would need to be transported from storage to the field. 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
P8 Fertilizer and Lime Use	Emissions associated with the use of the fertilizer and lime. Timing, composition, concentration and volume of fertilizer need to be tracked.	Controlled
P11 Pesticide Distribution (On-Site)	Pesticide distribution would need to be transported from storage to the field. 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
P12 Pesticide Use	Emissions associated with the use of the pesticide. Timing, composition, concentration and volume of fertilizer need to be tracked to ensure equivalency with the baseline condition.	Controlled
P13 Soil Crop Dynamics	Flows of materials and energy that comprise the cycling of soil and plant carbon and nitrogen, including deposition in plant tissue, decomposition of crop residues, stabilization in organic matter and emission as carbon dioxide and nitrous oxide.	Controlled
P14 Farm Operations	Greenhouse gas emissions may occur that are associated with the operation and maintenance of the farm facility and related equipment. This may include running vehicles and facilities at the project site. Quantities and types for each of the energy inputs would be tracked.	Controlled
P15 Crop Product Transportation (On-Site)	Crops would need to be harvested and transported from the field to storage. 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
Downstream SS's during Project Operation		
P16 Crop Product Transportation (Off-Site)	Crops would need to be transported from storage to the market 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
P17 Crop Product Processing	Inputs of materials and energy involved in the processing and end product utilization of the crop would need to be tracked to ensure functional equivalence with the baseline condition.	Related

Other		
P20 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
P21 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 train, truck, by some combination, or even by courier. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
P22 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

2.2 Identification of Baseline

The baseline condition for projects applying this protocol is considered as a performance-based approach. The performance standards for no-till and reduced till farming are set relative to a 1990 baseline and would be subject to revision over time. The uptake of no-till and reduced till farming is considered within the coefficients implicit within the default methodology approach to assessing the relevant performance standard.

The established baseline would be considered as static, where the coefficients remain constant, subject to periodic revision to reflect the evolving performance standard.

