



CLIMATE
ACTION
RESERVE

Nitrogen Management Project Protocol

Reducing Nitrous Oxide Emissions through
Improved Nitrogen Management in Crop Production

Version 1.0 for Board Approval

June 22, 2012

Acknowledgements

Staff

Teresa Lang
Derik Broekhoff
Kathryn Goldman
Rachel Tornek
Max DuBuisson
Heather Raven
Mark Havel
Robert Youngs
Syd Partridge

Workgroup

Wiley Barbour	Camco
Simon Bird	Wildlife Works Carbon
Sara Brodnax	<i>Formerly</i> The Clark Group, LLC / Agricultural Carbon Market Working Group
Adam Chambers	United States Department of Agriculture, Natural Resources Conservation Service
Hank Giclas	Western Growers Association
Dana Gunders	Natural Resources Defense Council
Noel Gurwick	Union of Concerned Scientists
Bruce Love	Preferred Carbon Group
Neville Millar	Michigan State University
Belinda Morris	<i>Formerly</i> Environmental Defense Fund
Meredith Niles	University of California, Davis
Adam Penque	Scotia Capital, Inc.
Todd Rosenstock	University of California, Davis, Agricultural Sustainability Institute
Richard Scharf	Environmental Services, Inc.
Paul Sousa	Western United Dairyman
Michael Wara	Stanford Law School
Roger Williams	Blue Source
Thomas Wirth	United States Environmental Protection Agency
Christina Tonitto	Ph.D. Ecosystem Modeling

Technical Support

Stephen De Gryze	Terra Global Capital
Charlotte Decock	University of California, Davis
Johan Six	University of California, Davis
William Salas	Applied Geosolutions
John Kimble	Soils Scientist Consultant (<i>Formerly</i> Research Soil Scientist, United States Department of Agriculture, Natural Resources Conservation Service)

Science Advisory Committee

Steven Del Grosso	United States Department of Agriculture ARS, Colorado/ Natural Resource Ecology Laboratory
Ray Desjardins	Agriculture and Agri-Food Canada
Peter Groffman	Cary Institute of Ecosystem Studies
Ardell Halvorson	United States Department of Agriculture ARS, Colorado
William Horwath	University of California, Davis
Tim Parkin	United States Department of Agriculture ARS, Iowa
Phil Robertson	Michigan State University
Cliff Snyder	International Plant Nutrition Institute
Rod Venterea	United States Department of Agriculture ARS/ University of Minnesota
Reynald Lemke	Agriculture and Agri-Food Canada

A special thanks to Alison Eagle and Lydia Olander of the Technical Working Group on Agricultural Greenhouse Gases (T-AGG), who helped to convene the SAC and facilitate SAC discussions, as well as provided invaluable feedback.

Credit Stacking Sub-Committee

Nicholas Bianco	World Resources Institute
Simon Bird	Wildlife Works Carbon
Bobby Cochran	Willamette Partnership
David Cooley	Duke University Carbon Offsets Initiative
Jessica Fox	Electric Power Research Institute
Belinda Morris	<i>Formerly</i> Environmental Defense Fund
Meredith Niles	University of California, Davis
Lydia Olander	Nicholas Institute for Environmental Policy Solutions / T-AGG
Michael Wara	Stanford Law School

Aggregation Sub-Committee

Ryan Anderson	Delta Institute
Wiley Barbour	Camco
David Miller	Iowa Farm Bureau Federation
Peter Weisberg	The Climate Trust
Roger Williams	Blue Source

Table of Contents

Abbreviations and Acronyms	1
1 Introduction	2
2 The GHG Reduction Project	3
2.1 Background	3
2.1.1 Nitrogen Management Practices Considered for this Protocol	4
2.2 Project Definition	6
2.2.1 Defining Field Boundaries	6
2.2.2 Defining the Cultivation Cycle	7
2.2.3 Implementation of Enabling Practices	7
2.3 Project Developer	8
2.4 Project Aggregates	9
2.4.1 Field Size Limits	9
2.4.2 Entering an Aggregate	9
2.4.3 Leaving an Aggregate	10
2.4.4 Changes in Land Ownership, Management or Tenant Occupancy	10
3 Eligibility Rules	12
3.1 Location and Crop System	12
3.2 Start Date	13
3.3 Crediting Period	13
3.4 Other Criteria	14
3.5 Additionality	15
3.5.1 The Performance Standard Test	15
3.5.2 The Legal Requirement Test	18
3.5.3 Ecosystem Services Payment Stacking	20
3.6 Regulatory Compliance	23
4 The GHG Assessment Boundary	24
5 Quantifying GHG Emission Reductions	30
5.1 Applicability Conditions for N Rate Reduction Projects	32
5.2 Determining Baseline and Project N Rates	33
5.2.1 Determining the Baseline N Rate	34
5.2.2 Determining the Project N Rate	34
5.2.3 Determining N Content of Fertilizer Application	34
5.3 Determining Primary Effect N ₂ O Emission Reductions	39
5.3.1 Baseline and Project Direct N ₂ O Emissions from Soils (SSR 1)	39
5.3.2 Baseline and Project N ₂ O Emissions from Leaching, Volatilization, and Runoff (SSR 2)	41
5.3.3 Primary Effect Baseline and Project N ₂ O Emissions	43
5.3.4 Adjusting Primary Effect GHG Reductions for Uncertainty	44
5.4 Determining Secondary Effect GHG Emissions	46
5.4.1 GHG Emissions from Cultivation Equipment (SSR 3)	47
GHG Emissions from	50
5.4.2 Shifting Crop Production Outside Project Boundaries (Leakage) (SSR 7)	52
6 Project Monitoring	55
6.1 Single-Field Project Monitoring Plan	55
6.2 Monitoring Plans for Aggregates and Participating Fields	55
6.2.1 Aggregate Monitoring Plan	56
6.2.2 Field Monitoring Plan for Project Participants in an Aggregate	56
6.3 Mandatory Field Data Monitoring Requirements	57

6.3.1	General Field Tracking Data	57
6.3.2	Field Management Data	57
6.3.3	Project Activity Data and Documentation	57
6.3.4	Field Monitoring Parameters	60
6.4	Supplemental Field Data Monitoring	65
7	Reporting and Record Keeping	66
7.1	Project Submittal Documentation	66
7.1.1	Determining Field Serial Numbers	67
7.2	Annual Reports and Documentation.....	67
7.2.1	Single-Field Report (Single-Field Projects Only).....	68
7.2.2	Aggregate Report	68
7.2.3	Field Report.....	69
7.3	Record Keeping.....	69
7.3.1	Record Keeping for Single-Field Projects	70
7.3.2	Record Keeping for Aggregate Projects	71
7.3.3	Supplemental Record Keeping.....	72
7.4	Reporting Period and Verification Cycle.....	72
7.4.1	Additional Reporting and Verification Options for Single-Field Projects.....	73
8	Verification Guidance.....	75
8.1	Preparing for Verification	75
8.2	Verification Schedule for Single-Field Projects.....	76
8.2.1	Option 1: Twelve-Month Maximum Verification Period.....	77
8.2.2	Option 2: Twelve-Month Verification Period with Desktop Verification.....	77
8.2.3	Option 3: Twenty-Four Month Maximum Verification Period	77
8.3	Verification Sampling and Schedule for Aggregates	77
8.3.1	Informing Site Visit Sampling with Corn Stalk Nitrate Test Results.....	79
8.3.2	Verification Schedule for Small Aggregates	80
8.3.3	Verification Schedule for Large Single-Participant Aggregates.....	80
8.3.4	Verification Schedule for Large Multi-Participant Aggregates	81
8.4	Standard of Verification	82
8.5	Monitoring Plan.....	82
8.5.1	Annual Reports.....	83
8.6	Verifying Eligibility at the Field Level	83
8.7	Core Verification Activities	84
8.8	Project Type Verification Items	85
8.8.1	Project Eligibility and CRT Issuance	86
8.8.2	Quantification	87
8.8.3	Risk Assessment.....	87
8.9	Successful and Unsuccessful Verifications	88
8.9.1	Field-Level and Project Participant-Level Errors	88
8.9.2	Aggregate-Level Errors	89
8.10	Completing Verification.....	89
9	Glossary of Terms	90
10	References.....	93
Appendix A	Summary of Performance Standard Development	95
Appendix B	Science Advisory Committee Process and Recommendations for Nitrogen Management Practices	134
Appendix C	Overview of Water Quality Regulations: Impacts on Legal Requirements and Regulatory Compliance.....	142
Appendix D	Minimum Standard for Data for Consideration in Quantification Methodology Development.....	150

List of Tables

Table 2.1. Priority List of Nitrogen Management Practices	5
Table 2.2. Definitions for Approved Project Activities	6
Table 2.3. Maximum Field Size as a Percent of Aggregate Acreage	9
Table 3.1. Eligible Practice: State-Crop Combinations	12
Table 4.1. Description of all Sources, Sinks, and Reservoirs	25
Table 6.1. Field Monitoring Parameters	61
Table 8.1. Summary of Eligibility Criteria for a Nitrogen Management Project	84
Table 8.2. Eligibility Verification Items	86
Table 8.3. Quantification Verification Items	87
Table 8.4. Risk Assessment Verification Items	87
Table A.1. Priority List of Practices and Data Availability	96
Table A.2. Default Values for Average Fertilizer N Concentration and Fertilizer Weights	102
Table A.3. Actual and Recommended N Rates for Corn in Selected States in the North Central Region	104
Table A.4. Factors Influencing Farmers' N Rate Decision	105
Table A.6. Summary of State N Rate Trends Over Time based on USDA-ARMS data	112
Table A.7. State N Rate and RTA Data for Corn in the North Central Region Based on USDA-ARMS Data and Yield Data from USDA-NASS	113
Table A.12. Trends in Penetration Rate of those Not Applying N in Fall Over Time	124
Table A.13. Trends in Penetration Rate of Use of N Inhibitors Over Time	127

List of Figures

Figure A.2. RTA for Corn Following Corn in the North Central Region, based on USDA-ARMS data	113
Figure A.3. Penetration Rate of those Not Applying N in Fall for Corn	124
Figure A.4. Penetration Rate of Use of N Inhibitors for Corn	126

List of Equations

Equation 3.1. Annual RTA	16
Equation 5.1. GHG Emission Reductions	32
Equation 5.2. Total Fertilizer N Rate for Field f	35
Equation 5.3. Synthetic Fertilizer N Rate for Field f	35
Equation 5.4. Organic Fertilizer N Rate for Field f	35
Equation 5.9. Direct Baseline N ₂ O Emissions from Soils for Field f	40
Equation 5.10. Direct Project N ₂ O Emissions from Soils for Field f	41
Equation 5.12. Project N ₂ O Emissions from LVRO for Field f ⁵⁶	43
Equation 5.13. Primary Effect Baseline and Project GHG Emissions	43
Equation 5.14. Total Primary Effect GHG Reductions for the Project	44
Equation 5.15. Structural Uncertainty Deduction	45
Equation 5.16. Total Secondary Effect Emissions from Project Activity for the Project Aggregate	47
Equation 5.17. Increased Emissions from Cultivation Equipment (Approach 1)	49

Equation 5.18. Increased Emissions from Cultivation Equipment (Approach 2).....	50
Equation 5.19. Normalized Yield for Each Year t	53
Equation 5.20. Increased Emissions Outside the Project Boundary.....	54

Abbreviations and Acronyms

BMP	Best management practices
CO ₂	Carbon dioxide
CO ₂ e	Carbon dioxide equivalent
CH ₄	Methane
CRT	Climate Reserve Tonne
CWA	Clean Water Act
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
GHG	Greenhouse gas
MT	Metric ton (or tonne)
N ₂ O	Nitrous oxide
N	Nitrogen
NCR	North Central Region of the United States
NH ₃	Ammonia
NH ₄ ⁺	Ammonium
NMP	Nutrient or Nitrogen Management Plan
NO ₃ ⁻	Nitrate
NO _x	Nitrogen oxides
NRCS	Natural Resource Conservation Service of the USDA
NPS	Non-point source
NUE	Nitrogen use efficiency
Reserve	Climate Action Reserve
RTA	Ratio of removed to applied nitrogen
SSR	Source, sink, and reservoir
USDA	United States Department of Agriculture

1 Introduction

The Climate Action Reserve (Reserve) Nitrogen Management Project Protocol (NMPP) provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with improvements in nitrogen use efficiency (NUE) in crop production. The NMPP is intended to be a modular protocol, which will expand to include additional activities that improve NUE, as more data becomes available.

The Reserve is a national offsets program working to ensure integrity, transparency, and financial value in the U.S. carbon market. It does this by establishing regulatory-quality standards for the development, quantification, and verification of GHG emission reduction projects in North America; issuing carbon offset credits known as Climate Reserve Tonnes (CRT) generated from such projects; and tracking the transaction of credits over time in a transparent, publicly-accessible system. Adherence to the Reserve's high standards ensures that emission reductions associated with projects are real, permanent and additional, thereby instilling confidence in the environmental benefit, credibility, and efficiency of the U.S. carbon market.

Project developers and aggregators that initiate nitrogen management projects use this document to quantify and register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve Verification Program Manual and Section 8 of this protocol.

This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with a nitrogen management project.¹

¹ See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

2 The GHG Reduction Project

2.1 Background

Nitrous oxide (N_2O), a potent agricultural greenhouse gas, is emitted as a product or by-product of the naturally occurring microbial processes of nitrification and denitrification. Nitrous oxide emissions from agricultural lands are generally related to the application of inorganic and organic nitrogen (N) fertilizer, or legume-derived N. Any factor or action that impacts N availability in the soil may impact N_2O emissions, due to the fact that higher levels of available mineral N increase the amount of N available for transformation through the nitrification-denitrification cycle.

Nitrous oxide emissions from agricultural lands in the U.S. are estimated at 204.6 Mt CO_2e , which make up 69.2 percent of total U.S. N_2O emissions, or 3.1 percent of total U.S. emissions. Although annual N_2O emissions from agricultural lands in the U.S. have fluctuated somewhat over the years, they were 3.4 percent higher in 2009 than they were in 1990.²

Nitrogen (N) is an essential nutrient for plants, and agricultural producers have long supplied additional N soil amendments to their crops. During much of history, N was supplied to crops primarily in organic form such as through manure application and N-fixing legumes. However, during the latter part of the 19th century, inorganic N (typically synthetic fertilizer) replaced organic N as the main source of this nutrient, and today, inorganic N has become essential to world food production, contributing significantly to the 18 percent increase in global atmospheric concentrations of N_2O since 1750.³ In addition to increased N_2O emissions, the increased use of inorganic N in agriculture has proliferated the N-losses to the environment in the forms of ammonia (NH_3), ammonium (NH_4^+), nitrogen oxides (NO_x), and nitrate (NO_3^-), which affect air and water quality and lead to significant disruptions to natural ecosystem functions.

Because N available to microbes drives N_2O emissions, any agricultural management practice that reduces the presence of excess mineral N in the soil is a good candidate N_2O emission reduction strategy. Specifically, N_2O emissions can be reduced with the implementation of nitrogen management practices that focus on improving the nitrogen use efficiency (NUE)⁴ by matching nitrogen supply as exactly as possible with plant nutrient uptake to avoid the presence of excess N in the soil (i.e. less N applied for the same crop productivity). Determining the proper rate and timing of N applications during the year are important management decisions for agricultural producers. Using too little N may result in lower yields, poorer crop quality, and hence, reduced profits. When too much N is applied, yields and quality are generally not compromised (for most crops), but profit may be reduced and negative environmental effects can occur related to N leaching and nitrous oxide (N_2O) emissions.

² U.S. EPA. 2011. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. EPA 430-R-11-005. Washington, D.C.: U.S. Environmental Protection Agency.

http://www.epa.gov/climatechange/emissions/usgginv_archive.html

³ IPCC Fourth Assessment Report: Climate Change 2007.

http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#1

⁴ The N Use Efficiency (NUE) is typically defined as “the proportion of all nitrogen inputs that are removed in harvested crop biomass” (Ribaudo 2011).

