TECHNICAL PROTOCOL PLAN FOR NITROUS OXIDE EMISSIONS REDUCTIONS

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PART B Technical Protocol Plan

A.1 Description of the Project Type and How Real Reductions Will be Achieved

Introduction

The use of nitrogen fertilizers has been recognized as a source of greenhouse gas emissions by the Intergovernmental Panel on Climate Change (IPCC)[1] and domestically by Environment Canada (EC) in the Canadian National GHG Inventory. The National Inventory reports GHG emissions from fertilizers in Section 6.4.1 under "Direct Emissions of N_2O from Soils". In 2007, GHG emissions under this category (including synthetic and manure nitrogen fertilizer application) totalled 9.40 Mt CO_2.[2]

Canada has developed a country-specific, Tier 2-type methodology to estimate N_2O emissions from synthetic nitrogen fertilizer application on agricultural soils, which takes into account local climate and topographic conditions. Emissions of N_2O are estimated by ecodistrict, by province, and for the country as a whole. Since 2003, fertilizer nitrogen data have been obtained from the Canadian Fertilizer Institute. All synthetic nitrogen fertilizers sold by retailers are assumed to be applied for crop production in Canada.

This technical protocol plan and the proposed protocol are focused on efficiency improvements in nitrogen fertilizer use including the rate, time, and place of nitrogen fertilizer use and the quantification of associated GHG emissions.

Overview of GHG Reduction Activity

In the environment, fertilizer-derived nitrogen is subject to emissions such as N_2O from nitrification or denitrification, and can accelerate decomposition of soil organic carbon. Based on a literature review completed by the International Plant Nutrition Institute (IPNI) the management of fertilizer application can result in a reduction of N_2O emissions. Management is not only defined by decreasing fertilizer use, as simply decreasing the rate of application on cropped land can decrease crop growth, resulting in a decrease of the rate of carbon assimilation, thus resulting in lower harvest yields and carbon stored per unit of cropped land. As such, a best management practice implemented to reduce the quantity of nitrogen fertilizer required must also optimize crop response per unit of added nitrogen and minimize the opportunity for mineral nitrogen to

[1] Smith, P., D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko, 2007: Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[2] National Inventory Report, 1990-2006: Greenhouse Gas Sources and Sinks in Canada (Environment Canada, May 2008)

accumulate in the soil[3]. The foundation of good fertilizer stewardship rests on the principles of using the right source, at the right rate, at the right time, and with the right placement.[4]

The scope of the proposed protocol is limited to on-farm sources, sinks, and reservoirs (SSRs) thereby excluding SSRs which are affected by the manufacture and distribution of nitrogen fertilizers. The exclusion of off-site reductions facilitates a more conservative measure and limits the scope of quantification to SSRs which are functionally equivalent and for which data is readily available, thereby increasing the integrity of the emissions reduction calculation.

It should be noted that there is potential for stacking the proposed protocol with other agriculture related activities (ie tillage management, summer fallow, etc.) as some facilities may be implementing multiple project activities concurrently.

Alberta Offset System Eligibility Criteria

In order for a GHG emission reduction activity to create eligible offsets in the Alberta Offset System, a number of eligibility criteria must be met under the Specified Gas Emitters Regulation (SGER), as specified in the February 2008 Offset Credit Project Guidance Document. A summary of how the proposed protocol will address each of the relevant eligibility criteria is given in Table 1, below.

Table 1: Alberta Offset System Eligibility Criteria

Principle	Analysis
Start Date	The proposed protocol is applicable to projects initiated after January 1, 2002 that have implemented BMPs which result in a reduction of the quantity of nitrogen fertilizer applied to soils annually.
Crediting Period	Projects applying this protocol will have a credit duration period of 8 years, consistent with Alberta Offset System guidelines.
Real	The implementation of best management practices pertaining to fertilizer stewardship are specific and tangible actions to reduce net GHG emissions associated with fertilizer use in agricultural activities. It must be proven that project activities are not considered to be business as usual prior to quantifying emission reductions.
Demonstrable, Quantifiable	GHG reductions from the application of fertilizer stewardship measures can be quantified following scientifically acceptable methods based on an expert evaluation of the environmental benefits of best practices and a verification of practices which are implemented. The quantification

[3] Snyder, C.S., T.W. Bruulsema, and T.L. Jensen. 2007. *Greenhouse gas emissions from cropping systems and the influence of fertilizer management—a literature review.* International Plant Nutrition Institute, Norcross, Georgia, U.S.A.