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

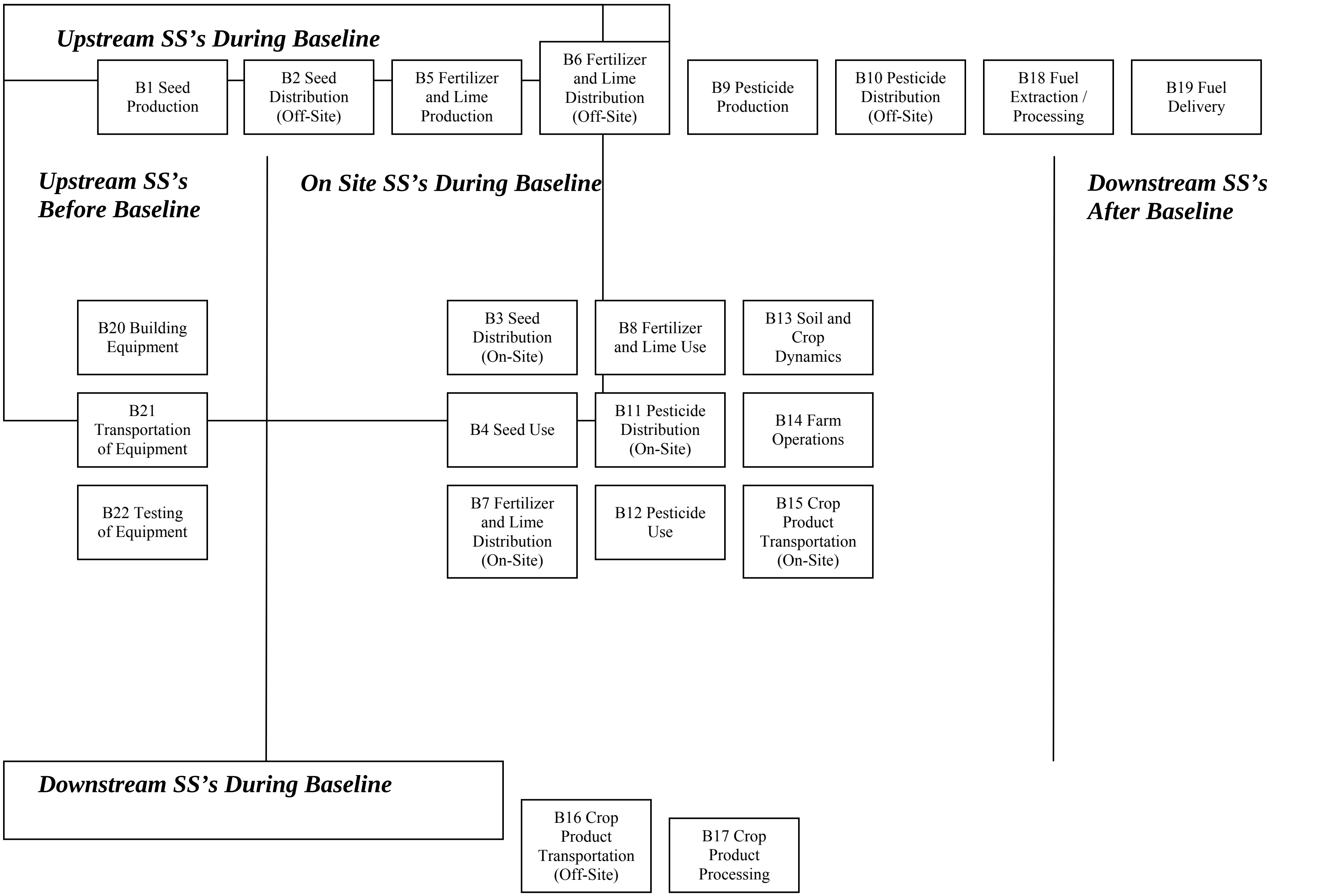


TABLE 2.2: Baseline SS's

1. SS	2. Description	3. Controlled, Related or Affected
Upstream SS's during Baseline Operation		
B1 Seed Production	Seed production may include several energy inputs such as natural gas, diesel and electricity. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
B2 Seed Transportation (Off-Site)	Seeds 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
B5 Fertilizer and Lime Production	Fertilizer and lime production may include several material and energy inputs such as natural gas, diesel and electricity. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
B6 Fertilizer and Lime Distribution (Off-Site)	Fertilizer and lime 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
B9 Pesticide Production	Pesticide production may include several material and energy inputs such as natural gas, diesel and electricity. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
B10 Pesticide Distribution (Off-Site	Pesticide 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
P18 Fuel Extraction and Processing	Each of the fuels used throughout the on-site component of the project will need to 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
B19 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 is no other delivery.	Related

Onsite SS's during Baseline Operation		
B3 Seed Distribution (On-Site)	Seed would need to be transported from storage to the field. 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
B4 Seed Use	Emissions associated with the use of the seeds. Inputs of embedded energy and materials would need to be tracked to ensure equivalency with the baseline condition.	Controlled
B7 Fertilizer and Lime Distribution (On-Site)	Fertilizer and lime would need to be transported from storage to the field. 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
B8 Fertilizer and Lime Use	Emissions associated with the use of the fertilizer and lime. Timing, composition, concentration and volume of fertilizer need to be tracked.	Controlled
B11 Pesticide Distribution (On-Site)	Pesticide distribution would need to be transported from storage to the field. 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
B12 Pesticide Use	Emissions associated with the use of the pesticide. Timing, composition, concentration and volume of fertilizer need to be tracked to ensure equivalency with the baseline condition.	Controlled
B13 Soil Crop Dynamics	Flows of materials and energy that comprise the cycling of soil and plant carbon and nitrogen, including deposition in plant tissue, decomposition of crop residues, stabilization in organic matter and emission as carbon dioxide and nitrous oxide.	Controlled
B14 Farm Operations	Greenhouse gas emissions may occur that are associated with the operation and maintenance of the farm facility and related equipment. This may include running vehicles and facilities at the project site. Quantities and types for each of the energy inputs would be tracked.	Controlled
B15 Crop Product Transportation (On-Site)	Crops would need to be harvested and transported from the field to storage. 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
Downstream SS's during Baseline Operation		
B16 Crop Product Transportation (Off-Site)	Crops would need to be transported from storage to the market 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
B17 Crop Product Processing	Inputs of materials and energy involved in the processing and end product utilization of the crop would need to be tracked to ensure functional equivalence with the baseline condition.	Related