The objective of a nitrogen management project under this protocol is to reduce N₂O emissions by adopting practices that further improve nitrogen use efficiency beyond what is projected to happen in the future, absent a carbon market.

This protocol provides eligibility criteria for approved nitrogen management practices and approaches for quantifying N₂O emission reductions that occur as a result of adopting the approved practices.

N₂O emissions are positively correlated with low soil pH, higher ambient temperatures, high water-filled pore space, soil compaction, available carbon substrate in soils, and available mineral N in soils.⁵ These relationships result in significant variability in expected N₂O emissions and reduction potentials associated with different regions and crops across the U.S. They are also responsible for significant differences in the feasibility and efficacy of various nitrogen management practices for reducing N₂O emissions while maintaining or improving crop yield. As a result, this protocol contains region- and crop-specific eligibility criteria, as noted below, and employs system-specific GHG quantification approaches that are applicable to specific circumstances.

2.1.1 **Potential Nitrogen Management Practices and N₂O Quantification in Considered for this Protocol**

Under this version of the Nitrogen Management Project Protocol (NMPP), reducing the N application rate on agricultural fields is the only eligible project activity. Appendix B contains on recommendations from the The Reserve's Science Advisory Committee on recommended certain practices that are likely to reduce N₂O emissions, and have shown consistent results in the scientific peer-reviewed literature, and as such, those practices were prioritized for consideration as project activities. These candidate activities are summarized in Appendix B and listed in Table 2.1, below, in Table 2.1, along with the Reserve's current assessment of data availability and existing quantification methods for these activities. Appendix A addresses the steps required for developing performance standards, particularly these data needs on for common nitrogen management practice practices, and Appendix D describes the criteria the Reserve believes are necessary to ensure that quantification methods are sufficiently rigorous and vetted in order to be included as a project activity in this protocol. The Reserve may add additional eligible project activities to in future versions of the protocol if data and analysis analyses support their inclusion and if robust quantification methods can be developed for them.

In addition, this This version of the NMPP Nitrogen Management Project Protocol includes only one method for quantifying N₂O emission reductions from reducing N application rates, which is applicable only to N rate reductions for corn in the Corn Belt, or the North Central Region, as it is called in this protocol.⁶ Information on Section 5 provides further information on regions where the currently approved project activity is applicable is detailed in Section 5. Additional quantification methods for N application rate reductions may be added in future versions of the protocol, covering additional regions and crop systems.

⁵ Chantigny et al., 2010; Farahbakhshazad et al., 2008; Venterea and Rolston, 2000.

⁶ See Table 2.2 below for applicability of the approved quantification methodology and for a list of states included in the North Central Region.

Table 2.1. Priority List of Nitrogen Management Practices

Potential Nitrogen Management Practice	Are comprehensive national data available to develop a performance standard? ^{7a}	Is a standardized quantification methodology for N ₂ O emissions currently available that meets Reserve criteria? ^{8b}
Reduce N Applied	Yes	Yes
Use of Nitrification and Urease <u>Inhibitors^c</u>	Yes	No
Use of Nitrification Inhibitors (only) ^{9c}	Yes	No
Switch from anhydrous to urea	No	No
Switch from Fall to Spring Application	Yes	No
Change to Slow Release Fertilizer	No	No
Change to Fertigation	No	No
Apply N Closer to Roots	<u>No^d</u>	No
Add N Scavenging Cover Crops	No	No

2.1.2 Project Aggregation

- a) Incorporated into the NMPP is an option for project aggregation, with clear rules for how aggregation must be undertaken, that aims to facilitate participation by farmers. This column represents whether or not data is available specifically through the USDA ARMS dataset, which the Reserve identified as the best available to develop performance standards for nitrogen management. Appendix A provides more detail on how the Reserve made this determination.
- b) The Reserve shall only adopt quantification methodologies that are standardized, scientifically vetted, and conservative. Appendix D outlines general criteria that the Reserve considered when determining which quantification methodologies were sufficiently evaluated to include in this protocol.
- c) Note that while the use of nitrification inhibitors was recommended both with urease inhibitors and on their own, the use of urease inhibitors (without nitrification inhibitors) is not a priority practice.
- d) Although some N application method data is available, the Reserve does not believe the data is sufficient to develop a performance standard for changing N placement to apply N closer to the roots.

Aggregators may provide appropriate technical expertise and fulfill protocol requirements on behalf of farmers in addition to providing other technical consulting services. In addition, aggregation allows for “economies of scale” within the methodology, allowing streamlined requirements for individual farmers while upholding rigorous quantification and verification standards at an aggregate level. This is primarily accomplished through pooling uncertainty and sampling fields for verification activities.

⁷ This column represents whether or not data is available specifically through the USDA ARMS dataset, which the Reserve identified as the best available to develop performance standards for nitrogen management. Appendix A provides more detail on how the Reserve made this determination.

⁸ The Reserve shall only adopt quantification methodologies that are standardized, vetted, and conservative. Appendix D outlines general criteria that the Reserve considered when determining which quantification methodologies were sufficiently vetted to include in this protocol.

2.2 Project Definition

For the purpose of this protocol, a GHG reduction project (“project”) is defined as the adoption and maintenance of an approved project activity⁹ that reduces nitrous oxide (N₂O) emissions.

The approved project activity may be implemented on a single field, known as a “single-field project,” or may be implemented on two or more individual fields combined into a single project area, also known as ~~the an~~ “aggregate.” Specific requirements for aggregates are outlined in Section 2.4. Physical boundaries for individual fields must be defined according to the requirements in Section 2.2.1.

At present, only project activities listed in Table 2.2 below are considered ~~“approved project activities.”~~approved project activities. However, implementation of additional best management practices and adaptive management practices are encouraged under this protocol, as discussed in Section 2.2.3, below.

Table 2.2. Definitions for Approved Project Activities

Approved Project Activity	Description	Applicable Crop(s)	Applicable Region(s)
Reduce N Applied	Reduction in the annual nitrogen application rate compared to recent historic application rates ¹⁰ at the site, without going below N demand ¹¹	Corn ¹²	North Central Region ¹³

2.2.1 Defining Field Boundaries

For the purposes of this protocol, an individual field must be defined by the following criteria:

1. The field must be under the direct management control of a single entity.
2. The field area must be ~~contiguous~~continuous.
3. Management practices within the field boundary must be homogeneous, within a reporting period.¹⁴ More specifically, in a reporting period, the same crop must be grown throughout the field and N fertilization dates must be the same (within ~~the same~~ week fourteen days); N fertilization composition, ~~rates~~, placement, and cover crops must be implemented consistently throughout the field. N-application rate may vary across

⁹ Note that a project is defined by the adoption of practices; however, GHG reductions are quantified based on actual project performance in terms of reduced N₂O emissions.

¹⁰ Nitrogen application rates in the project description are meant to include total N rate (e.g. the total of all synthetic and organic sources of N)

¹¹ The NMPP ~~SAC~~Science Advisory Committee recommended that “without going below N demand” be included in the project definition to ensure that this project activity should not be implemented such that yields are significantly affected. To prevent going below N demand, this protocol includes a performance standard based on a nitrogen use efficiency metric (see Section 3.5.1¹⁵), encourages implementation of additional enabling practices (Section 2.2.3), and accounts for any leakage ~~affect~~effects if yield is affected (see Section -1.1.1).

¹² Multi-year rotations that include other crops (e.g. soy, wheat) are eligible under this protocol; however, only emission reductions related to the corn cultivation cycle shall be credited.

¹³ ~~Defined in Section 3.1, the North Central Region (NCR) is comprised of the following states: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin.~~

¹⁴ Changes in management practices may be made from year to year (e.g. in different reporting periods), so long as management within a given field is homogenous for the purposes of defining the field’s spatial boundary.

¹⁵ ~~If management within a field varies beyond what the protocol’s “field boundary” definition allows, a field is not necessarily excluded from eligibility. Rather, for the purposes of implementing a project under this protocol, the~~

the field, so long as the total N applied is used as the input for all equations in Section 5. This protocol also explicitly encourages use of variable rate technology and other adaptive management strategies, as they may help enable the project activity while maintaining or increasing yields (See Section 2.2.3, below).

3- The field boundary, as defined by this protocol, should generally be similar, if not exactly the same, as the field boundaries that have been historically observed by the farmer for other BAU management purposes (e.g. tracking yield per field over time, but particularly during the baseline), and/or the field boundaries referenced in legal documents pertaining to all, or part of a parcel, of the property (e.g. contracts and other documentation of property sales). Fields should only be sub-divided beyond the traditional or legal boundaries if doing so is required to meet all three of the above criteria.

2.2.2 Defining the Cultivation Cycle

For the purposes of this protocol, a cultivation cycle is generally defined as the period starting immediately after harvest of one primary crop and ending after the next primary planted crop is harvested the following calendar year. A primary crop is defined as the main production crop grown on a field in a given year (e.g. corn is a primary crop, and may be grown on its own or with a cover crop).- If there are multiple primary crops in rotation, each type of crop (e.g. corn in a corn-soybean rotation) has a distinct cultivation cycle. As Version 1.0 of this protocol is only applicable to annual corn crops, the cultivation cycle in Version 1.0 is further defined as approximately 365 days.¹⁶ One complete cultivation cycle for corn in a corn-soy rotation, for example, begins with post-harvest residue management for the soy crop harvested in the fall of year one, continues with field preparation, seeding, and cultivation of the corn crop, and culminates upon completion of the corn harvest in the fall of year two.

2.2.3 Implementation of Enabling Practices

As noted in the project definition (Table 2.2), implementation of the project activity (reducing N application rate) should not result in such a significant N rate reduction that the N applied falls below N demand of the crop, resulting in yield loss. Though reducing one's N rate is the only creditable activity at this time, the NMPP recognizes that improved nitrogen use efficiency can be achieved through a variety of nitrogen best management practices that minimize the risk of yield losses.

This protocol encourages the adoption of additional best management practices as a way to enable N rate reductions, while maintaining or increasing yield. These enabling practices include, but are not limited to: practices listed in Table 2.1, practices listed in NRCS Conservation Practice Standard (CPS) 590, precision agriculture practices (particularly variable rate technology and yield monitors), and adaptive management tools (such as corn stalk nitrate tests,¹⁷ pre-plant or pre-sidedress soil nitrate tests, field-composite soil tests, and replicated strip trials). In some cases, these practices may result in additional N₂O reductions beyond those

~~boundaries of that field may need to be defined differently than the grower typically thinks of it. This definition of field boundaries is not meant to exclude the implementation of variable rate technology; small variations in rates across a yield are acceptable (within 15 percent of the average application rate for the entire field).~~

¹⁶ As the protocol expands in future versions, primary crops with cultivation cycles of less than a year (e.g. lettuce) or more than a year (e.g. perennials) may be included, which would likely necessitate changes in the definition of "cultivation cycle" as approximately 365 days.

¹⁷ Corn Stalk Nitrate Tests (CSNTs) are required by this protocol for monitoring and verification of the project activity, at a frequency of one CSNT per field or one CSNT per 100 acres, whichever is lower. However, it is up to each individual project participant to use the CSNT results as an adaptive management tool.

quantified in this protocol; such reductions may be creditable under future versions of the protocol.

2.3 Project Developer

The project developer is an entity that has an active account in good standing on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Under this protocol, project developers may act as aggregators, who represent one or more fields participating in a project, or as developers of single-field projects. Project developers/aggregators may be a corporation or other legally constituted entity, city, county, state agency, agricultural producer, or a combination thereof. An individual farmer may serve as a project developer of a single-field project, as an aggregator for his/her/their own fields, or as an aggregator for a group of fields under different ownership or management. Farmers who elect to enroll in an aggregate and not serve as a project developer are referred to as “project participants.” Project participants must have authority to make cultivation management decisions on their fields that are enrolled in the aggregate.

Project developers/aggregators act as official agents to the Reserve on behalf of project participants and are ultimately responsible for submitting all required forms and complying with the terms of this protocol. Project developers/aggregators manage the flow of ongoing monitoring and verification reports to the Reserve and may engage in other project development activities such as developing monitoring plans, modeling emission reductions, managing data collection and retention etc., or may hire technical contractors to perform these services on their behalf. The scope of project developer/aggregator services is negotiated between the project participants and the project developer/aggregator and should be reflected in contracts between the project participants and the project developer/aggregator.

Project aggregators have the authority to develop their own internal monitoring, reporting, and other participation requirements for individual fields as they deem necessary, as long as these internal requirements do not conflict with any requirements outlined in this protocol.

Aggregators also have the discretion to exclude individual fields enrolled in their aggregate from participating in verification activities for any given reporting period; however, in such cases, there can be no CRTs issued for those fields in the aggregate total.

In all cases, the ~~Project Developer/Aggregator~~project developer/aggregator must attest to the Reserve that they have exclusive claim to the GHG reductions resulting from all fields in the project. The ~~Project~~project developer/aggregator must attest to this requirement by submitting a signed Attestation of Title form for single-field projects or Aggregator Attestation of Title¹⁸ form for aggregates, prior to the commencement of verification activities each time the project is verified (see Section 8).

Although the aggregator must have exclusive claim to CRTs for the project to complete verification, this protocol does not dictate the terms for how that exclusive title will be established; allowing the aggregator, project participant, and land owner (if separate from the project participant) maximum flexibility for the terms of contracts between the respective parties. In the case of project activities taking place on leased fields (e.g. the project participant is not

¹⁸ The Reserve Aggregator Attestation of Title form is available at:
<http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/>

the land owner, but rather a lessee), the aggregator must notify the land owner with a Letter of Notification of the Intent to Implement a GHG Mitigation Project on the respective field.

As part of verification activities, verifiers/verification bodies shall review contracts and letters of notification as a means of confirming exclusive title to the CRTs. The Reserve will not issue CRTs for GHG reductions that are reported or claimed by entities other than the aggregator.

2.4 Project Aggregates

As noted above, incorporated into the NMPP is an option for project aggregation, with clear rules for how aggregation must be undertaken. Aggregators may provide appropriate technical expertise and fulfill protocol requirements on behalf of farmers in addition to providing other technical consulting services. In addition, aggregation allows for “economies of scale” within the methodology, allowing streamlined requirements for individual farmers while upholding rigorous quantification and verification standards at an aggregate level. This is primarily accomplished through pooling uncertainty and by sampling fields for verification activities.

2.4.1 Field Size Limits and Other Requirements

The aggregate does not need to be comprised of contiguous fields, and can encompass numerous fields located on one farming operation or distributed amongst different farms and/or producers.

There is no limit on the total number of acres enrolled in an aggregate, assuming each individual field meets the requirements of Section 2.2.1. There are, however, limits on how large a single field may be, in relation to the total combined acreage in an aggregate, as defined by Table 2.3 below. Field size limitations are in place to minimize the influence that a single large field may have on an aggregate’s total emission reduction calculations, due to the random sampling used to verify aggregates.

Table 2.3. Maximum Field Size, as a Percent of Aggregate Acreage

Number of Fields in Aggregate	Maximum Acreage of a Single Field (% of Aggregate Acreage)
2	70%
3	50%
4	33%
5 or more	25%

2.4.2 Entering and Leaving an Aggregate

2.4.2.12.4.2 Entering an Aggregate

Individual fields may join an aggregate by being added to the aggregate’s Project Submittal Form (if joining an aggregate at initiation) or by being added through the New Field Enrollment Form (if joining once the aggregate is underway).