[4] Roberts, T.L. 2007. Right product, right rate, right time and right place...the foundation of best management practices for fertilizer. pp 29-32. *In* Fertilizer Best Management Practices:General Principles, Strategy for their Adoption, and Voluntary Initiatives vs Regulations. IFA International Workshop on Fertilizer Best Management Practices. 7-9 March 2007.

	approaches discussed in this document and the proposed protocol are derived from consensus-based good practice guidance documents.
Not Required by Law	Under current Alberta legislation, there are no requirements or performance standards mandating the implementation of a management practice to limit nitrogen fertilizer application.
Ownership	For consistency with other Alberta Offset System protocols, the proposed protocol does not explicitly assign ownership but instead states the minimum data collection requirements in order to adequately quantify the net GHG benefit from the project activity. It is therefore up to each project proponent to provide proof of ownership of all offsets claimed at the time of third-party verification or upon request by Alberta Environment.
Counted Once	The proposed protocol is not applicable to facilities defined as large final emitters (LFEs) under the Specified Gas Emitters Regulation (SGER). Provided that this criterion is followed, the creation of offsets using the proposed protocol would result in GHG reductions that had not already been counted for compliance purposes.
Verifiable	The data should be of sufficient quality to fulfill quantification requirements and be substantiated by company records for the purpose of verification. The primary data would be type and quantity of fertilizer applied to land. Therefore, the proposed approach would be for the project proponent to conduct regular monitoring of the rate of fertilizer application, including the type of fertilizer, time and location of application.
Occurred in Alberta	Only projects located in Alberta are eligible for offsets. The proposed protocol applies to projects located in Alberta that implement a 4R Nitrogen Stewardship Plan.

A.2 Description of Background Information / Best Practice Guidance Used

During the development of the proposed protocol, background information on the environmental benefits of fertilizer management was primarily drawn from the Canadian Fertilizers Institutes 4-R principles and the International Plant Nutrition Institute's Literature Review pertaining to Greenhouse Gas Emissions from Cropping Systems and the Influence of Fertilizer Management. The information collected from these reports, and other guidance documents, provided the foundation to identify relevant sources and sinks of GHG emissions, to identify potential project and baseline scenarios, to develop the GHG quantification approaches for relevant sources and sinks, and to account for relevant policies. A list of the guidance documents used is provided in Table 2, below.

Table 2: Good Practice Guidance Documents

1. Document Title	2. Publishing Body / Date	3. Description
General Protocol Guidance		
ISO 14064-2: 2006: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements	International Standards Organization, 2006	ISO 14064-2:2006 specifies principles and requirements and provides guidance at the project level for quantification, monitoring and reporting of activities intended to cause greenhouse gas (GHG) emission reductions or removal enhancements. It includes requirements for planning a GHG project, identifying and selecting GHG sources, sinks and reservoirs relevant to the project and baseline scenarios, monitoring, quantifying, documenting and reporting GHG project performance, and managing data quality.
National Inventory Report, 1990-2005: Greenhouse Gas Sources and Sinks in Canada	Environment Canada, April 2007	On behalf of the Government of Canada, Environment Canada develops and publishes Canada's GHG inventory annually. The inventory reporting format is based on international reporting methods agreed to by the Parties to the UNFCCC, using the procedures of the Intergovernmental Panel on Climate Change (IPCC).
Alberta Offset System Offset Credit Project Guidance Document	Alberta Environment, February 2008	This Offset Credit Project Guidance Document is one of a series of guidance documents prepared for the Specified Gas Emitters Regulatory Framework. The purpose of this Guide is to outline the process and requirements for undertaking offset projects in Alberta.
Technical Resources		
Greenhouse Gas Emissions from Cropping Systems and the Influence of Fertilizer Management	Snyder, C.S., T.W. Bruulsema, and T.L. Jensen. 2007. Greenhouse gas emissions from cropping systems and the influence of fertilizer management—a literature review. International Plant Nutrition Institute, Norcross, Georgia, U.S.A.	This paper was written to review the available science and to extend information that will lead to a better understanding of fertilizer N and best management practices, to minimize impacts on the global warming potential.
Technical Background Document for Nitrogen Fertilizer Use Efficiency Protocol	Climate Check	This Technical Background Document (TBD) is a compilation of the science relevant to the quantification of emissions associated with the baseline scenario, and of the emissions associated with the specified scope of the fertilizer management practices.