Other		
B20 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
B21 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 train, truck, by some combination, or even by courier. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
B22 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

2.4 Selection of Relevant Project and Baseline SS's

Each of the SS's from the project and baseline condition were compared and evaluated as to there relevancy using the guidance provided in Annex VI of the "Guide to Quantification Methodologies and Protocols: Draft", dated March 2006. The justification for the exclusion or conditions upon which SS's may be excluded is provided below. All other SS's listed previously are included. This information is summarized 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				
P1 Seed Production	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. Further, the baseline and project conditions will be functionally equivalent.
B1 Seed Production	Related	N/A	Exclude	
P2 Seed Transportation (Off-Site)	N/A	Related	Exclude	Excluded as the emissions from transportation are negligible and likely functionally equivalent to the baseline scenario.
B2 Seed Transportation (Off-Site)	Related	N/A	Exclude	
P5 Fertilizer and Lime Production	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. Further, the baseline and project conditions will be functionally equivalent.
B5 Fertilizer and Lime Production	Related	N/A	Exclude	
P6 Fertilizer and Lime Distribution (Off-Site)	N/A	Related	Exclude	Excluded as the emissions from transportation are negligible and likely functionally equivalent to the baseline scenario.
B6 Fertilizer and Lime Distribution (Off-Site)	Related	N/A	Exclude	
P9 Pesticide Production	N/A	Related	Include	N/A
B9 Pesticide Production	Related	N/A	Include	
P10 Pesticide Distribution (Off-Site	N/A	Related	Exclude	Excluded as the emissions from transportation are negligible and likely functionally equivalent to the baseline scenario.
B10 Pesticide Distribution (Off-Site	Related	N/A	Exclude	
P17 Fuel Extraction and Processing	N/A	Related	Exclude	Excluded as the emissions from the baseline are greater than the project condition so this is a conservative approach, allowing application of the default methodology with available factors.
B17 Fuel Extraction and Processing	Related	N/A	Exclude	
P18 Fuel Delivery	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.
B18 Fuel Delivery	Related	N/A	Exclude	

Onsite SS's				
P3 Seed Distribution (On-Site)	N/A	Controlled	Include	N/A
B3 Seed Distribution (On-Site)	Controlled	N/A	Include	
P4 Seed Use	N/A	Controlled	Exclude	Excluded as the emissions from seeding are negligible and likely functionally equivalent to the baseline scenario.
B4 Seed Use	Controlled	N/A	Exclude	
P7 Fertilizer and Lime Distribution (On-Site)	N/A	Controlled	Include	N/A
B7 Fertilizer and Lime Distribution (On-Site)	Controlled	N/A	Include	
P8 Fertilizer and Lime Use	N/A	Controlled	Exclude	Excluded as the emissions from seeding are likely functionally equivalent to the baseline scenario.
B8 Fertilizer and Lime Use	Controlled	N/A	Exclude	
P11 Pesticide Distribution (On-Site)	N/A	Controlled	Include	N/A
B11 Pesticide Distribution (On-Site)	Controlled	N/A	Include	
P12 Pesticide Use	N/A	Controlled	Exclude	Excluded as the emissions from pesticide use are likely functionally equivalent to the baseline scenario.
B12 Pesticide Use	Controlled	N/A	Exclude	
P13 Soil Crop Dynamics	N/A	Controlled	Include	N/A
B13 Soil Crop Dynamics	Controlled	N/A	Include	
P14 Farm Operations	N/A	Controlled	Exclude	Excluded as the farm operations are likely functionally equivalent to the baseline scenario.
B14 Farm Operations	Controlled	N/A	Exclude	
P15 Crop Product Transportation (On-Site)	N/A	Controlled	Exclude	Excluded as the emissions from crop harvesting and transportation are likely functionally equivalent to the baseline scenario.
B15 Crop Product Transportation (On-Site)	Controlled	N/A	Exclude	
Downstream SS's				
P16 Crop Product Transportation (Off-Site)	N/A	Related	Exclude	Excluded as the emissions from transportation are negligible and likely functionally equivalent to the baseline scenario.
B16 Crop Product Transportation (Off-Site)	Related	N/A	Exclude	
P17 Crop Product Processing	N/A	Related	Exclude	Excluded as the emissions from crop product processing are functionally equivalent to the baseline scenario.
B17 Crop Product Processing	Related	N/A	Exclude	
Other				
P20 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.