Single-field projects that have already been submitted to the Reserve may choose to join an existing aggregate by submitting an Aggregate Transfer Form to the Reserve. The project aggregator will also need to submit a New Field Enrollment Form, listing that field. -Emission reductions occurring on single- fields or new fields entering an aggregate will start counting toward the aggregate CRTs in the reporting period immediately following the transfer.- Because project start dates and reporting periods are tied to annual cultivation cycles, fields are

encouraged to begin the process of entering an aggregate prior to completion of the cultivation cycle (e.g. prior to harvest) of the year immediately preceding that in which emission reductions will be registered as part of the aggregate.

2.4.2.22.4.3 Leaving an Aggregate

Fields must meet the requirements in this section in order to leave or change aggregates and continue reporting emission reductions to the Reserve. In all cases, emission reductions must be attributed to one project for a complete reporting period, as defined in Section 2.2.23.3, and no CRTs may be claimed by a project for a field that does not participate and report data for a full reporting period.

Project activities on an individual field may be terminated and the field may elect to leave the aggregate at any time.

Individual fields may elect to leave an aggregate and participate as a single-field project for the duration of their crediting period. To leave an aggregate and become a single-field project, the project participant must open a project developer account on the Reserve and submit a “Project Submittal Form” to the Reserve, noting ~~both~~ that it is a “transfer project” and identifying the aggregate from where it transferred.

Fields can switch their participation to another aggregate during a crediting period if, and only if:

1. The field changes ownership, tenant occupancy or management control during the crediting period and the new owner, tenant or manager has other fields already enrolled with a different aggregator, ~~or,~~
2. The original aggregate is terminated (e.g. goes out of business),
3. The aggregator breaches its contract with the project participant and the contract is terminated.

Fields seeking to change aggregates during a crediting period under one of the above allowed circumstances must submit an “Aggregate Transfer Form” to the Reserve prior to enrolling in the new aggregate.

2.4.32.4.4 Changes in Land Ownership, Management or Tenant Occupancy

A field in an aggregate can change ownership, tenant occupancy or management control during a crediting period, and remain in the aggregate with uninterrupted crediting, if, and only if, the following criteria are met:

1. The contract with the aggregator is transferred from the old to the new project participant.
2. The new project participant submits a “Field Management Transfer Form” to the Reserve via their aggregator prior to the beginning of the subsequent reporting period.
3. Implementation of the approved project activity continues without change until the end of the current reporting period.¹⁹

Where any of these criteria are not met, a field will forfeit the opportunity to generate CRTs for the reporting period during which the ownership, tenant occupancy or management control

¹⁹ See Sections 3.3 and 7.4 for ~~definition~~ a description of reporting periods.

change occurs. The field may re-enter the aggregate at any time during the remainder of the 5-year crediting period by fulfilling the three requirements above.

3 Eligibility Rules

Projects must fully satisfy all eligibility rules in order to register with the Reserve. All fields participating in a project must meet the following criteria, as well as the definition of a GHG reduction project (Section 0), in order for the project to be eligible.

Eligibility Rule I:	Location and Crop System	→	<i>U.S. and U.S. tribal areas, in areas corresponding to approved quantification approaches (see Table 3.1).</i>
Eligibility Rule II:	Start Date	→	<i>No more than six months prior to submission*</i>
Eligibility Rule III:	Additionality	→	<i>Meet performance standard</i>
		→	<i>Exceed regulatory requirements</i>
Eligibility Rule IV:	<u>Regulatory Compliance</u>	→	<i>Compliance with all applicable laws</i>

* See Except as otherwise permitted in Section 3.2 for further detail.

3.1 Location and Crop System

Only projects located in the United States and on U.S. tribal lands are eligible to register reductions with the Reserve under this protocol. Fields that make up the project must be located in regions and employ crop systems for which there is an applicable quantification approach in this protocol. Table 3.1 lists the quantification approaches currently contained in this protocol along with their applicable geographic regions and crop systems. Not all fields within a project are required to be located in the same region.

Please also refer to the additional applicability criteria included in Section 5.1, which may further restrict eligibility in some of the states included in Table 3.1.

Table 3.1. Eligible Practice: State-Crop Combinations

Approved Practice	Eligible State-Crop Combinations ²⁰	
Reducing Amount of N Applied	Illinois	Corn
	Indiana	Corn
	Iowa	Corn
	Kansas	Corn
	Michigan	Corn
	Minnesota	Corn
	Missouri	Corn
	Nebraska	Corn

²⁰ Multi-year rotations that include other crops than those listed herein Table 3.1 are eligible under this protocol; however, only emission reductions related to the corn cultivation cycle shall be credited. Both corn grown for grain and corn for silage are eligible.

	North Dakota	Corn
	Ohio	Corn
	South Dakota	Corn
	Wisconsin	Corn

3.2 Start Date

Each field has a unique start date, defined as the first day of a new cultivation cycle during which an approved project activity is implemented. The first day of a new cultivation cycle is defined as the first day after the field's previous harvest was completed: for that field. The start date may be chosen as any date on or after June 27, 2010 that coincides with the start of a cultivation cycle during which a project activity is implemented. It is important to note, however, that if the field is Further, fields under the same management control or even within the same aggregate may have different start dates within the same year and/or may have start dates in different years, depending on when the project activity is first implemented on a given field. It is important to note, however, for fields that are part of an aggregate, the aggregate's reporting start date might differ from the field's start date (see Section 7.3.3).

To be eligible, a field must be submitted as a single-field project or join an aggregate before the end of the first cultivation cycle after the start date, unless the field is submitted during the first 12 months following the date of adoption of this protocol by the Reserve Board (the Effective Date)-, i.e. June 27, 2012).

For a period of 12 months from the Effective Date of this protocol (Version 1.0), fields with start dates on or after June 27, 2010 are eligible to register with the Reserve if submitted by June 27, 2013. Fields with start dates prior to June 27, 2010 are not eligible under this protocol. Fields may always be submitted for listing by the Reserve prior to their start date.

3.3 Crediting Period

The crediting period for fields under this protocol is defined as five eligible crop years, which may occur over a period of up to ten years.²¹ An eligible crop year is defined as a year in which an eligible crop (see Table 3.1) is grown on the field.²² Eligible crop years do not have to be consecutive, but project reporting for each field must be continuous during a crediting period, with no gaps between reporting periods. This means that multi-year rotations that alternate between eligible and non-eligible crops must report project data for all time periods, including ineligible crop years, to maintain continuous reporting between reporting periodsthroughout the crediting period (see Section 6.4 for reporting requirements).

²¹ The time period over which a crediting period of five eligible crop years must be completed is based on a variable period of time (five to ten years), depending on how many eligible crop years are planted. For example, in the case of a corn-corn monoculture, the crediting period must be five consecutive years, while a corn-soy rotation may have a five year crediting period that extends over ten years, if corn is planted every other year. A more complex multi-crop rotation, however, in which the eligible crop is grown only every fourth year will likely be limited specifically by the ten year maximum crediting period, as opposed to limited by the five eligible crop years.

²² The time period over which a crediting period of five eligible crop years must be completed is based on a variable period of time (five to ten years), depending on how many eligible crop years are planted. For example, in the case of a corn-corn monoculture, the crediting period must be five consecutive years, while a corn-soy rotation may have a five year crediting period that extends over ten years, if corn is planted every other year. A more complex multi-crop rotation, however, in which the eligible crop is grown only every fourth year will likely be limited specifically by the ten year maximum crediting period, as opposed to limited by the five eligible crop years.

Crediting periods may be renewed one time (for a potential of ten eligible crop years of crediting). During the last six months of a field's first crediting period, project developers/aggregators may apply for a field's eligibility under a second crediting period. -The project must meet the eligibility requirements of the most currentrecent version of this protocol, including any updates to the Performance Standard Test (Section 3.5.1.1). The historic baseline established in the first crediting period of the project shall be used for the project's second crediting period.

The reporting period under this protocol is one complete cultivation cycle of an annual crop, approximately 365 days. Reporting periods in which a field does not meet the performance standard (see Section 3.5.1.1), or a field is withdrawn from participation in verification activities, still count towardsas one of the five eligible crop years in the crediting period. Similarly, the field must continue to meet monitoring and continuous reporting requirements for fields, even if not eligible to generate CRTs in a given year.

Crediting periods do not apply to aggregates, only to individual fields within an aggregate and to single-field projects.

The Reserve will issue CRTs for GHG reductions quantified and verified according to this protocol for a maximum of two five-year crediting periods after the field's start date, as defined above. If, at any point in the future, the approved project activity adopted on a field becomes legally required, emission reductions may be reported to the Reserve for that field up until the date that the practice is required by law to be adopted. Upon the effective date of the new legal requirement, the Reserve will cease to issue CRTs for GHG reductions for the legally required N rate reduction for that field (see Section 0 for further guidance).

3.4 Other Criteria

Section 5.1 specifies additional "applicability conditions," specific to each approved project activity, that must be met by each field implementing that respective project activity. Currently, Section 5.1 includes applicability conditions for implementing the only approved project activity: reducing N application rate.

Lands that have no cropping history prior to the earliest eligible start date under this protocol (June 27, 2010) are not eligible under this protocol. Further, project fields may not be located on lands that are classified as either highly erodible land (HEL) or wetlands, as classified by USDA NRCS's sodbuster and swampbuster provisions, respectively. In other words, to be eligible, project fields must meet the 1985 and subsequent Farm Bills' basic conservation compliance standards.²³

Management records and/or data must be available on the history of crop production practices for at least the past five years prior to the field's start date. ~~Management records and/or data must be available on the history of crop production practices for at least the past five years prior to the field's start date.~~ In case less than three eligible crop years were planted in the five years

²³ Please refer to the classifications for the HEL (Sodbuster) and wetlands (swampbuster) as defined in the U.S. Code, Title 16, Chapter 58, Subchapter I-III. These classifications were established in the 1985 Food Security Act and were amended in 1990, 1996 and 2002. In general, the term "highly erodible land" includes land classified by the NRCS as class IV, VI, VII, or VIII, while "wetlands" have a predominance of hydric soil and are inundated or saturated by surface or groundwater for various durations over the year.

prior to the field's start date, the period shall be extended so that at least three eligible crop years are included. Further, the crop production system on a project field must be consistent with the past five years of management data (or extended years including the three eligible crop years) for that field.- More specifically, the frequency ~~and sequencing~~ of eligible crops grown in a multi-crop rotation must not ~~change significantly~~increase due to the project (e.g. a multi-crop rotation shall not be replaced during the project with a corn-corn rotation nor awith any other rotation such as three years that increases the frequency of corn, followed by one year crops while decreasing the frequency of others and/or the decreasing the diversity of a multi-crop rotation. However, the frequency of eligible crops grown may decrease (e.g. a corn-corn rotation may be changed to corn-soy or other multi-crop rotation).

Increases or decreases in yields compared to pre-project yields are allowable. However, yield reductions may result in leakage effects that must be estimated and accounted for (see Section ~~for further guidance on accounting for leakage).~~ 1.1.1 for further guidance on accounting for leakage). The Reserve also encourages implementation of the additional best management practices listed in Section 2.2.3 as a way to mitigate the risk of perceived yield loss and to help ensure that yields are maintained (or increased) while the N-rate decreases.

~~While all projects must meet all eligibility criteria in Section 3, Section 5 includes additional "applicability conditions," specific to each approved project activity, that must be met by each field implementing that respective project activity. Currently, Section 5.1 includes only applicability conditions for implementing the approved project activity, reducing N rate.~~

3.5 Additionality

The Reserve strives to register only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of a carbon offset market.

Projects must satisfy the following tests to be considered additional:

1. The Performance Standard Test
2. The Legal Requirement Test

3.5.1 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold, i.e. a standard of performance applicable to all nitrogen management projects, established by this protocol. Performance standards are specified below according to the type of project activity being implemented.

The performance standard research and rationale for the specific performance standards outlined below are summarized in Appendix A.

3.5.1.1 Performance Standard for ~~Reduction in N~~Reducing Nitrogen Application Rate

The performance standard for this project activity is based on a nitrogen use efficiency metric, calculated as a ratio of the amount of N removed by crop biomass to the amount of N available to the crop as a function of how much total nitrogen was applied to the crop. This ratio is referred to as the ratio of ~~Removed~~removed to ~~Applied~~Applied nitrogen (RTA). The RTA can be interpreted as a general measure of the Nnitrogen use efficiency.

A field passes the Performance Standard Test when its annual RTA, calculated for each eligible crop year of the project,²⁴ exceeds the applicable performance standard RTA threshold in Table A.7, which represents approximately the 75th percentile of a given state's calculated state average RTA.²⁵

A field's RTA is calculated using Equation 3.1 below.²⁶ The calculation to determine a field's RTA and to demonstrate that a field must pass the performance standard test in a passes the Performance Standard Test occurs ex post (e.g. after completion of the reporting period). However, the field's RTA is calculated using average historic yield, so a farmer can estimate ex ante the maximum N rate that will allow a given field to pass the Performance Standard Test.

Equation 3.1. Annual RTA

$RTA_{f,c,t} = \frac{(Y_{f,c,t} \times NC_c)}{NR_{f,c,t}}$		
<u>Where,</u>		<u>Units</u>
$RTA_{f,c,t}$	\equiv <u>RTA calculated for field f and crop c over time t</u>	
<u>(e.g. $Y_{f,c,t}$</u>	\equiv <u>Average historical yield for field f and crop c over time t (as defined below)</u>	<u>unit*/ha</u>
NC_c	\equiv <u>Default N concentration for crop c. [0.36 kg N/bushel for corn grain and 3.22 kg N/US ton for silage]</u>	<u>kg N/unit</u>
$NR_{f,c,t}$	\equiv <u>Annual nitrogen application rate (including organic and synthetic forms of N) for field f and crop c over time t</u>	<u>kg N/ha</u>
* Unit may be bushels (in the case of corn grain) or short tons (in the case of corn for silage). To convert from unit/acre to unit/ha, divide by 0.405. Additional guidance on determining this equation's input parameters is provided in Section 5.1.		

Average historical yield ($Y_{f,c,t}$) is defined as the average yield (per hectare per year) of the eligible crop (corn) over the five years prior to the field's start date. If less than three eligible crop years were planted in the five years prior to the field's start date, the average yield is calculated from at least three (and up to five) consecutive eligible crop years prior to the start date. If a catastrophic yield loss occurred due to anomalous weather during a historic eligible crop year, yield data for that year may be excluded from the calculation of average historical yield; however, if those yield data are excluded, the historic period over which the average historical yield is calculated must be extended to include the another historic eligible year (i.e., so that the same number of valid eligible crop years is used to determine the average historical yield). Verifiers will use their professional judgment to determine whether it was appropriate to exclude an anomalous yield for calculating $Y_{f,c,t}$. The average historical yield value will be fixed for the duration of a field's crediting period, but shall be (re)calculated at the start of each crediting period.

²⁴ Fields are not excluded from program participation based on their pre-project RTA levels.

²⁵ The Reserve calls this the "calculated state average RTA" because this value is calculated based on mean N rate application and mean yield for each state. Data for calculating the true mean RTA of each state is not available.

²⁶ Equation 3.1 mirrors the equation used to calculate the state average RTA, with the exception that the yield and N rate values are state average values from a given survey year.

A field must pass the Performance Standard Test in a reporting period (i.e. annually) in order to be awarded CRTs for that reporting period. However, if a field does not pass the performance standard in an eligible crop year, it does not necessarily forfeit eligibility for the remainder of the crediting period. Rather, the field loses one of the five eligible crop years of its crediting period but maintains eligibility for the remainder of the crediting period, so long as the field maintains continuous reporting to the Reserve and is able to pass the performance standard in a future reporting period.

A field growing both eligible and non-eligible crops does not need to pass the performance standard in its non-eligible crop years to maintain eligibility, so long as N use does not increase significantly in the non-eligible crop years. Specifically, the N application rate in a non-eligible crop year of the project must be within 15 percent of the average N rate from the past five seasons-planting ~~that~~ seasons for the non-eligible crop.²⁷ If the N rate for the non-eligible crop year is greater than 15 percent of the historic average, the field will forfeit eligibility for the subsequent eligible crop year.²⁸ Verifiers shall review non-eligible crop year reporting data as part of their eligibility assessment for the next eligible crop year. See Section 6.3.3.2 for continuous-reporting requirements in non-eligible crop years.