1. Document Title	2. Publishing Body / Date	3. Description
Decision Paper Results for Nitrous Oxide Emissions Reduction Protocol	Climate Check	As a follow up to the release of the above TBD, experts and stakeholders were engaged to evaluate the document. The Decision Paper presents the background, context and decisions related to the approach to quantifying emissions reductions associated with the NER protocol.

A.3 Regulatory, Legal Requirements and/or Government Incentive/Grant Programs

Relevant Climate Change Regulations

In Alberta, the Specified Gas Emitters Regulation applies to facilities with GHG emissions of greater than 100,000 tonnes CO_2e per year, which are referred to as large final emitters (LFEs). All facilities exceeding this threshold are required to reduce GHG emissions by 12% on an intensity basis beginning July 1, 2007. Because of these requirements, any facility classified as an LFEs is not eligible for offset generation, as any GHG emission reduction activity that occurs within the boundary of an LFE site will be subject to the SGER. As this protocol is targeted at the farm-level for the agricultural sector no regulations are applicable.

In April 2007, the federal government of Canada released the Regulatory Framework for Air Emissions, which outlined the broad design for regulations of industrial emissions of air pollutants and greenhouse gases. In March 2008, the federal government then provided further details on the proposed regulation of GHGs through the “Turning the Corner” document titled “Regulatory Framework for Industrial Greenhouse Gas Emissions.” This framework provided more detailed sector specific regulations for large emitting facilities and included mention of the planned use of a sector-wide approach that would require an 18% reduction based on 2006 intensity levels for many industries. Although indications have been made that the proposed framework will likely transition to a cap-and-trade system, the exact details of the revised approach have yet to be released. Based on previous announcements, no emissions reduction targets have been identified for the agriculture industry.

Potentially relevant climate change incentives

There were no incentives or subsidies identified for the agriculture industry related to fertilizer management.

A.4 Barriers to Implementation

Barriers to implementation include the following:

1. **Availability of Certified Crop Advisors:**

Participants of the Nitrous Oxide Emissions Reductions Consultation Workshop agreed that a qualified professional should be involved in designing and implementing Best Management Practices. This would ease the verification process and verifiers would rely on the assurance of soil/crop professionals rather than examining each individual plan. The training and availability of these Certified Crop Advisors may present a barrier to potential project development.

A.5 Review of Technology / Scientific Knowledge

Canada's fertilizer industry has a vested interest in managing products to protect the environment and has developed an approach to nutrient management which provides farmers with a variety of science-based best management practices (BMPs) to ensure the **right source** of fertilizer is applied at the **right rate**, **right time** and **right place**.

BMPs are designed to ensure crops get the nutrients they need while minimizing nutrient losses to the environment. The fertilizer industry works with government, university, and private sector researchers to develop these BMPs.

Table 3: Examples of Best Management Practices:

Practice:	Examples:
Right Source: *Using the right product to meet crop needs*	• Ammonium-based formulations • Slow/controlled release fertilizers • Inhibitors • Stabilized nitrogen
Right Rate: *Matching the right amount of fertilizer to crop needs*	• Soil Testing • Yield Goal Analysis • Crop Removal Balance • Nutrient Management Planning • Plant Tissue Analysis • Applicator Calibration • Crop Scouting • Record Keeping • Variable Rate Technology
Right Time: *Making nutrients available when crops need them*	• Application Timing • Controlled Release Technologies • Inhibitors • Fertilizer Product Choice
Right Place: *Keep nutrients where crops can use them*	• Application Method • Incorporation of Fertilizer • Buffer Strips • Conservation Tillage • Cover Cropping • On-Farm Fertilizer Storage

A.6 Review of Existing Projects

Referencing the Canadian Fertilizer Institute, every farm and field is different, as such farmers should select management practices which are best suited to regional and farm-specific conditions. Factors that may influence the selection of practices include soil conditions, climate, topography and crops grown. With the help of industry experts such as Certified Crop Advisers (CCAs), farmers can assess soil and environmental conditions on their individual farms and develop a customized nutrient management plan that incorporates the most appropriate management practices.