B20 Building Equipment	Related	N/A	Exclude	Emissions from building equipment are not material for the baseline condition given the minimal building equipment typically required.
P21 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.
B21 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.
P22 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.
B22 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.

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 the emission reductions from the comparison of the baseline and project conditions.

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

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions}_{\text{Energy Use}} + \text{Emissions}_{\text{Carbon Sequestration}} * \text{Assurance Factor} + \text{Emissions}_{\text{Nitrogen}}$$

$$\text{Emissions}_{\text{Project}} = 0$$

Where:

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

$\text{Emissions}_{\text{Energy Use}}$ = component of emissions under SS's B9 Pesticide Production, B3 Seed Distribution (On-Site), B7 Fertilizer and Lime Distribution (On-Site), B11 Pesticide Distribution (On-Site)

$\text{Emissions}_{\text{Carbon Sequestration}}$ = component of emissions under SS B13 Soil and Crop Dynamics

Assurance Factor = Factor to account for reversals due to tillage events. Relevant assurance factors are provided in **Appendix B**.

$\text{Emissions}_{\text{Nitrogen}}$ = component of emissions under SS B13 Soil and Crop Dynamics

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

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						
P9 Pesticide Production	Captured in Baseline Adjusted Factors					
P3 Seed Distribution (On-Site)						
P7 Fertilizer and Lime Distribution (On-Site)						
P11 Pesticide Distribution (On-Site)						
P13 Soil and Crop Dynamics						
Baseline SS's						
B9 Pesticide Production B3 Seed Distribution (On-Site) B7 Fertilizer and Lime Distribution (On-Site) B11 Pesticide Distribution (On-Site)	$Emissions_{Energy\ Use} = \sum Area_{Till\ Practice\ y} * EF_{Energy\ Use}$					
	Emission Reductions from Carbon Sequestration / $Emissions_{Energy\ Use}$	kg CO_{2E} / yr	N/A	N/A	N/A	Quantity being calculated.
	Area of Field under Each Till Practice / $Area_{Till\ Practice\ Y}$	ha	Measured		Continuous	
	Reduction Factor For Relevant Till Practice in Relevant Area and Geographic Zone / $EF_{Energy\ Use}$	kg CO_{2E} / ha / yr	Estimated	Default factor based on project farm location, as available at January 1 of the first year of the project. Transition zones should be characterized based on the dominant soil zone.	Annually	As per NCGAVS process.

B13 Soil and Crop Dynamics	$Emissions_{Carbon\ Sequestration} = \sum Area_{Till\ Practice\ y} * EF_{20\ yr\ Linear\ SOC\ Coefficient}$					
	Emission Reductions from Carbon Sequestration / $Emissions_{Carbon\ Sequestration}$	kg CO_{2E} / yr	N/A	N/A	N/A	Quantity being calculated.
	Area of Field under Each Till Practice / $Area_{Till\ Practice\ Y}$	ha	Measured		Continuous	
	Sequestration Factor For Relevant Till Practice in Relevant Area and Geographic Zone / $EF_{10\ yr\ Linear\ SOC\ Coefficient}$	kg CO_{2E} / ha / yr	Estimated	Default factor based on project farm location, as available at January 1 of the first year of the project. Transition zones should be characterized based on the dominant soil zone.	Annually	As per NCGAVS process.
	$Emissions_{Nitrogen} = \sum Area_{Till\ Practice\ y} * EF_{N2O\ Coefficient}$					
	Emission Reductions from Nitrogen Oxide Reduction / $Emissions_{Nitrogen}$	kg CO_{2E} / yr	N/A	N/A	N/A	Quantity being calculated.
	Area of Field under Each Till Practice / $Area_{Till\ Practice\ Y}$	ha	Measured		Continuous	
	Reduction Factor For Relevant Till Practice in Relevant Area and Geographic Zone / $EF_{N2O\ Coefficient}$	kg CO_{2E} / ha / yr	Estimated	Default factor based on project farm location, as available at January 1 of the first year of the project. Transition zones should be characterized based on the dominant soil zone.	Annually	As per NCGAVS process.

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 the management system for the data, the more easily the audit will be for the project.