~~The calculation to determine a field's RTA and to demonstrate that a field passes the performance standard occurs ex post (e.g. after completion of the reporting period) using Equation 3.1 below.~~²⁹

²⁷ In the case that five previous seasons of data are not available for the non-eligible crop on ~~that~~ field, the average of the number of years available shall be used. If no data is available for ~~that~~ field, N rates for the same non-eligible crop applied to other fields managed by ~~that~~ the project participant; or N rate recommendations from Extension Service representatives for those non-eligible crops shall be used, whichever is lower.

²⁸ ~~The assumption here being that if this percent threshold prevents the project participant is from increasing the non-eligible crop's N-use so much, there is a risk that the project participant is to intentionally trying to build residual N on the field, to allow which would result in N reductions in subsequent eligible years that may be larger than would have otherwise been possible without risk of yield loss.~~

²⁹ ~~Though the actual performance standard test occurs ex post using data from the reporting period, for planning purposes, project developers are encouraged to use a field's historic yields and the target RTA threshold for that field (in Table A.8), to estimate the N rate necessary for a given field to pass the Performance Standard Test.~~

Equation 3.1. Calculating a Field's Annual RTA

$RTA_{f,c,t} = \frac{(Y_{f,c,t} \times NC_c)}{NR_{f,c,t}}$		
Where:		<u>Units</u>
RTA_{f,c,t}	=	RTA calculated for field f and crop c over time t
Y_{f,c,t}	=	Annual yield for field f and crop c over time t unit*/ha
NC_c	=	Default N content for crop c based on the look-up table, Table A.2 kg N/unit
NR_{f,c,t}	=	annual nitrogen application rate (including organic and synthetic forms of N) for field f and crop c over time t kg N/ha
* Unit may be bushels or other measure of crop biomass. To convert from unit/acre to unit/ha, divide by 0.405. Additional guidance on determining this equation's input parameters is provided in Section 5.1.		

3.5.1.1.1 Modified Performance Standard during a Field's Grace Period

At the beginning of a field's first crediting period, each field shall be given a grace period for the first two eligible crop years to meet or exceed the applicable RTA performance threshold in Table A.7. During ~~that the~~ grace period, a modified performance standard shall be applied, in which the field passes the performance standard so long as the field's RTA increases each reporting period. ~~More specifically, the field's RTA in the first eligible crop year must be greater than the field's historical RTA,³⁰ and then the field's RTA in the second eligible crop year must be greater than the RTA of the first.~~ Implementation of the approved project activity shall be fully creditable during this grace period. ~~In the reporting period associated with the third eligible crop year, however, the field's RTA must meet or exceed the RTA threshold established in Table A.9 to pass the performance standard and be awarded CRTs for that reporting period. However, CRT issuance will be delayed for all CRTs generated by a field during its grace period, until such time as the field's RTA meets or exceeds the RTA threshold established in Table A.7. Once a field has completed verification for the reporting period in which it meets or exceeds the RTA threshold, CRTs shall be issued for all emission reductions achieved during the grace period. Fields must pass the performance standard in the reporting period associated with the third eligible crop year to receive any credits for the grace period; if the field does not pass the performance standard in the third eligible crop year, CRTs generated, but not issued, during the grace period will be forfeited.~~

The historical RTA, calculated for years prior to the field's start date, is also used as a basis for determining whether the field shall use a historic or default baseline when calculating GHG reductions, as prescribed in Section 5.3.

3.5.2 The Legal Requirement Test

All fields enrolled in a project or aggregate are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by approved project activities on those fields would not

³⁰ ~~The historical RTA is calculated for years prior to the field's start date. See Section 5.3 for specific guidelines on how to calculate the field's historical RTA.~~

otherwise have occurred due to federal, state or local regulations, or other legally binding mandates. A field passes the Legal Requirement Test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, binding contractual obligations,³¹ or other legally binding mandates (including, but not limited to, legally mandated nutrient management plans,³² conservation management plans, and deed restrictions) that require adoption or continued use of approved nitrogen management project activities on the field.

To satisfy the Legal Requirement Test, project developers of single-field projects must submit a signed Attestation of Voluntary Implementation form, while aggregators must submit a signed Attestation of Voluntary Implementation form on behalf of all project participants in the aggregate.³³ Attestations of Voluntary Implementation must be signed and submitted to the Reserve prior to the commencement of verification activities each time the project or aggregate is verified (see Section 8). Individual project participants who are part of an aggregate will not be required to attest to the voluntary nature of project activities to the Reserve. However, supporting documentation should be made available to the ~~verifier~~verification body during verification, if requested. In addition, ~~the Aggregate Monitoring Plan (Section 6.2) must include procedures that the aggregator will follow to ascertain and demonstrate that all fields in the aggregate at all times pass the Legal Requirement Test. Similarly,~~ the Single-Field Monitoring Plan (Section 6.1) must include procedures that the project developer will follow to ascertain and demonstrate that the project field at all times passes the Legal Requirement Test, while the Aggregate Monitoring Plan (Section 6.2) must similarly include procedures that the aggregator will follow to ascertain and demonstrate that all fields in the aggregate at all times pass the Legal Requirement Test.

A ~~complete~~ summary of research performed on federal, ~~and~~ state, ~~and local legal~~ requirements is provided in Appendix C. This summary includes extensive background on the Clean Water Act (CWA) and other important water quality laws, as well as other regulations related to synthetic N fertilizer, manure N, and their uses.

As of the Effective Date of this protocol, the Reserve could identify no existing federal regulations that explicitly obligate agricultural producers to adopt the nitrogen management practices approved under this protocol. When watersheds are successfully meeting the CWA water quality standards, agriculture sources are generally unregulated. However, the Reserve has identified circumstances, particularly where watersheds are not in compliance with CWA water quality standards, in which state- and local-level regulations enacted to implement the federal CWA may require nutrient management plans (NMPs) and/or require implementation of some of the nitrogen management practices approved as project activities. More specifically, once a watershed is identified as “impaired,”³⁴ if any ~~agriculture~~agricultural non-point source

³¹ Contracts with NRCS that must be signed by a grower in order to receive EQIP funds are not considered “legally binding mandates” for the purposes of this Legal Requirement Test, if the only repercussion of violating the contract is not receiving the aforementioned financial incentive (e.g. there is no fine, notice of violation, or other legal penalty levied).

³² If Nutrient Management Plans are legally required, but do not require N rate reductions or specify N rate targets that would require reductions, the field passes the Legal Requirement Test. ~~Verifiers because the project activity (reduce N rate) is not specifically required. Verification bodies~~ shall evaluate such ~~NMPs~~plans and use their professional judgment to make a determination.

³³ Form available at <http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/>.

³⁴ A watershed is identified as impaired when it is not in compliance with Clean Water Act water quality standards. Once identified as “impaired,” a watershed is added the “Impaired or Threatened Waters List,” also known as the CWA’s “303(d) List.” As this list is updated frequently, project developers and ~~verifiers~~verification bodies should refer

(NPS)³⁵ is identified as contributing to a watershed's impairment (~~e.g. nitrate levels exceeding 10 mg/L~~³⁶), agricultural non-point sources in that watershed may become limited by ~~an NPS~~ non-point source pollution obligation (e.g. a field- or region-specific obligation to help meet a Total Maximum Daily Load ~~total maximum daily load~~ (TMDL)³⁷ or other policy mechanism chosen to meet that obligation).

Due to localized implementation of the CWA and TMDL strategies, the extent to which nutrient management plans become effectively required by law may vary greatly in terms of flexibility and what is explicitly required (e.g. a project participant may be allowed to self-select practices to include in an NMP for their field, while elsewhere an explicit N rate reduction may be required). Once a practice is required or is self-selected by a project participant for CWA compliance, the Reserve considers that practice a non-voluntary legally binding mandate, as continued implementation of that practice is required by law, and that practice will not be considered an eligible project activity for that farm.

~~Fields~~ Further, fields that are located in impaired watersheds with established TMDLs for ~~Nitrogen~~ nitrogen that identify agriculture as a source of impairment shall not pass the Legal Requirement Test *unless* the field (and/or appropriate non-point source under which discharges from the field would be categorized) has been specifically ~~been~~ identified as *not* contributing to the watershed's impairment.

If the approved project activity (N rate reduction) of an eligible field later becomes legally required, emission reductions may be reported to the Reserve for that field up until the date that the practice is required by law to be adopted. Upon the effective date of the new legal requirement, a field may no longer report emission reductions to the Reserve.

The Legal Requirement Test is applied to each field, so if one field in an aggregate becomes legally required, it shall not affect the other fields in the aggregate.

3.5.3 Ecosystem Services Payment Stacking

When multiple ecosystem services credits or payments are sought for a single activity on a single field, it is referred to as "credit stacking" or "payment stacking," respectively.³⁸ Under this protocol, credit stacking is defined as ~~issuing~~ receiving more than one mitigation credit for the same activity on spatially overlapping areas (i.e. in the same acre). Payment stacking is defined as issuing mitigation credits for a best management or conservation practice that is funded by the government or other parties via grants, subsidies, payment, etc. Mitigation credits are used

to the U.S. EPA website for the most current list of impaired watersheds:
http://iaspub.epa.gov/waters10/attains_nation_cy.control?p_report_type=T

³⁵ A ~~nonpoint~~ non-point source" is defined by the Clean Water ~~act~~ Act as any source of water pollution not meeting the legal CWA definition of "point source." The term "point source" is defined by the CWA Section 502(14) as "any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged." The CWA point source definition goes on to explicitly state that agricultural storm water discharges and return flows from irrigated agriculture are not considered point sources.

³⁶ ~~10 mg/L is the Maximum Contaminant Level (MCL) for nitrate according to the Safe Drinking Water Act (e.g. The highest level of a contaminant allowable in drinking water). However, the MCL is often referenced when developing TMDLs and can serve as a minimal target.~~

³⁷ The maximum contaminant level for Nitrate-N (concentration of 10 mg/L) according to the Safe Drinking Water Act (e.g. the highest level of a contaminant allowable in drinking water), is often referenced when developing total maximum daily loads (TMDL) and can serve as a minimal target, and is included here for reference.

³⁸ Cooley, D., & Olander, L. (September 2011).

to offset the environmental impacts of another entity such as emissions of GHGs, removal of wetlands, or discharge of pollutants into waterways, to name a few.

3.5.3.1 Credit Stacking

Based on a review of mitigation credit markets in the U.S., water quality trading is the only ~~other~~ ecosystem services market that would credit nutrient-reducing activities. Water quality trading programs (WQTP) are being developed across the country as an optional tool for compliance with the Clean Water Act. While there are many water quality trading programs under development, as of the effective date of this protocol, there were no active WQT markets identified that had issued nutrient reduction credits to agricultural sources for the approved practice (N rate reduction) in eligible project locations under this protocol (see Table 3.1).³⁹ As such, credit stacking is not addressed by the protocol at this time.

Research on WQTP to date suggests that these programs are highly variable due to the localized nature of program development and enforcement as allowed under the Clean Water Act. The Reserve will continue to track the development of relevant WQTP and will update this section as programs are implemented. This section will also be updated as the protocol is revised to include additional approved practices and/or geographic regions.

3.5.3.2 Payment Stacking

The Reserve has identified three USDA Natural Resource Conservation Service (NRCS) programs that provide payments nationwide to support the implementation of agricultural best management practices (BMPs). Authorized by the 2008 Farm Bill, the Environmental Quality Incentives Program (EQIP), the Agricultural Water Enhancement Program (AWEP), and the Conservation Stewardship Program (CSP) are national programs that are implemented at the state- and county-level. NRCS expressly allows the sale of environmental credits from enrolled lands,⁴⁰ but does not provide any additional guidance on ensuring the environmental benefit of any payment for ecosystem service stacked with an NRCS payment.

All NRCS programs share a common set of conservation practice standards that contain information on why and where the practice is to be applied, and set forth the minimum quality criteria that must be met during the application of that practice in order for it to achieve its intended purpose(s).

NRCS Conservation Practice Standard 590 – *Nutrient Management* (CPS 590) provides assistance to farmers to manage the amount (rate), source, placement (method of application), and timing of plant nutrients and soil amendments on lands where plant nutrients and soil amendments are applied.⁴¹

Data obtained from NRCS show that no state eligible under this protocol has more than 2two percent of cropland acres receiving NRCS funding under CPS 590, suggesting that existing

³⁹ The following ~~WQT programs~~WQTP that allow nutrient trading between point sources and agricultural non-point sources were assessed: The Great Miami River Watershed Water Quality Credit Trading Pilot (OH), Red Cedar River Nutrient Trading Pilot Program (WI), Southern Minnesota Beet Sugar Cooperative Program, Alpine Cheese Phosphorus Nutrient Trading Plan (OH), Kalamazoo River Demonstration (MI), and Rahr Malting Company NPDES Permit (MN). None of these programs have issued water quality credits to cropland for fertilizer reduction activities.

⁴⁰ EQIP, 7 CFR §1466.36; CSP, 7 CFR §1470.37.

⁴¹ Natural Resources Conservation Service *Conservation Practice Standard Nutrient Management, Code 590*, December 2011. State-specific conservation practice standards can be downloaded from http://efotg.sc.egov.usda.gov/efotg_locator.aspx.

payments are not adequate to further incentivize nitrogen application reductions.⁴² Analyses also show that farmers base their fertilizer application rate decisions on routine practice and there is significant opportunity for farmers to reduce fertilizer application without affecting yields (see Appendix A).

Therefore, the use of NRCS payments to help support reductions in nitrogen application under this protocol is allowed, except as specified below. Fields seeking to stack payments must also meet all other eligibility requirements in this protocol, including the start date requirement in Section 3.2.

Stacking NRCS payments under CPS 590 with CRTs under this protocol is not allowed if the nutrient management plan required by CPS 590 was under a signed agreement with NRCS prior to the project ~~field being submitted~~field's start date or prior to the field's submittal to the Reserve, whichever is earlier, and the plan included a reduction in fertilizer application. - For a period of 12 months from the Effective Date of this protocol (Version 1.0), fields with start dates on or after June 27, 2010 are allowed to stack, so long as no agreement with NRCS to implement CPS 590 with a nutrient management plan including N rate reductions was signed prior to the field's start date.

Note that if a field is under an agreement with NRCS to receive payments for activities that do not include reduced fertilizer application under CPS 590 (or NRCS payments under any other CPS), those payments do not affect field eligibility since the payments were awarded for different activities than those credited by this protocol and are therefore not considered "stacked."

Furthermore, other fields owned by the farmer are eligible if they are not under agreement to receive NRCS funding for CPS 590 activities that include reduced fertilizer application. Fields that have received CPS 590 payments in the past (e.g. prior to the field's start date) but ~~are no longer receiving~~have not received payments for at least one year are also eligible.

To be conservative, fields stacking NRCS CPS 590 payments are only eligible to receive CRTs for the portion of the project not funded by public dollars. For example, EQIP payment rates are estimated to provide 50 percent, 75 percent or 90 percent of the cost of practice implementation, depending on with higher percentages awarded if the farmer qualifies as "historically underserved" or as a "limited resource farmer," respectively. If a farmer receives an EQIP payment for CPS 590 at the 50 percent level, the number of CRTs issued is to be reduced by 50 percent. This is to support the additionality of the project and to protect against public funds for voluntary natural resource protection and/or restoration being used to finance mitigation projects undertaken to satisfy regulatory requirements (i.e. offset a regulated entity's CO₂ emissions in a cap-and-trade system).

For informational purposes, any other type of ecosystem service payment or credit received for activities on a project field must be disclosed by the project developer/aggregator to the verification body and the Reserve.