Since management practices are specific to individual farming operations, the exact methods applied at Alberta farming facilities will vary. Referencing Statistics Canada's 2001 Farm Environmental Management Survey, a significant proportion (30%) of Alberta farms do not perform annual soil nutrient testing at all, with 44% of farms performing the test on a periodic basis (every 2 to 5+ years). Also, according to the same survey, only 11% of Alberta's farms had developed and implemented nutrient management plans[5].

A.7 Summary of Quantification Approaches

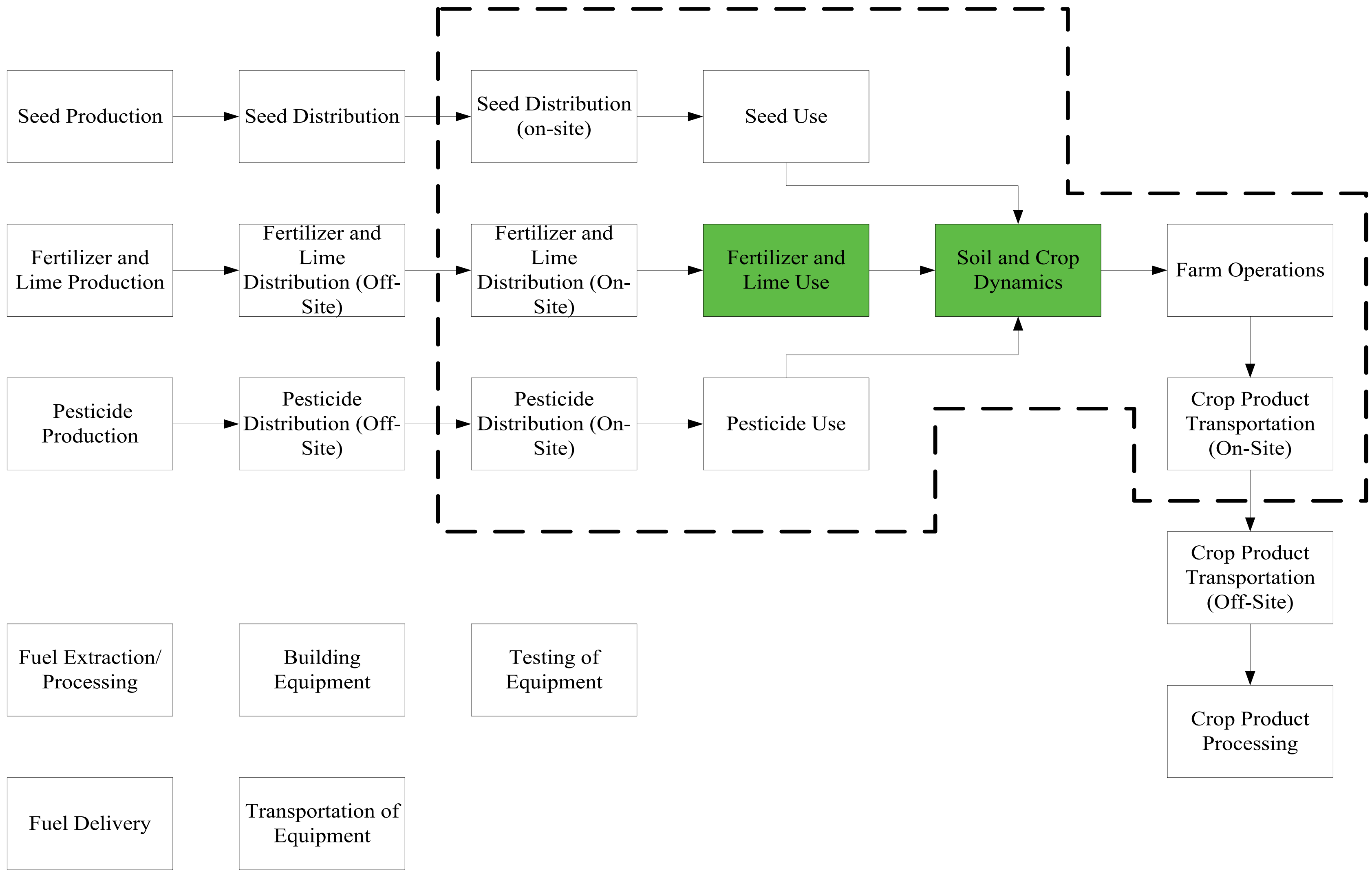
Identification of Sources and Sinks of GHG Emissions

In order to develop quantification approaches around the Nitrous Oxide emissions avoided by applying various management practices, it was necessary to examine a typical crop planting lifecycle processes flow diagram to identify all potential sources of GHG emissions and reductions. The identification of sources and sinks was completed using the best practice guidance documents listed in Table B.1 and by examining typical project configurations in Alberta. This life cycle analysis was done following the ISO-14064-2 standard where the different sources and sinks (SSs) of GHG emissions were classified as upstream, on-site, downstream, controlled, related and affected.