2.6.1 Record Keeping

Record keeping practises should include:

a. Electronically record values of logged primary parameters for each measurement interval.
b. Print monthly back-up hard copies of all logged data.
c. Keep written logs of operations and maintenance of the project system including notation of all shut-downs, start-ups and process adjustments.
d. Retain copies of logs and all logged data for a period of 7 years.
e. Keep 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.

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. Contingency Method	6. Frequency	7. Justify measurement or estimation and frequency
Baseline SS's						
B9 Pesticide Production	Area of Field under Each Till Practice / Area $_{Till\ Practice\ Y}$	ha				
B17 Fuel Extraction and Processing						
B3 Seed Distribution (On-Site)						
B7 Fertilizer and Lime Distribution (On-Site)						
B11 Pesticide Distribution (On-Site)						

APPENDIX A:

Relevant Emission Factors

Determination of Baseline Adjusted Emission Factors

The analysis described below is described in more detail in the original work completed under the Soil Management Technical Working Group (SMTWG). Dennis Haak from Agriculture and Agri-Food Canada was the lead author.

Table A1: Designation of Protocol Areas within Canada's Ecostratification Framework

Protocol Area	In Canada Ecozone	Ecoregions	Ecodistricts
1 East	Atlantic Canada, Boreal Shield (Newfoundland)	106-109, 112-116, 117-131	453-456, 458, 460-464, 466-468, 470-472, 475-539
2 East Central	St. Lawrence Lowlands, Manitoulin– Lake Simcoe-Frontenac, Lake Erie Lowland, Boreal Shield (eastern Ontario, Québec)	132-135	400, 401, 407-415, 418, 419, 422-426, 434, 438, 440, 441, 540-572
3 Parkland	Black Soil Zone, Boreal Plains, Lake Manitoba Plain, Boreal Shield (AB, SK, MB, and NW Ont), Montane Cordillera (AB)	136-156, 161-164	358, 371, 375-377, 379-381, 383, 386, 391, 573-766, 839-855, 998, 1016-1019
4 Dry Prairie	Dark Brown Soil Zone, Brown Soil Zone	157-160	767-838
5 West	Pacific Maritime, Montane Cordillera (BC)	184-214	940, 943, 944, 948, 950, 951, 955-960, 971-982, 984

Figure A1. The boundary between Dry Praire and Parkland is the Black-Dark Brown soil zone boundary. The east-central and east is the boundary is that between the Atlantic Maritime and Mixed Wood Plains ecozones. From McConkey 2006.

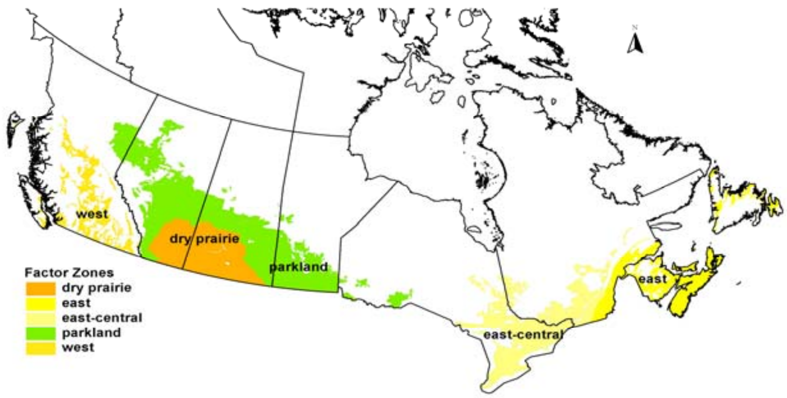


Table A2: 2001 Census data land area in No Till (NT), Reduced Till (RT), and Full Till (FT) in percent of total seeded plus summerfallowed land area.

	NT (%)	RT (%)	FT (%)
East	4.80	19.10	76.10
East-Central	20.72	20.81	58.46
Parkland	23.66	33.90	42.44
Dry Prairie	36.25	29.66	34.09
West	15.06	17.39	67.56

Table A3: Summary of raw coefficients associated with tillage change between No Till (NT), Reduced Till (RT) and Full Till (FT) management, (adapted from Haak, 2006.)