⁴² Based on data obtained from NRCS Performance Results System database (<http://ias.sc.egov.usda.gov/prshome/>); FY 2010 data updated as of March 30, 2011, FY 2011 data updated as of October 1, 2011. Accessed April 2012.

This section will also be updated as the protocol is revised to include additional approved practices.

3.6 Regulatory Compliance

As a final eligibility requirement, project developers must attest that the project is in material compliance with all applicable laws relevant to the project activity (e.g. air, water quality, water discharge,⁴³ safety, labor, endangered species protection, etc.) prior to verification activities commencing each time a project is verified. Project developers are required to disclose in writing to the verifier any and all instances of non-compliance of the project with any law. If a verifier finds that a field is in a state of recurrent non-compliance or non-compliance that is the result of negligence or intent, then CRTs will not be issued for GHG reductions that occurred on the field during the period of non-compliance. Non-compliance solely due to administrative or reporting issues, or due to “acts of nature,” will not affect CRT crediting.

Additional information on legal requirements potentially relevant to a project’s status of regulatory compliance is included in Appendix C.

⁴³ See Appendix C for an overview of water quality rules and regulations that may impact a farm’s legal requirements or regulatory compliance.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that must be assessed by project developers in order to determine the net change in emissions caused by a nitrogen management project.⁴⁴

The GHG Assessment Boundary encompasses all the GHG SSRs that may be significantly affected by project activities, including sources of N₂O and CH₄ emissions from the soil, biological CO₂ emissions and soil carbon sinks, and fossil fuel combustion GHG emissions. For accounting purposes, the SSRs included in the GHG Assessment Boundary are organized according to whether they are predominantly associated with a nitrogen management project's "primary effect" (i.e. the project's intended N₂O reduction), or its "secondary effects" (i.e. unintended changes in carbon stocks, CH₄ emissions, or other GHG emissions).⁴⁵ Secondary effects may include increases in mobile combustion CO₂ emissions associated with site preparation, as well as increased GHG emissions caused by the shifting of cultivation activities from the project area to other agricultural lands (often referred to as "leakage"). Projects are required to account for all SSRs that are included in the GHG Assessment Boundary regardless of whether the particular SSR is designated as a primary or secondary effect.

Table 4.1 provides a comprehensive list of the GHG SSRs that may be affected by a nitrogen management project, and indicates which SSRs must be included in the GHG Assessment Boundary.

⁴⁴ The definition and assessment of sources, sinks, and reservoirs (SSRs) is consistent with ISO 14064-2 guidance.

⁴⁵ The terms "~~Primary Effect~~primary effect" and "~~Secondary Effect~~secondary effects" come from [WRI/WBCSD, World Business Council on Sustainable Development / World Resources Institute. \(2005-\).](http://www.wri.org/publications/2005/01/050101.htm) The Greenhouse Gas Protocol for Project Accounting, *World Resources Institute*, Washington, DC. Available at <http://www.ghgprotocol.org>.

Table 4.1. Description of all Sources, Sinks, and Reservoirs

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
Primary Effect Sources, Sinks, and Reservoirs					
1. Soil Dynamics	Biogeochemical interactions occurring in the soil that produce emissions of nitrous oxide, as well as carbon dioxide (biogenic), and possibly methane.	N ₂ O	I	A method for quantifying direct N ₂ O emissions from an approved project activity, as provided in Section 5.3.1	The primary effect of a nitrogen management project is a reduction in nitrous oxide emissions from soil. ⁴⁶
		CO ₂	E	N/A	Changes in soil carbon stocks may result from implementation of a nitrogen management project activity; however, the effect is negligible since it is unlikely that growers will reduce N application rates such that crop yields are significantly reduced. It is conservative to not account for increases in soil carbon from increases in organic fertilizer (i.e., manure) application rates. The impact of project-related reductions in organic fertilizer application rates on stable soil organic carbon pools ⁴⁷ are likely going to be insignificant due to the small size of the expected change in organic N fertilization rate.
		CH ₄	E	N/A	Methane production and oxidation is insignificant for non-flooded soils.

⁴⁶ These N₂O emissions are referred to as “direct N₂O emissions from soils” by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

⁴⁷ Changes in organic fertilizer may significantly impact total soil organic carbon. However, due to aerobic carbon decomposition, only a small fraction of the added organic fertilizer is transformed into a carbon pool that is stable during the permanence period (100 years).

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
2. Leaching, Volatilization, and Runoff	Leaching, volatilization, and runoff of applied nitrogen, followed by denitrification into N ₂ O. ⁴⁸	N ₂ O	I	IPCC emission factor methodology, as provided in Section 5.3.2	Also a primary effect of nitrogen management projects, this may be a significant portion of overall N ₂ O emission reductions, due to the project's reduction in losses of total N from the project field.
Secondary Effect Sources, Sinks, and Reservoirs					
3. GHG Emissions from Cultivation Equipment	Fossil fuel emissions from equipment used for field preparation, seeding, fertilizer/pesticide/herbicide application, and harvest.	CO ₂	I	Method in Section 5.4.1	Emissions may be significant if management requires an increase in the use of cultivation equipment or a change in the type of equipment required (e.g. increased number of fertilizer applications). Increased emissions due to project activity must be accounted for. Decreased emissions due to project activity are not accounted for, to be conservative and to avoid double counting under a cap (e.g. in regions such as California where emissions from transportation fuels will be capped).
		CH ₄	E	N/A	Excluded, as this emission source is assumed to be very small.
		N ₂ O	E	N/A	Excluded, as this emission source is assumed to be very small.
4. GHG Emissions from Irrigation	Changes to nutrient nitrogen management practices may require changes to the field's irrigation system. As irrigation water pumping and transport requires energy, certain nutrient nitrogen management changes may increase energy use for irrigation and lead to energy-related GHG emissions.	CO ₂	E	N/A	Excluded, as currently approved project activities are not expected allowed to result use irrigation, except in an emergencies, and as such any increase in water usage or changes to the irrigation system are not likely to be due to the project .
		N ₂ O	E		
		CH ₄	E		

⁴⁸The IPCC National Inventory Guidelines refer to the N₂O emissions from leaching, volatilization, and runoff (LVRO) as "indirect N₂O emissions" because these emissions typically occur off-site due to denitrification of the N lost from the project site due to LVRO.- Reductions in "indirect N₂O emissions" are still considered reductions in "primary effect" emissions because reducing N-losses from the project site is one of the primary goals of the approved project activity "(reducing N-rate-"). Reductions of these "indirect" N₂O emissions" are not to be confused with "indirect emission reductions" or "secondary effect emission reductions," (e.g. emission reductions occurring outside the control of the project participant). To avoid confusion, this protocol refers to emissions from leaching, volatilization, and runoff as emissions from "LVRO," instead of "indirect N₂O emissions."

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
5. GHG Emissions from Off-Site Storage of Manure	Indirect emissions from changes in storage of manure at the facilities from which the manure originates.	N ₂ O	I (if storage increased) or E (if storage decreased)	Method in Section 5.5.2 N/A	As a waste product, the supply of manure is relatively inelastic. A significant reduction of total organic N land applied to land will not result in any less organic N produced, but rather , may lead to the shifting of the end-of-life fate of manure across the landscape and a. The most likely increase in off-site end-of-life fate for manure storage (e.g. manure storage onsite at facilities from which the manure originates, such as dairy farms). If is to be land-applied elsewhere, resulting in no real reductions in organic N applied, due to the project maintains, or increases the total amount of organic N applied (at the in a worst-case scenario, manure may spend more time in storage before being land-applied. The reverse is also true; an increase in organic N application is likely to result in a reduction in organic N applied elsewhere (or a reduction in storage), leading to little or no net change in N₂O emissions. Changes in organic N application therefore do not need to be included in project/aggregate level), it is conservative to exclude this source, as the total manure stored off-site will likely decrease. accounting.
		CH ₄	I (if storage increased) or E (if storage decreased)	ers (frequently re5.5.2 N/A	
		CO ₂	E	N/A	

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
6. GHG Emissions from Fertilizer Transportation	Changes to nutrient nitrogen management practices may include increasing proportions of organic to synthetic N applied. An increase in the amount of organic N applied may increase emissions from transporting that fertilizer. ⁴⁹	CO ₂	I E	Method in Section 5.5.3 N/A	Included only when the total amount of organic N applied (at the aggregate level) increases, resulting in an increase in vehicle miles traveled per ton of N applied. Because organic N fertilizers have a greater weight per unit N compared to synthetic fertilizers, emissions from organic N transportation are higher compared to emissions from synthetic N transportation when organic N transportation distances exceed ~5 miles. However, GHG emissions from organic N transportation are not included because any increases in organic N inputs will not likely be due to the project. Furthermore, since the supply of organic N is mostly inelastic, organic N will be transported regardless of absence or presence of the project.
		N ₂ O	E	N/A	Excluded, as this emission source is assumed to be very small.
		CH ₄	E	N/A	Excluded, as this emission source is assumed to be very small.
7. GHG Emissions from Shifted Production (Leakage)	Increases in production outside the project area, sometimes referred to as Indirect Land Use Change , "indirect land use change," may occur if yields are significantly and negatively affected by a project activity.	CO ₂	I	Method in Section 1.1.1	If aggregate level yields are found to have statistically decreased due to project activities, there is an assumed increase in GHG emissions from shifted production that must be estimated and included.
		CH ₄	I	Method in Section 5.5.4	
		N ₂ O	I	Method in Section 5.5.4	
8. GHG Emissions from Synthetic Fertilizer Production	Decreases in use of synthetic N fertilizer on fields may affect the amount of synthetic fertilizer produced and indirectly cause reduction of GHGs associated with fertilizer production.	CO ₂	E	N/A	It is conservative to exclude this category because, in all cases, emissions from this SSR will decrease. Also, the source is "indirect," meaning that reductions take place off-site, and are difficult to link directly to project activities of a single field. Finally, in
		N ₂ O	E	N/A	

⁴⁹ Organic N weighs more per unit of N than synthetic N, resulting in more GHG emissions per unit of N applied, and it is distributed less efficiently than commercial synthetic fertilizer.

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
		CH ₄	E	N/A	some regions, emissions from fertilizer production will be directly regulated under a capped industry and including this source would lead to double counting.
9. GHG Emissions from Production and Use of Chemical Inputs	Changes in nutrient management practices may impact how much lime or herbicides are used on fields	CO ₂	E	N/A	Excluded, as approved project activities are unlikely to materially increase the use of lime or herbicides used on fields. The very small changes in herbicide and/or lime demand due to nitrogen management projects are unlikely to have an effect on herbicide and/or lime production.
		N ₂ O	E		
		CH ₄	E		

5 Quantifying GHG Emission Reductions

GHG emission reductions from a nitrogen management project are quantified by comparing actual project emissions to baseline emissions related to nitrogen management. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the nitrogen management project. Project emissions are actual GHG emissions that occur from sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions. GHG emission reductions are calculated separately for each individual field, and, in the case of an aggregate, summed together over the entire aggregate. The calculation approach in this section is applicable to single-field projects and aggregates.

Project emission reductions must be quantified and verified on an annual basis, reflecting a reduction in annual N rate over a complete cultivation cycle. The length of time over which GHG emission reductions are quantified and verified is called the "reporting period." For reporting purposes, the reporting period must be uniformly defined for the aggregate, with a start date chosen by the aggregator (i.e. an aggregator may choose for the reporting period to start on any date during the year, with all subsequent reporting periods following the same annual cycle). Individual fields within an aggregate may have cultivation cycles that start on different dates; however, the cultivation cycles for all fields within an aggregate must be complete before the aggregate is able to undergo verification. To ensure that only emission reductions occurring during an aggregate's fixed reporting period is credited during that reporting period, emission reductions from each field shall be prorated, according to the methodology in Section 7.3.3. For single-field projects, the reporting period shall be defined using the exact dates corresponding to the beginning and the end of the cultivation cycle for the particular field.

The primary effect of a nitrogen management project is the total reduction in direct N₂O emissions from soil (SSR 1) and in N₂O emissions from leaching, volatilization, and runoff (LVRO, SSR 2), due to implementation of an approved project activity (a reduction in N application rate).

In addition to the primary effect (SSR 1 and 2), nitrogen management projects may result in unintended increases of GHG emissions from other SSRs. Section 5.4 provides requirements for calculating these secondary effect GHG emissions resulting from the project activity.

Total emission reductions from a project are equal to the combined primary emission reductions from SSR 1 and 2 for all fields in the project area, minus the increase in emissions from all other SSRs due to the project activity- (secondary effects). Total net GHG reductions for a reporting period are calculated by subtracting actual project emissions from baseline emissions ~~from actual emissions~~ for all SSRs over the reporting period, as prescribed in Sections 5.2 to 5.4. Equation 5.1 below provides the general GHG reduction calculation.



Figure 5.1. Equation Organizational Chart

Equation 5.1. GHG Emission Reductions

$$ER = PER - SE$$

Where,

Units

ER	=	Total emission reductions from the project area for the reporting period	Mg CO ₂ e
PER	=	Total primary effect GHG emission reductions over the entire project area, see Section 0	Mg CO ₂ e
SE	=	Total secondary effect GHG emissions caused by project activity during the reporting period for the entire project aggregate, ⁵⁰ see Section 5.4	Mg CO ₂ e

5.1 Applicability Conditions for N Rate Reduction Projects

The following applicability conditions must be met for all fields implementing the approved project activity: reducing N rate in corn cropping systems in the NCR.⁵¹

1. The project area shall not contain any organic soils (e.g. histosols).⁵²
2. N₂O emissions reductions from reducing N rates of The mean annual temperature on all fields in the project area must be between 600 mm and 1200 mm (see Figure 5.2 below).⁵³
3. The project area shall not include irrigated corn cropping systems. However, emergency irrigation to prevent crop failure in years of severe drought will be allowed in systems that are typically not irrigated.⁵⁴
4. The project area shall not include tile-drained fields.
- 2-5. Both synthetic and as well as organic fertilizer N sources must be accounted for may be applied to project fields. However, only N₂O emission reductions from reductions in the synthetic N rate shall be credited. Synthetic fertilizers⁵⁵ may be applied in dry form (e.g. granular urea, ammonium nitrate) or liquid form (e.g. urea ammonium nitrate, UAN). Eligible organic Organic fertilizers may be liquid or solid, and may include unprocessed manure (e.g. beef cattle manure, hog manure, digester effluent and/or solids), other unprocessed organics (e.g. compost) and processed

⁵⁰ Throughout Section 5, equations will distinguish between calculations which must be performed at the field versus aggregate level. For a single-field project, the entire project area is comprised of only the single field. As such, in this section, when guidance is provided for the aggregate, but not the single-field project, the guidance should be assumed to apply to both.

⁵¹ "Corn cropping systems" includes both corn grown for grain and corn grown for silage.

⁵² See USDA-NRCS, Keys to Soil Taxonomy. http://soils.usda.gov/technical/classification/tax_keys/

⁵³ This precipitation range was constrained by a sensitivity analysis. Figure XX was developed based on data from the NOAA Climate Prediction Center. The area-weighted average of mean annual precipitation was determined for each county in the NCR. Source: CPC US Unified Precipitation data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at <http://www.esrl.noaa.gov/psd/>

⁵⁴ Verifiers (e.g. the agronomist on the verification team) shall use professional judgment to assess whether the local weather in the reporting year was dry enough to consider emergency irrigation necessary.

⁵⁵ Even though urea is technically an "organic" fertilizer, it is considered a "synthetic" fertilizer for the purposes of this protocol.

commercial organic fertilizers. On any particular field, a number of different fertilizer types can be applied.

6. Total organic N applied may increase or decrease in the project area, ~~but total synthetic N applied may not increase on any one field. As defined in Table 2.1, However,~~ total annual N applied (synthetic and organic) must decrease below baseline levels. Only reductions in synthetic N rate shall generate creditable emission reductions under this protocol.