Figure 1, below, summarizes the different SSs identified for typical Canadian farms. Those SSRs identified for inclusion in the quantification of GHG reductions are identified in green.

[5] Statistics Canada - http://www.statcan.gc.ca/pub/21-021-m/2004002/t/4144642-eng.htm

Figure 1: Recommended Process Flow Diagram



Determination of Material Sources and Sinks of GHG Emissions

Following the lifecycle analysis that facilitated the identification of relevant sources and sinks of GHG emissions, a preliminary analysis of these SSs was performed to identify the most material sources of GHG emissions in the project and baseline conditions. These material SSs were then the focal point for the development of quantification approaches. The evaluation of these SSs was completed based on a review of the best practice guidance documents discussed in Table 3, below. These technical seed documents (TSDs) formed the basis of the scientific consensus behind the quantification of GHG emissions.

The Alberta Quantification Protocol for Tillage Systems Management (2007) was referenced in order to define the process flow for farm operations in Alberta.

Selection of a Quantification Approach

The most recent Canadian National Inventory Report was referenced in order to establish the best approach to quantifying N_2O emissions and removals (based on guidance pertaining to the effects of no-till/reduced-till activities.) As a result of the integrated consequences of decreased tillage intensity for "decomposition of soil organic matter, soil carbon and nitrogen availability, soil bulk density, and water content", the NIR uses a 'modifier', F_{TILL}, to calculate the N_2O emissions or removals associated with the practice of NT or RT, N_2O_{TILL}.

In a similar manner, the proposed protocol applies modifiers to calculate the N_2O emission reductions achieved with the implementation of the comprehensive 4-R stewardship plan and associated BMPs.

A.8 Assessment of Baseline Scenarios

An assessment of potential baseline scenarios was conducted based on the recommended methodology from best practice guidance in the Alberta Offset Credit Project Guidance Document and using the Alberta Tillage Systems Management Approved Protocol (February 2009). Potential baseline options were assessed based on their capacity to quantify the baseline fertilizer stewardship activities in a practical manner using available data. Each baseline scenario also contemplated the selection of a static or dynamic approach. Table 4, below, provides a summary of the different baselines considered.

Table 4: Assessment of Possible Baseline Scenarios

1. Baseline Options	2. Description	3. Static/ Dynamic	4. Accept or Reject and Justify
1.Historic Benchmark	Assessment of the baseline GHG emissions based on three years of site-specific data from farm operations prior to the installation of a 4-R Nitrogen Stewardship Plan.	Static	**Accept.** Accurate, historical data of crop management practices and nitrogen use is available for most farms for an appropriate operating period. Historical data best represents the conditions that would have taken place on a specific farm in the absence of the farm implementing a 4-R Nitrogen Stewardship Plan .
2.Performance Standard	Assessment of the GHG emissions from a typical farm. This approach would likely require an industry-wide characterization of fertilizer based GHG emissions per acre of cropland for specific crops.	Dynamic or Static	**Accept**. This approach will be acceptable for a flexibility mechanism within the protocol in cases where the Project Developer does not have the three years of historic data. Additional information on using the flexibility mechanism will be contained within an appendix, including developed values (by AAFC researchers) based on the average nitrous oxide emissions from fertilizer activities associated specific crops throughout the growing season. These developed values ensure conservativeness and minimizes errors on the Project Developers trying to determine factors on their own.
3.Comparison-based	Assessment of the baseline GHG emissions based on the performance of the project site as compared to a control group.	Dynamic	**Reject.** The fertilizer requirements of individual farms will vary significantly depending on the farm's characteristics and types of crops being grown. Further, this approach would create unnecessary monitoring and measurement burdens for the project developer without increasing the accuracy of the emission reduction claim.
4. Projection -Based	Assessment of the baseline GHG emissions from the farm site using a model to predict the baseline nitrous oxide emissions per unit of crop produced based on site specific temperatures.	Dynamic	**Reject.** Although a number of pertinent simulation models are available, obtaining the data required to initialize and to drive these models remains a challenging deficiency.