Region	Tillage Change	10 year CO2e (t CO2E / ha / yr)	N_2O (t CO2E / ha / yr)	Energy (t CO2E / ha / yr)
East	FT to NT	0.25		0.1649
	FT to RT	0.20		0.1186
	RT to NT	0.08		0.0463
	NT to FT	-0.25		-0.1649
	RT to FT	-0.20		-0.1186
	NT to RT	-0.08		-0.0463
East Central	FT to NT	0.41		0.1649
	FT to RT	0.16		0.1186
	RT to NT	0.26		0.0463
	NT to FT	-0.41		-0.1649
	RT to FT	-0.16		-0.1186
	NT to RT	-0.26		-0.0463
Parkland	FT to NT	0.59	0.045	0.1091
	FT to RT	0.22	0.045	0.0239
	RT to NT	0.31	0.000	0.0852
	NT to FT	-0.59	-0.045	-0.1091
	RT to FT	-0.22	-0.045	-0.0239
	NT to RT	-0.31	0.000	-0.0852
Dry Prairie	FT to NT	0.41	0.014	0.0589
	FT to RT	0.15	0.014	0.0250
	RT to NT	0.19	0.000	0.0339
	NT to FT	-0.41	-0.014	-0.0589
	RT to FT	-0.15	-0.014	-0.0250
	NT to RT	-0.19	0.000	-0.0339
West	FT to NT	0.20		0.1091
	FT to RT	0.03		0.0239
	RT to NT	0.16		0.0852
	NT to FT	-0.20		-0.1091
	RT to FT	-0.03		-0.0239
	NT to RT	-0.16		-0.0852

The following equations are used to adjust the above raw coefficients for tillage change with 2001 Census adoption rates (Table A2) for relevant regions:

Net NT coefficient = Raw Coeff(FT to NT)*(%Area in FT)/100%
+ Raw Coeff(RT to NT)*(%Area in RT)/100%]

Net RT coefficient = [Raw Coeff(FT to RT)*(%Area in FT)/100%
+ Raw Coeff(NT to RT)*(%Area in NT)/100%]

Table A4: Baseline adjusted emission factors for 2002 through 2012 (inclusive) for No Till (NT) and Reduced Till (RT) management.

Region	Practise	Baseline Adjusted Emission Factors		
		Sequestration of Carbon in Soil (t CO2E / ha / yr)	Nitrous Oxide Reduction (t CO2E / ha /yr)	Energy (t CO2E / ha / yr)
East	NT	0.21		0.134
	RT	0.15		0.088
East Central	NT	0.29		0.106
	RT	0.04		0.060
Parkland	NT	0.36	0.019	0.075
	RT	0.02	0.019	-0.010
Dry Prairie	NT	0.20	0.005	0.030
	RT	-0.02	0.005	-0.004
West	NT	0.17		0.089
	RT	0.00		0.003

Note: These values will remain constant for the 2002 to 2012 crediting period, as indicated by a verification for any of these years. **On a go-forward basis, per revised version being published, additional acres and years, these emission factors are to be used for quantification.**

APPENDIX B:

Relevant Assurance Factors

Development of Assurance Factors

The assurance factor accounts for the average risk of reversal across all farms within a given region. Prairie-based technical experts (6 contributing sources) were consulted to assess both the range of values and to explore the relationships across regions and across practises. Their mandate was to conservatively estimate the number of tillage reversal events for each of the regions and practise types. As such, there is an intended bias within the assurance factors as a means of managing the liability to the provincial government for reversals. Given the outcome, however, it was found that the range of values represents a reasonable balance of conservativeness and reasonableness, for the prairie region. For the East, West and East-Central soil zones, further expert consultation will need to occur. Further scientific analysis may serve to adjust the assurance factor over time as better data becomes available. This adjustment, coupled with improved practise and technological innovation would be anticipated to push the assurance factor higher over time.