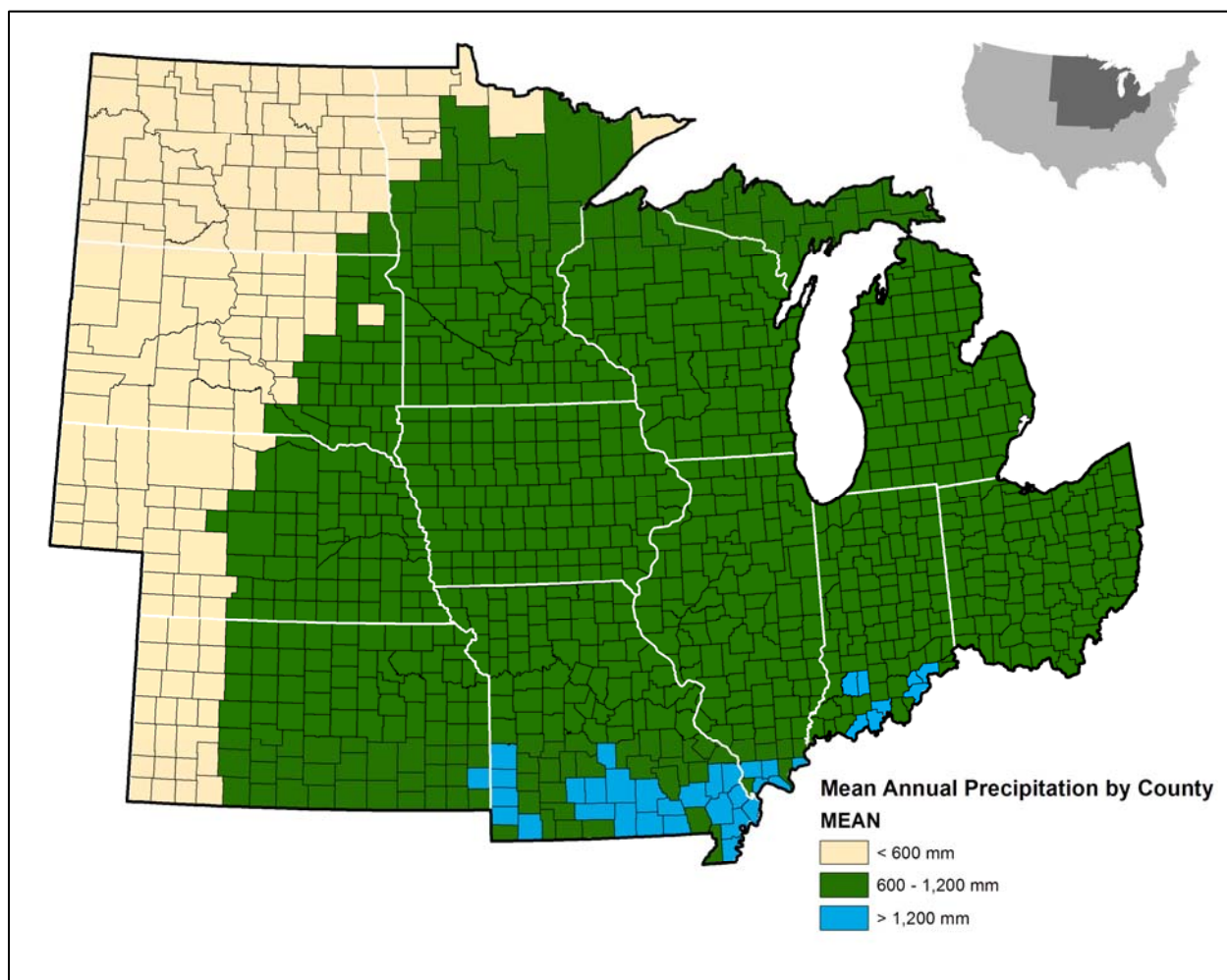


Figure 5.2. Map of Mean Annual Precipitation per County in the North Central Region (Green denotes eligible counties.)

5.2 Determining Baseline and Project N Rates

3. A baseline N rate ($NR_{B,i}$) and project N rate ($NR_{P,i}$), used to calculate baseline and project N_2O emissions for N rate reduction projects shall be calculated separately for each individual field. The process for calculating the total annual N rate, and total annual synthetic and organic N rates respectively, is the same for any given year, whether that year is one of the eligible crop years in the baseline look-back period or a reporting period during the project-crediting period of the project. Section 5.2.3 provides equations to determine a field's N rate in terms of kg N per hectare for each different type of fertilizer, based on information

typically more readily available to the project participant (such as fertilizer mass and volume). The parameters calculated in Section 5.2.3, combined with the guidance below, are then used in the equations in Section 0.

5.2.1 Determining the Baseline N Rate

The baseline N rate ($NR_{B,f}$) is calculated using the equations in Section 5.2.3 below, and is used in Equation 5.9 and Equation 5.11. The baseline N rate shall be based on a historic average N rate value calculated using N rate data from all eligible crop years within at least the five years prior to a field's start date. If less than three eligible crop years were planted in the five years prior to the field's start date, the historical look-back period shall be extended until at least three eligible crop years are included.⁵⁶ Once the appropriate baseline look-back period is identified, the respective annual N rates for both synthetic and organic N sources for each eligible crop year must be calculated using Equation 5.3 through Equation 5.8, in Section 5.2.3.

5.2.2 Determining the Project N Rate

For each reporting period, the project N rate ($NR_{P,f}$) is calculated using Equation 5.3 through Equation 5.8, in Section 5.2.3 below. The project N rate is subsequently used in Equation 5.10 and Equation 5.12. The respective annual N rates for both synthetic and organic N sources for each eligible crop year must be calculated according to Section 5.2.3.

If the project organic N rate ($NR_{P,O,f}$) is equal to or greater than the baseline organic N rate ($NR_{B,O,f}$), the total project N rate ($NR_{P,f}$) must be calculated as the sum of project synthetic and project organic N rates ($NR_{P,S,f}$ and $NR_{P,O,f}$) in Equation 5.12.⁵⁷

If the project organic N rate ($NR_{P,O,f}$) is less than the baseline organic N rate ($NR_{B,O,f}$), the baseline organic N rate ($NR_{B,O,f}$) must be used instead of the project organic N rate ($NR_{P,O,f}$) in Equation 5.12.

5.2.5.2.3 Determining N Content of Fertilizer N Rates Application

This section provides equations to determine each field's respective N rate in terms of kg N per hectare for each different type of fertilizer, using information more readily available to the project participant (such as fertilizer mass and volume). These equations shall be used for both the baseline and project, as necessary, to calculate necessary values in Equations 5.3 and 5.4, which in turn produce values necessary for use in Equations 5.9 to 5.12 below.

Regardless of whether baseline ($NR_{B,f}$) or project ($NR_{P,f}$) N rates are being calculated, the total N rate for a field f is calculated as the sum of N rates of synthetic and organic fertilizer N, calculated as indicated in the general equation below- (Equation 5.2).

⁵⁶ For example, if the cropping sequence prior to the project start is corn-soybean-corn-soybean-corn, and all corn cropping years are eligible, a look-back period of five years suffices. However, if the cropping sequence prior to the project start is soybean-corn-soybean-corn-soybean, the look-back period shall be extended until one more corn cropping year is included.

⁵⁷ This approach conservatively disallows the quantification of N₂O emission reductions from reducing organic N rate, while ensuring the largest N₂O emission reductions from reducing synthetic N rate, by taking full advantage of the exponential N₂O response at higher total N rates.

Equation 5.2. Total Fertilizer N Rate for Field f

$$NR_f = NR_{S,f} + NR_{O,f}$$

Where,

Units

NR_f	=	Total fertilizer N rate for field f	kg N/ha
$NR_{S,f}$	=	N rate of total synthetic fertilizer for field f , see Equation 5.3	kg N/ha
$NR_{O,f}$	=	N rate of total organic fertilizer for field f , see Equation 5.64	kg N/ha

The total synthetic fertilizer N rate for a particular field is calculated as the sum of N rates of all dry and liquid synthetic N sources and calculated in Equation 5.3 below.

Equation 5.3. Synthetic Fertilizer N Rate for Field f

$$NR_{S,f} = \sum_j NR_{DS,j,f} + \sum_j NR_{LS,j,f}$$

Where,

Units

$NR_{S,f}$	=	N rate of total synthetic fertilizer for field f	kg N/ha
$NR_{DS,j,f}$	=	N rate of dry synthetic fertilizer type j on field f , see Equation 5.5	kg N/ha
$NR_{LS,j,f}$	=	N rate of liquid synthetic fertilizer type j on field f , see Equation 5.6	kg N/ha

The total organic fertilizer N rate for a particular field is calculated as the sum of N rates of all solid and liquid (slurry) organic N sources and calculated in Equation 5.4 below.

Equation 5.4. Organic Fertilizer N Rate for Field f

$$NR_{O,f} = \sum_j NR_{SO,j,f} + \sum_j NR_{LO,j,f}$$

Where,

Units

$NR_{O,f}$	=	N rate of total organic fertilizer for field f	kg N/ha
$NR_{SO,j,f}$	=	N rate of solid organic fertilizer type j on field f , see Equation 5.7	kg N/ha
$NR_{LO,j,f}$	=	N rate of liquid organic fertilizer type j on field f , see Equation 5.8	kg N/ha

Fertilizer N rates used in the equations throughout in this protocol are in [kg N/ha]. ~~This section provides~~ Use the following guidance ~~on to determine~~ how to convert project participants' reported synthetic and organic fertilizer N rates to kg N/ha, yielding values for $NR_{DS,j,f}$, $NR_{LS,j,f}$, $NR_{SO,j,f}$ and $NR_{LO,j,f}$.

In general, the amount of N-containing fertilizer is multiplied by the N ~~content concentration~~ (NC_i) of the fertilizer, and relevant conversions to SI- units are applied. Equation 5.5, ~~and~~ Equation 5.6 ~~and Equation 5.7~~ show calculations for fertilizer N rates for dry N-containing synthetic fertilizers, ~~and~~ liquid N-containing synthetic fertilizers, ~~and respectively, which are used in~~ Equation 5.3, ~~above, while~~ Equation 5.7 ~~and~~ Equation 5.8 ~~show calculations for fertilizer N rates for solid~~ N-containing organic fertilizers, ~~respectively and liquid N-containing organic fertilizers, respectively, which are used in Equation 5.4, above.~~ Default information on N ~~contents concentrations~~ and weights of various N-containing fertilizers is provided in ~~Appendix A,~~

Table A.2, although farm management records, commercial fertilizer labels, and N soil tests /or laboratory tests on the N content of organic sources are preferable, when available, as discussed further in Section 6.

Equation 5.5. Fertilizer N Rates of Dry N-Containing Synthetic Fertilizer j

$$NR_{DS,j,f} = \frac{MF_{DS,j,f} \times NC_j \times 0.454}{0.405}$$

Where,

		Units
$NR_{DS,j,f}$	= N rate of dry synthetic fertilizer j for field f	kg N/ha
$MF_{DS,j,f}$	= Mass of dry synthetic N-containing fertilizer j applied to field f	lbs fertilizer/acre
NC_j	= N <u>content/concentration</u> of fertilizer j , see Table A.2 ⁵⁸	lbs N/(lbs fertilizer)
0.454	= Factor to convert lbs to kg	
0.405	= Factor to convert acre to ha	

Equation 5.6. Fertilizer N Rates for Liquid N-Containing Synthetic Fertilizer j

$$NR_{LS,j,f} = \frac{VF_{LS,j,f} \times MF_{LS,j} \times NC_j \times 0.454}{0.405}$$

Where,

		Units
$NR_{LS,j,f}$	= N rate of liquid synthetic fertilizer j for field f	kg N/ha
$VF_{LS,j,f}$	= Volume of liquid synthetic N-containing fertilizer j applied to field f	gallons/acre
$MF_{LS,j}$	= Mass of liquid synthetic fertilizer j per gallon of fertilizer ⁵⁹	lbs fertilizer/gallon
NC_j	= N <u>content/concentration</u> of fertilizer j , see Table A.2	lbs N/(lbs fertilizer)
0.454	= Factor to convert lbs to kg	
0.405	= Factor to convert acre to ha	

Similarly, the total solid and liquid organic fertilizer N rate for a particular field is calculated as the sum of N rates of all organic N sources and calculated using the equation below.

Equation 5.7. Fertilizer N Rates for Solid N-containing Organic Fertilizer N-Rate for Field f

$$NR_{O,f} = \sum_j (NR_{O,j,f}) \quad NR_{SO,j,f} = \frac{MF_{SO,j,f} \times NC_j \times 0.454}{0.405}$$

Where,

		Units
$NR_{O,f}$	= N-rate of total organic fertilizer for field f	kg N/ha
$NR_{O,j,f}$	= N-rate of organic fertilizer j on field f , see Equation 5.7	kg N/ha

⁵⁸ Fertilizer N contents, fertilizer weights and unit conversion factors are adopted from:

www.mn.nrcs.usda.gov/technical/ecs/nutrient/planning/conversion%20factors/conversionfactors3.pdf

⁵⁹ Fertilizer N contents, fertilizer weights and unit conversion factors are adopted from:

www.mn.nrcs.usda.gov/technical/ecs/nutrient/planning/conversion%20factors/conversionfactors3.pdf

Equation 5.7. Calculating Fertilizer N Rates for N-Containing Organic Fertilizer j

$$NR_{O,j,f} = \frac{MF_{O,j,f} \times NC_j \times 0.454}{0.405}$$

Where,

Units

$NR_{O,j,f}$	=	N rate of organic fertilizer j for field f	kg N/ha
$MF_{O,j,f}$	=	The mass of organic N-containing fertilizer j applied to field f	lbs fertilizer/acre
NC_j	=	The N content <u>concentration</u> of organic fertilizer j , see Table A.2 ⁶⁰	lbs N/ <u>1</u> lbs fertilizer)
0.454	=	Factor to convert lbs to kg	
0.405	=	Factor to convert acre to ha	

5.3 ~~Determining Baseline N Rates for Calculating Baseline N₂O Emissions from N Rate Reduction Projects~~

A baseline N rate to calculate N₂O emissions from N rate reduction projects shall be calculated separately for each individual field in an aggregate using the approach below.

Step 1: ~~Determine the historical look-back period and collect historical yield and N rate data.~~ A historic average RTA value must be calculated for each individual field in a project using data from all eligible crop years during a period of at least 5 years prior to the field's start date. In case less than 3 eligible crop years were planted in the 5 years prior to the field's start date, the historical look-back period shall be extended until at least 3 eligible crop years are included.⁶¹ From the historical look-back period, and for each of the eligible crop years, identify the total N rate, including mineral and organic fertilizer as well as the historical cropping yields.

Step 2: ~~Calculate the historical average RTA.~~ Using the field's historical yield and N rate data, calculate the RTA value for the field for each of the eligible crop years in the historical look-back period, according Equation 5.8 below, and then average the RTA values to determine the "historical average RTA" for that field.

⁶⁰ For processed commercial organic fertilizer, N contents following ~~manufacturers~~manufacturers' specification can be used. For unprocessed manure, default manure N contents are shown in Table A.2 in Appendix A ~~and are consistent with Edmonds et al. (2003) cited in U.S. EPA. 2011. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009. EPA 430 R-11-005. Washington, D.C.: U.S. Environmental Protection Agency.~~

⁶¹ For example, if the cropping sequence prior to the project start is Corn-Soybean-Corn-Soybean-Corn, and all corn cropping years are eligible, a look-back period of 5 years suffices. However, if the cropping sequence prior to the project start is Soybean-Corn-Soybean-Corn-Soybean, the look-back period shall be extended until one more corn cropping year is included.