1. Baseline Options	2. Description	3. Static/ Dynamic	4. Accept or Reject and Justify
5.Adjusted Baseline	Assessment of the baseline GHG emissions using site specific data and adjusting for existing nitrous oxide emission reductions occurring due to common industry practices. This approach could be used in conjunction with a performance standard if nitrogen management plans were the normal industry practice	Static or Dynamic.	**Reject.** There is too much variability among fertilizer application practices to generalize the business as usual GHG emission reductions that might be occurring across Canada. The types of fertilizer used, the types of soils which are being farmed, the crops which are being grown and the types of crop rotations used are far to variable to develop an accurate adjusted baseline.

A.9 Selection of Baseline Scenario

The baseline scenario represents the GHG emissions (N_2O) resulting from biological and abilogical processes affecting agricultural soils (ie: nitrification, denitification, nitrate reduction etc.)

The baseline condition is considered as a historic benchmark, as the emissions reductions are site specific and are calculated taking into account average emissions of three previous years, where the application of BMPs result in a reduction of N_2O emissions in the project condition. As such, the baseline scenario represents the practices in place on each farm before the implementation of BMPs.

The method for quantifying N_2O emissions is developed referencing the Canadian National Inventory Report, section A.3.4.5. Applying the factors and formulae relevant to specific geographic locations and specific practices will provide a calculation of the N_2O emissions in the baseline year. The emissions are corrected for predominant soil types, regional topography, and climatic conditions.

A.10 Definition of the Project Condition

As indicated earlier, the baseline scenario represents the practices in place on each farm before the implementation of a N Stewardship Plan and associated BMPs. Emissions reductions are achieved through the implementation of farm specific practices, where a specific source of fertilizer is applied to land at the right rate, place, and time.

As defined through stakeholder and expert consultation, the exact BMPs to be addressed by the Alberta Offset System Quantification Protocol for Nitrous Oxide Emissions Reductions are as follows:

Table 5: Project Condition Scenarios

	Right Source	**Right Rate**	**Right Time**	**Right Place**
Basic	• Ammonium-based formulation;	• Apply nitrogen according to recommendation of 4-R N stewardship plan, using annual soil testing and/or N balance to determine application rate.	• Apply in spring; or • Split apply; or • Apply after soil cools in fall	Apply in bands / inject directly
Intermediate	• Ammonium-based formulation; and • Use slow / controlled release fertilizers; or • Inhibitors; or • Stabilized nitrogen.	• Apply nitrogen according to qualitative estimates of field variability (landscape position, soil variability)	• Apply fertilizer in spring; or • Split apply; or • Apply after soil cools in fall if using slow / controlled release fertilizer or inhibitors / stabilized nitrogen	Apply in bands / inject directly

Advanced	• Formula must be Ammonium-based formulation; and • Use slow / controlled release fertilizers; or • Inhibitors; or • Stabilized nitrogen.	• Apply nitrogen according to quantified field variability (e.g. digitized soil maps, grid sampling, satellite imagery, real time crop sensors.) and complimented by in season crop monitoring	• Apply fertilizer in spring; or • Split apply; or • Apply after soil cools in fall if using slow / controlled release fertilizer or inhibitors / stabilized nitrogen	Apply in bands / inject directly

A.11 Functional Equivalence

The project and the baseline should provide the same function and quality of products or services. This type of comparison requires a common metric or unit of measurement for comparison between the project and baseline activities.

In the proposed protocol functional equivalence is established as the scope of the quantification is limited to on-farm SSRs. That is, the estimated GHG reductions associated with BMPs can be related directly to indices of nitrogen use efficiency calculated on a per unit crop yield (mass/unit area/per year).

A.12 Flexibility Mechanisms

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

1. A project proponent may choose to select non-consecutive years to set the baseline to match with data availability and to account for any extra-ordinary growing seasons. However, any gaps between baseline seasons or gaps between the baseline period and project implementation period must be justified such that they are not contributing to an over-estimate of GHG emission reductions. The verifier must provide a written statement of agreement with the approach selected by the Project Proponent; and
2. 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 lower overall greenhouse gas emission reductions.
3. A project proponent which does not have the required three years of historical data for the baseline may choose to use a standardized baseline approach in order to qualify for use of this protocol.

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