Based on the feedback from the contributing technical experts, the range of data for the number of reversals anticipated over a 20 year tillage period is provided. Where the range was slim, a simplified analysis was facilitated. Where the range was broader, a review of the ranges was completed to assess whether outliers were robust. Based on this analysis, a chosen average number of reversals were selected. As the sequestration of carbon over time is linearized, reversals are assumed to be equivalent in magnitude. As such, the assurance factor could then be estimated using the following formula:

Assurance Factor = (1 - (# of Reversal Events / 20 year period)) * 100%

Table B1: Assurance factors by region and practise type*

Region	Factor	Reduced Till	No Till
East	Assurance Factor	85.0%	80.0%
	Chosen Number of Reversals	3	4
	Range of Values	Range: 2-4	Range: 1-6
East-Central	Assurance Factor	87.5%	85.0%
	Chosen Number of Reversals	2.5	3
	Range of Values	Range: 2-3	Range: 1-5
Parkland	Assurance Factor	87.5%	87.5%
	Chosen Number of Reversals	2.5	2.5
	Range of Values	Range: 2-3	Range: 1-4
Dry Prairie	Assurance Factor	90.0%	92.5%
	Chosen Number of Reversals	2	1.5
	Range of Values	0 - 3	1 - 2
West	Assurance Factor	87.5%	92.5%
	Chosen Number of Reversals	2.5	1.5
	Range of Values	2 - 3	1 - 2

Note – assurance factors for the West, East and East-Central require more expert review.

APPENDIX C:

Deriving Total Coefficients for a Region

Calculating Total Coefficients for a Region, using Tables A2 - A4, and B1.

Example Calculation for Deriving the Total Coefficient for a No Till in the Parkland Region

Step 1. Take the numbers in Table A2 and A3 and the Net Coefficient Equations indicated at the base of Table A3, to produce the Net Coefficients/Baseline Adjusted numbers as calculated for Table A4.

SOC Net NT Coefficient = [Raw Coeff(FT to NT)*(%Area in FT)/100%+ Raw Coeff(RT to NT)*(%Area in RT)/100%]

= [(0.59*42.44/100) + (0.31*33.90/100)] (Table A3 and A2)
= 0.25 + 0.10
= 0.36 tonnes of C02e/ha (Table A4 result)

N20 Net NT Coeff. = [Raw Coeff(FT to NT)*(%Area in FT)/100%+ Raw Coeff(RT to NT)*(%Area in RT)/100%]

= [(0.045*42.44/100) + (0.000*33.90/100)]
= 0.019 + 0.000
= 0.019 tonnes of C02e/ha (Table A4 result)

Energy Net NT Coeff = [Raw Coeff(FT to NT)*(%Area in FT)/100%+ Raw Coeff(RT to NT)*(%Area in RT)/100%]

= [(0.1091*42.44/100) + (0.0852*33.09/100)]
= 0.046 + 0.029
= 0.075 tonnes of CO2e/ha (Table A4 result)

Step 2. Apply the Assurance Factor to SOC only and add N20 and Energy Coefficients to derive the Total Coefficient

Total Coefficient = (Net SOC Coefficient * Assurance factor) + (Net N20 Coefficient) + (Net Energy Coefficient)
= (0.36*0.875) + (0.019) + (0.075)
= **0.41 tonnes of CO2e/ha for Parkland Region under No Till.**

APPENDIX D:

References

This protocol is largely based on the historical document called *Tillage System Default Coefficient Technical Background Document* (TBD) dated October 2006. The TBD work was completed by the Soil Management Technical Working Group, listed within the document. Dennis Haak, Sr. Soil Resource Specialist, Agriculture and Agri-Food Canada was the principal author of the work. This work represents the culmination of a number of multi-stakeholder consultation processes and reliance on a number of guidance documents. This document represents an abridged and re-formatted version of this work. Therefore, TBD remains the source of additional detail on any of the technical elements of the protocol. While not a complete listing of references, Tables A1, A2, A3 are adapted from the following sources:

McConkey, B.G. 2006. Carbon Change Estimation Method Used for Agricultural Practice Changes in Canadian Greenhouse-Gas Inventory. National Carbon and Greenhouse Gas Accounting and Verification System (NCGAVS) Report.

Nagy, C.N. 1999. Energy Coefficients for Agriculture Inputs in Western Canada. Canadian Agricultural Energy End-Use Data Analysis Centre (CAEEDAC) Report.

Rochette, P. and D. Worth. 2005. Inventory of N_2O Emission from Canadian Agricultural Soils at the EcoDistrict Scale Using an IPCC Tier II Methodology. National Carbon and Greenhouse Gas Accounting and Verification System (NCGAVS) Report.