Equation 5.8. Equation to Calculate a Field's Historical RTA Fertilizer N Rates for Liquid N-Containing Organic Fertilizer j

$$RTA_{Hist,f,e} = \frac{\sum_{t=1}^n RTA_{f,e,t}}{n} NR_{LO,j,f} = \frac{VF_{LO,j,f} \times MF_{LO,j,f} \times NC_j \times 0.454}{0.405}$$

$$RTA_{f,e,t} = \frac{Y_{f,e,t} \times NC_e}{NR_{f,e,t} NC_j} \quad \text{(Equation 3.1)}$$

Where,

Units

RTA_{Hist}	$NR_{LO,j,f,e}$	=	Historical RTA-calculated N rate of liquid organic fertilizer j for field f and crop e ⁶²	kg N/ha
N		=	Number of eligible crop years available in the historical look-back period	
$RTA_{f,e,t}$	$VF_{LO,j,f}$	=	Annual RTA calculated for field f , crop e , and over time t . This equation was repeated from Equation 3.1 Volume of liquid organic N-containing fertilizer j applied to field f	gallons/acre
$Y_{f,e,t}$	$MF_{LO,j,f}$	=	Annual yield on field f and crop e over time t The mass of organic N-containing fertilizer j applied to field f	unit*/halbs fertilizer/gallon
NC_e		=	N content for crop e based on default look-up Appendix A	kg N/unit
$NR_{f,e,t}$	NC_j	=	Annual total nitrogen application rate (including organic and synthetic forms of N) on field f and crop e over time t The N content of organic fertilizer j , see Table A.2 ⁶³	kg N/halbs N / lbs fertilizer
0.454		=	Factor to convert lbs to kg	
0.405		=	* Unit could be bushels or other measure of crop biomass. To Factor to convert from unit/acre to unit/ha, divide by 0.405	

Step 3: Determine whether the historical baseline N rate or a default baseline N rate shall be used. Look up the relevant state- and crop-specific “RTA default” in Table A.9 in Appendix A ($RTA_{e,s}$) and compare the threshold to the historic average RTA for the field.

If the historic average RTA, $RTA_{Hist,f,e}$, determined in step 2, is greater than or equal to the relevant state- and crop-specific default RTA then the historic baseline N rate for the field shall be used to calculate baseline N_2O emissions (i.e. $NR_{B,f}$ from Equation 5.9).

Equation 5.9. Equation to Calculate Baseline N Rate if the Historical Average RTA is Greater than or Equal to the Performance Threshold

⁶² Crop e refers to the specific crop being grown on the field f . In the current version of the NMPP protocol, crop e essentially differentiates between corn for grain or silage. For the calculation of the RTA, it is important to distinguish between corn for grain versus corn for silage because the amount of N removed by harvest differs between the two crops. In contrast, the quantification of N_2O emissions and emission reductions is the same for corn for grain and corn for silage, and as such, no subscript e is used in the equations in Sections 5.4 to 5.5.2.

⁶³ For processed commercial organic fertilizer, N contents following manufacturers specification can be used. For unprocessed manure, default manure N contents are shown in Table A.2 in Appendix A and are consistent with Edmonds et al. (2003) cited in U.S. EPA. 2011. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. EPA 430-R-11-005. Washington, D.C.: U.S. Environmental Protection Agency.

$$NR_{B,f,\epsilon} = \frac{\sum_{t=1}^n NR_{f,\epsilon,t}}{n}$$

Where,

Units

$NR_{B,f,\epsilon}$	=	Baseline N rate for field f , crop ϵ	kg N/ha
n	=	Number of eligible crop years available in the historical look-back period	
$NR_{f,\epsilon,t}$	=	Annual total nitrogen application rate (including organic and synthetic forms of N) on field f and crop ϵ over time t	kg N/ha

If the historic average RTA, $RTA_{Hist,f,\epsilon}$, determined in step 2, is less than the relevant state and crop-specific default RTA in Table A.9 then a default N rate shall be used to calculate baseline N_2O emissions. The default baseline N rate shall be derived from the relevant default RTA and the field's historic average yield.

Equation 5.10. Equation to Calculate Baseline N Rate if the Historical Average RTA is Less than or Equal to the Performance Threshold

$$NR_{B,f,\epsilon} = \frac{\sum_{t=1}^n Y_{f,\epsilon,t}}{n} \times \frac{NC_{\epsilon}}{RTA_{\epsilon,S}}$$

Where,

Units

$NR_{B,f,\epsilon}$	=	Baseline N rate for field f , crop ϵ	kg N/ha
n	=	Number of eligible crop years available in the historical look-back period	
$Y_{f,\epsilon,t}$	=	annual yield for field f and crop ϵ grown over year t .	unit*/ha
NC_{ϵ}	=	N content for crop ϵ based on default look-up Appendix A	kg N/unit
$RTA_{\epsilon,S}$	=	State and crop-specific RTA performance threshold. Available from Table A.8 in Appendix A	

* Unit could be bushels or other measure of crop biomass. To convert from unit/acre to unit/ha, divide by 0.405

5.3 ~~Calculating the~~Determining Primary Effect N_2O Emission Reductions for N Rate Reduction Projects in Corn Crops

5.4 This section provides the calculation method for primary effect N_2O emission reductions for N rate reduction projects in corn crops in the North Central Region of the United States.

5.4.15.3.1 ~~Calculating~~ Baseline and Project Direct N_2O Emissions from Soils⁶⁴ (SSR 1)

The baseline direct N_2O emissions are calculated ~~based on using~~ the baseline N rate and the MSU-EPRI Tier 2 ~~emission~~emission factor developed for the project activity “(N rate reduction)”

⁶⁴ As noted in Section 4, SSR 1 refers to the N_2O emissions from soil dynamics or, to follow IPCC nomenclature, refers to the “direct N_2O emissions from soils.”

in corn cropping systems in the North Central Region of the U.S.⁶⁵ ~~Where organic N constitutes part of the total N rate, a correction factor (i.e. 0.8) applies to account for lower N₂O emissions from organic N.~~⁶⁶ See Equation 5.11 below.

Equation 5.9. Direct Baseline N₂O Emissions from Soils for Field *f*

$$N_2O_{Dir,B,f} = (NR_{B,S,f} + NR_{B,O,f} \times 0.8) NR_{B,f} \times EF_{Dir,B,f} \times \frac{44}{28} \times \frac{310}{1000}$$

$$EF_{Dir,B,f} = \frac{0.67 \times (e^{(0.0067 \times (NR_{B,S,f} + NR_{B,O,f} \times 0.8))} - 1)}{(NR_{B,S,f} + NR_{B,O,f} \times 0.8)} \times \frac{0.67 \times (e^{(0.0067 \times NR_{B,f})} - 1)}{NR_{B,f}}$$

Where⁶⁷:

		Units
N ₂ O _{Dir,B,f}	= Annual baseline direct N ₂ O emissions from field <i>f</i>	Mg CO ₂ e/ha
NR _{B,S,f}	= <u>Total baseline N rate of total synthetic fertilizer</u> for field <i>f</i>	kg N/ha
NR _{B,O,f}	= <u>N rate of total organic fertilizer for field <i>f</i></u>	kg N/ha
EF _{Dir,B,f}	= Emission factor for baseline direct N ₂ O emissions from baseline N inputs	kg N ₂ O-N/(kg N input)
0.844/28	= <u>Correction factor to account for lower manure-induced emissions compared to fertilizer-induced emissions</u> ⁶² <u>Unit conversion from kg N₂O-N to kg N₂O, where 44 is the molecular weight of N₂O and 28 is twice the atomic weight of N</u>	
310	= Global <u>Warming Potential</u> <u>warming potential</u> of N ₂ O	
1000	= <u>Converts</u> <u>Conversion of</u> kg CO ₂ e/ha to Mg CO ₂ e/ha	

Similarly, the project direct N₂O emissions are calculated based on the project total N rate applied during the cultivation cycle, and the MSU-EPRI Tier 2 emission~~emission~~ factor ~~and a correction factor to account for lower N₂O emissions from organic N.~~ See Equation 5.10 below.

⁶⁵ Millar, ~~Neville,~~ et al., “(2012). Quantifying N₂O Emissions Reductions in U.S. Agricultural Crops through Nitrogen Fertilizer Rate Reduction,” Version 1.4.6, 25 Jan 2012, ~~Developed by,~~ Michigan State University and Electric Power Research Institute, Undergoing 2nd Assessment with Verified Carbon Standard.

⁶⁶ ~~The MSU-EPRI Tier 2 emission factor is based on experimental data from fields where only synthetic fertilizer N was applied. However, bottom-up and top-down approaches estimated that manure induces, on average, 20 percent less N₂O emissions compared to synthetic N. More specifically, a compilation of field measurements indicated that direct N₂O emissions from soil were 1 percent of synthetic N and 0.8 percent of manure N (Bouwman et al. 2002), while Davidson (2009) estimated that 2.0 percent of manure N and 2.5 percent of synthetic N was converted to nitrous oxide based on time series of atmospheric N₂O concentrations and industry trends between 1860 and 2005. Therefore, a correction factor of 0.8 is used in this protocol when estimating N₂O emissions from organic N using the MSU-EPRI Tier 2 emission factor. Note that the study by Davidson (2009) includes N₂O emissions from N leaching and volatilization and manure-derived N₂O emissions associated with storage and handling of manure, in addition to direct N₂O emissions, explaining the higher values for the percentage of manure and synthetic N-derived N₂O compared to Bouwman et al. (2002).~~

⁶⁷ ~~Throughout the protocol, the factor 44/28 is a unit conversion from kg N₂O-N to kg N₂O, where 44 is the molecular weight of N₂O and 28 is twice the atomic weight of N.~~

Equation 5.10. Direct Project N₂O Emissions from Soils for Field *f*

$$N_2O_{Dir,P,f} = (\cancel{NR_{P,S,f}} + \cancel{NR_{P,O,f}} \times 0.8)(NR_{P,S,f} + NR_{P,O,f}) \times EF_{Dir,P,f} \times \frac{44}{28} \times \frac{310}{1000}$$

$$EF_{Dir,P,f} = \frac{0.67 \times \left(\frac{e^{(\cancel{NR_{P,S,f}} + \cancel{NR_{P,O,f}} \times 0.8)} - 1}{\cancel{NR_{P,S,f}} + \cancel{NR_{P,O,f}} \times 0.8} \right) (e^{(NR_{P,S,f} + NR_{P,O,f})} - 1)}{(NR_{P,S,f} + NR_{P,O,f} \times 0.8)}$$

Where,⁶⁸

Units

$N_2O_{Dir,P,f}$	=	Annual project direct N ₂ O emissions from field <i>f</i>	Mg CO ₂ e/ha
$NR_{P,S,f}$	=	N rate of total Total project synthetic fertilizer N rate for field <i>f</i>	kg N/ha
$NR_{P,O,f}$	=	N rate of total organic fertilizer for field <i>f</i> Total project organic N rate for field <i>f</i> (If the project organic N rate is smaller than the baseline organic N rate, use $NR_{B,O,f}$ instead of $NR_{P,O,f}$ in this equation.)	kg N/ha
$EF_{Dir,P,f}$	=	Emission factor for project direct N ₂ O emissions from project N inputs	kg N ₂ O-N/(kg N input)
$0.844/28$	=	Correction factor to account for lower manure-induced emissions compared to fertilizer-induced emissions ⁵² Unit conversion from kg N ₂ O-N to kg N ₂ O, where 44 is the molecular weight of N ₂ O and 28 is twice the atomic weight of N	
310	=	Global Warming Potentialwarming potential of N ₂ O	
1000	=	ConvertsConversion of kg CO ₂ e/ha to Mg CO ₂ e/ha	

5.4.25.3.2 Calculating Baseline and Project N₂O Emissions from Leaching, Volatilization, and Run-OffRunoff (SSR 2)

N₂O emissions from leaching, volatilization, and ~~run-off~~runoff (LVRO)⁶⁹ of N must be accounted for in determining primary effect GHG reductions. Baseline N₂O emissions from LVRO are determined according to Equation 5.11 below.

⁶⁸ Throughout the protocol, the factor 44/28 is a unit conversion from kg N₂O-N to kg N₂O, where 44 is the molecular weight of N₂O and 28 is twice the atomic weight of N.

⁶⁹ As noted in Section 4, the IPCC refers to these emissions as "indirect N₂O emissions."

Equation 5.11. Baseline N₂O Emissions from ~~Leaching, Volatilization, and Run-Off~~ (LVRO) for Field *f*⁷⁰

$$N_2O_{LVRO,B,f} = \left(\left((NR_{B,S,f} \times 0.10 + NR_{B,O,f} \times 0.20) \times 0.01 \right) + (NR_{B,f} \times Frac_{LEACH} \times 0.0075) \right) \times \frac{44}{28} \times \frac{1}{310 \div 1000}$$

Where,

Units

$N_2O_{LVRO,B,f}$	=	Annual baseline N ₂ O emissions from leaching, volatilization, and run-off (LVRO) from field <i>f</i>	Mg CO ₂ e/ha
$NR_{B,S,f}$	=	Baseline N rate of total synthetic fertilizer for field <i>f</i>	kg N/ha
$NR_{B,O,f}$	=	Baseline N rate of total organic fertilizer for field <i>f</i>	kg N/ha
0.10	=	Frac _{GASF} , IPCC default factor, representing the The fraction of all synthetic fertilizer N inputs that volatilizes as NH ₃ and NO _x	
0.20	=	Frac _{GASM} , IPCC default factor, representing the The fraction of all organic fertilizer N inputs that volatilizes as NH ₃ and NO _x	
0.01	=	EF ₄ , IPCC default emission factor for N ₂ O emissions from atmospheric deposition of N on soil and water surfaces and subsequent volatilization	kg N ₂ O-N/(kg NH ₃ -N + kg NO _x -N)
$NR_{B,f}$	=	Baseline total N rate determined for field <i>f</i> , see Section 5.3.	kg N/ha
Frac _{Leach}	=	Fraction of N inputs (equal to 0.30) that is lost through leaching and runoff, in regions where leaching and runoff occurs, defined as where [Σ(rain in rainy season) - Σ (potential evaporation in same period)] > soil water holding capacity, or where irrigation (except drip irrigation) is employed	
0.0075	=	EF ₅ , IPCC default emission factor for N ₂ O emissions from N leaching and runoff	kg N ₂ O-N/(kg NO ₃ -N)
310	=	Global warming potential of N ₂ O	

Project N₂O emissions during the cultivation cycle from leached and volatilized N must be accounted for according to [Equation 5.12](#) below:

⁷⁰ ~~This~~The methodology (to calculate LVRO emissions) reflects the MSU-EPRI methodology's adaptation of the ~~IPCC's~~IPCC 2006 National GHG Inventory Guidelines for calculating LVRO emissions (Vol. 4 Ch. 11 Table 11.3). MSU-EPRI's adaptation excluded N₂O emissions from crop residue management from Equation 5.4411 and 5.12, as those ~~emission~~emission reductions are not eligible for crediting. The IPCC methodology accounts for differences in LVRO emissions from organic and synthetic fertilizers, so no correction factor is needed to account for potential increases in N₂O emissions from N volatilization in cases where the organic fertilizer increases as a project activity. IPCC default factors are used for Frac_{GASF}, EF₄, Frac_{LEACH} and EF₅.

Equation 5.12. Project N₂O Emissions from ~~Leaching, Volatilization, and Run-Off (LVRO)~~ for Field *f*⁷⁰

$$N_2O_{LVRO,P,f} = \left(\left((NR_{P,S,f} \times 0.10 + NR_{P,O,f} \times 0.20) \times 0.01 \right) + (NR_{P,f} \times Frac_{LEACH} \times 0.0075) \right) \left((NR_{P,S,f} \times 0.10 + NR_{P,O,f} \times 0.20) \times 0.01 \right) + ((NR_{P,S,f} + NR_{P,O,f}) \times Frac_{LEACH} \times 0.0075) \times \frac{44}{28} \times 310 \div 1000$$

Where,

Units

$N_2O_{LVRO,P,f}$	=	Annual project indirect N ₂ O emissions from field <i>f</i>	Mg CO ₂ e/ha
$NR_{P,S,f}$	=	Project N rate for total synthetic fertilizer for field <i>f</i>	kg N/ha
$NR_{P,O,f}$	=	Project N rate for total organic fertilizer for field <i>f</i> . (If the project organic N rate is less than the baseline organic N rate, use $NR_{B,O,f}$ instead of $NR_{P,O,f}$ in this equation.)	kg N/ha
$NR_{P,f}$	=	Project total N rate determined for field <i>f</i>	kg N/ha

* 0.10, 0.20, 0.01 and 0.0075 are IPCC defaults, as defined in Equation 5.11.

5.4.35.3.3 ~~Calculating the~~ Primary Effect Baseline and Project N₂O Emissions

Based on direct N₂O emissions from soil and N₂O emissions from LVRO from the baseline and the project, primary ~~effect~~ effect baseline and project GHG emissions for each field are calculated using Equation 5.13.

Equation 5.13. Primary Effect Baseline and Project GHG Emissions

$$N_2O_{B,f} = N_2O_{Dir,B,f} + N_2O_{LVRO,B,f}$$

$$N_2O_{P,f} = N_2O_{Dir,P,f} + N_2O_{LVRO,P,f}$$

Where,

Units

$N_2O_{B,f}$	=	Total annual baseline N ₂ O for field <i>f</i>	Mg CO ₂ e/ha
$N_2O_{Dir,B,f}$	=	Annual baseline direct N ₂ O emissions from field <i>f</i>	Mg CO ₂ e/ha
$N_2O_{LVRO,B,f}$	=	Annual baseline N ₂ O emissions from leaching, volatilization and runoff from field <i>f</i>	Mg CO ₂ e/ha
$N_2O_{P,f}$	=	Total annual project N ₂ O for field <i>f</i>	Mg CO ₂ e/ha
$N_2O_{Dir,P,f}$	=	Annual project direct N ₂ O emissions from field <i>f</i>	Mg CO ₂ e/ha
$N_2O_{LVRO,P,f}$	=	Annual project N ₂ O emissions from leaching, volatilization and runoff from field <i>f</i>	Mg CO ₂ e/ha

5.4.45.3.4 Adjusting Primary Effect GHG Reductions for Uncertainty

Box 5.1. Uncertainty in the NMPP

According to C-AGG's white paper on uncertainty, "When models are used, analyses of both structural and input uncertainty related to their use must be completed."⁷¹ For the NMPP, the Reserve intends to apply an uncertainty deduction methodology that is similar to that used in the Reserve's Rice Cultivation Project Protocol (RCPP). Input uncertainty for an empirical model (such as the MSU-EPRI model adapted for use in this version of the NMPP) is subject to less uncertainty than a biogeochemical model (such as the DNDC model used by the RCPP), simply because there are significantly fewer critical inputs. However, no additional field emissions measurement datasets for N rate trials are available at this time for the North Central Region, other than the robust dataset used to develop the MSU-EPRI methodology. With no independent field data, the Reserve cannot explicitly quantify the structural uncertainty of the quantification approach included in the NMPP at this time. The Reserve proposes to increase the uncertainty deduction used in the MSU-EPRI methodology, calculated using dependent data, by 25 percent to account for having no independent field data to evaluate the quantification approach. It is expected, however, that in the future independent data will become available to quantify the structural uncertainty explicitly, at which time the Reserve expects to adjust the NMPP's structural uncertainty deduction.

The total primary effect GHG reductions (Mg CO₂e) for the entire project area are calculated and adjusted for uncertainty in Equation 5.14. Equation 5.14 shall be applied in the same way to both single-field projects and aggregates, with the exception that the aggregate must sum the entire project area's GHG reductions (e.g. sum the GHG reductions from all fields).

Equation 5.14. Total Primary Effect GHG Reductions for the Project

$$PER = \sum_{f=1}^{nrFields} \mu_{struct,f} \times [(N_2O_{B,f} - N_2O_{P,f}) \times A_f]$$

Where,

		Units
PER	= Primary effect GHG reductions over the entire project area	Mg CO ₂ e
nrFields	= Number of fields included in the project area	
$\mu_{struct,f}$	= Accuracy deduction for structural uncertainty for field <i>f</i> (as determined in Equation 5.15)	
$N_2O_{B,f}$	= Total annual baseline N ₂ O for field <i>f</i>	Mg CO ₂ e/ha
$N_2O_{P,f}$	= Total annual project N ₂ O for field <i>f</i>	Mg CO ₂ e/ha
A_f	= Size of field <i>f</i>	ha

The value of $\mu_{struct,f}$ is calculated in two steps, so as to adjust for structural uncertainty, including measurement uncertainty of emission reductions. First, the uncertainty in emission reductions, $UNC_{PER,f}$, is calculated. Then, based on the value of $UNC_{PER,f}$ the accuracy deduction for structural uncertainty $\mu_{struct,f}$ can be determined. The two-step calculation is included in Equation 5.15.

⁷¹ C-AGG (Discussion Draft, February 2012). Executive Summary: Uncertainty in Models and Agricultural Offset Protocols.

Equation 5.15. Structural Uncertainty Deduction⁷²**Step 1:**

In case the project is located in Michigan:

$$UNC_{PER,f} = \frac{1}{\sqrt{nrFields}} \left(100 - 63 \times e^{-40 \times 10^{-6} \times NR_{P,f}^2} + 25 \right) \left(1 + \frac{32}{\sqrt{nrFields}} \right) (100 - 63 \times e^{-40 \times 10^{-6} \times NR_{P,f}^2})$$

Step 2:

In case the project is not located in Michigan:

$$UNC_{PER,f} < 15: \left(1 + \frac{32}{\sqrt{nrFields}} \right) (100 - 63 \times e^{-40 \times 10^{-6} \times NR_{P,f}^2} + 15)$$

$$\mu_{struct,f} = 1$$

In case $UNC_{PER,f} \geq 15$:

$$\mu_{struct,f} = 138 \times 10^{-7} \times \frac{UNC_{PER,f}^2}{395 \times 10^{-5} \times UNC_{PER,f} + 0.999}^{73}$$

Step 2:In case $UNC_{PER,f} < 15$: $\mu_{struct,f} = 1$ In case $UNC_{PER,f} \geq 15$: $\mu_{struct,f} = e^{-UNC_{PER,f}/300}$

Where,

Units

$UNC_{PER,f}$	=	Uncertainty in N ₂ O emissions reductions associated with a reduction in N rate for field f relative to the average emission reduction value-	%
$nrFields$	=	Number of fields included in the project area (e.g. the number of fields in the aggregate, or equal to one for a single-field project) ⁷⁴	
$NR_{P,f}$	=	Project total N rate determined for field f (If the project organic N rate is smaller than the baseline organic N rate, use $NR_{B,o,f}$ instead of $NR_{P,o,f}$ summed with $NR_{P,S,f}$ to calculate $NR_{P,f}$ for use in this equation.)	kg N/ha
2515	=	Additional uncertainty factor to account deduction for potential bias introduced by using non-independent data for model validation ⁷⁵ states other than MI (i.e., outside the area where field measurements occurred).	%

⁷² This approach is identical to the uncertainty discounting approach of the MSU-EPRI protocol, except for three changes noted in the footnotes to the equation.

⁷³ This function is used to simplify the use of a look-up table, as was the case in the original MSU-EPRI protocol. It was made by fitting a quadratic function through the discrete values in the look up table of the MSU-EPRI protocol.

⁷⁴ The $\frac{1}{\sqrt{nrFields}}$ factor ensures that the uncertainty decreases with an increase in the number of fields in the aggregate. This factor accounts for the smoothing effect of having more fields in an aggregate on the emissions that are calculated by the quantification approach. Note that this factor was not included in the MSU-EPRI protocol.

⁷⁵ The increase in uncertainty by 25 percent accounts for the lack of independent field data (i.e. data that was not used to develop the quantification approach) to evaluate the quantification approach. When independent data

$\mu_{\text{struct},f}$	=	Accuracy deduction for structural uncertainty for field f
-------------------------	---	---

5.55.4 Quantifying~~Determining~~ Secondary Effects~~Effect~~ GHG Emissions

Secondary effect ~~GHG~~ emissions are unintentional changes in GHG emissions from the secondary SSRs within the GHG Assessment Boundary. Secondary effect emissions may increase, decrease or go unchanged as a result of the project activity. If emissions from secondary SSRs increase as a result of the project, these emissions must be subtracted from the total calculated primary effect GHG reductions for each reporting period. Equation 5.16, below, summarizes the changes in secondary effect GHG emissions.

Equation 5.16, ~~below, summarizes the changes in secondary effect GHG emissions.~~

~~Secondary effect GHG emissions may result when the application rate of organic fertilizer changes as part of a project activity. When the application rate of organic fertilizer increases, increased CO₂ emissions associated with transportation of manure (SSR 4) may occur, but when the application rate of organic fertilizer decreases, GHG emissions may increase due to increased manure storage (SSR 3).~~

~~Equation 5.18~~ also accounts for any increased CO₂ emissions from increased combustion of fossil fuels associated with the operation of cultivation equipment (SSR 5), as well as increased GHG emissions due to shifted crop production outside the project boundary (SSR 6).

~~becomes available in the future, however, it is expected that this term will be reduced as the uncertainty is better represented.~~

Equation 5.16. Total Secondary Effect Emissions from Project Activity for the Project Aggregate

$$SE = \sum_f (SE_{FF,f}) + SE_{MS} + SE_{MT} + SE_{PS} \quad SE = \sum_f (SE_{FF,f}) + SE_{PS}$$

Where, Units

<u>SE</u>	=	<u>Net secondary effect GHG emissions for project aggregate due to project activities</u>	
<u>SE_{FF,f}</u>	=	<u>TheNet secondary effect GHG emissions from increased cultivation equipment emissions due to fossil fuel combustion for field f (SSR 3), as calculated in Section 5.5.14.1, using either Equation 5.17 or 5.18</u>	Mg CO ₂ e
<u>SE_{MS}</u>	=	<u>The secondary effect GHG emissions from increased manure storage (SSR 3), as calculated in Section 5.5.1</u>	Mg CO ₂ e
<u>SE_{MT}</u>	=	<u>The secondary effect GHG emissions from increased manure transport (SSR 4), as calculated in Section 5.5.2</u>	Mg CO ₂ e
<u>SE_{PS}</u>	=	<u>The secondarySecondary effect GHG emissions for the project aggregate from production shifting outside of the project boundary (SSR 6), as calculated in Section 5.5.2</u>	Mg CO ₂ e

5.5.15.4.1 Calculating GHG Emissions from Cultivation Equipment (SSR 3)

Included in the GHG Assessment Boundary are CO₂ emissions resulting from increased fossil fuel combustion associated with increased use of onsite equipment used for performing nitrogenN management activities related to seeding, fertilizer application, and herbicide application due to the project activity. Note that this includes GHG. Specifically, secondary emissions from increased field passes or changes in cultivation equipment associated with spreading and incorporating manure in cases where must be quantified if the proportionnumber of manure Nfield operations for N application increases relative(e.g. a switch from single to split application) or if the equipment for N application changes (e.g. from a gasoline- to synthetic N-diesel-powered tractor). Secondary emissions from cultivation equipment need not be quantified if there is no change in cultivation equipment due to implementation of the project (e.g. there is no change to the equipment used for N application and/or the number of field operations associated with N application).

If

Two approaches are provided to calculate secondary emissions from cultivation equipment. Approach 1 calculates emissions based on the changes in project-time needed for each N management related field operation, the horsepower required for this field operation, and a default emission factor for GHG emissions per horsepower-hours. Approach 2 calculates emissions based on the fuel consumption for field operations related to N management and a default emission factor for GHG emissions per unit of fuel consumed.

Approach 1 is designed to require new equipment or an increase in the operational hours and/or number of field passes for existingminimal documentation. In approach 1, the project participant must provide manufacturers' specifications on the horsepower requirements for the N application equipment, the CO₂ emissions from the increased fossil fuel combustion shall used, and the time needed per ha for N application. The time needed for N application should be calculated using Equation 5.19 below. It is important to note that if the project activity, as implemented on a given field, does not require newreported based on work-hour records. However, lacking those records, they may be derived based on the average operation or ground

speed of the equipment nor increase field passes, and the application width per pass (e.g. width of boom). Following Approach 1, secondary emissions from cultivation equipment shall not be quantified. are determined as follows:

Equation 5.17. Project Increased Emissions from Fossil Fuel Combustion Cultivation Equipment (Approach 1)

$$SE_{FF,f} = \left(\sum_{k'} (EF_{HP-hr,P,k',f} \times HP_{P,k',f} \times t_{P,k',f}) - \sum_k (EF_{HP-hr,B,k,f} \times HP_{B,k,f} \times t_{B,k,f}) \right) \times 10^{-6}$$

If $SE_{FF,f} < 0$, set $SE_{FF,f}$ to 0

[Optional (e.g. if time records are not available): if used, must be used in both baseline and project estimates: $t = 10000 / (\text{width} \times \text{speed} \times 1000) \times A_f$]

Where,

Units

$SE_{FF,f}$	=	<u>Increase in secondary emissions from a change in cultivation equipment on field f</u>	<u>Mg CO₂-eq/ha</u>
$EF_{HP-hr,P,k',f}$	=	<u>Emission factor for project operation k' on field f. Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations⁷⁶.</u>	<u>g CO₂-eq/HP-hr</u>
$HP_{P,k',f}$	=	<u>Horsepower requirement for project operation k' on field f</u>	<u>HP</u>
$t_{P,k',f}$	=	<u>Time required to perform project operation k' on field f</u>	<u>hr/field</u>
$EF_{HP-hr,B,k,f}$	=	<u>Default emission factor for baseline operation k on field f. Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations.⁷⁶</u>	<u>g CO₂-eq/HP-hr</u>
$HP_{B,k,f}$	=	<u>Horsepower requirement for baseline operation k on field f</u>	<u>HP</u>
$t_{B,k,f}$	=	<u>Time required to perform baseline operation k on field f</u>	<u>hr/field</u>
10^{-6}	=	<u>Converting g CO₂e to Mg CO₂e</u>	
t	=	<u>Time requirement for field operation</u>	<u>hr</u>
10000	=	<u>Area-unit conversion</u>	<u>m²/ha</u>
width	=	<u>Application width covered by equipment</u>	<u>m</u>
speed	=	<u>Average ground speed of the operation equipment</u>	<u>km/hr</u>
1000	=	<u>Length-unit conversion</u>	<u>m/km</u>
A_f	=	<u>Size of field f</u>	<u>ha</u>

As an alternative to Approach 1, project participants may choose to quantify secondary emissions from changes in the use of cultivation equipment based on their fuel consumption records (see Equation 5.18, Approach 2, below). If insufficient fuel consumption records are available, Approach 1 must be used.

⁷⁶California Air Resources Board (2007). OFFROAD2007. Mobile Source Emissions Inventory Program. Sacramento, CA.

Equation 5.18. Increased Emissions from Cultivation Equipment (Approach 2)

$$SE_{FF,f} = \frac{\sum_j (FF_{PR,j} \times EF_{FF,j})}{1000}$$

If $SE_{FF,f} < 0$, set $SE_{FF,f}$ to 0

Where,

		Units
$FF_{PR,j}$	Total increase change in fossil fuel combustion for field f during the reporting period, by fuel type j	volume fossil fuel gallons
$EF_{FF,j}$	Fuel-specific emission factor. <u>Default values are 17.4 for gasoline and 13.7 for diesel⁷⁷.</u>	kg CO ₂ /volume gallon fossil fuel
1000	Kilograms per Megagrams megagram	kg CO ₂ / Mg CO ₂

5.5.2 Calculating GHG Emissions from Manure Storage (SSR 5)

Because manure is a waste product, its supply is highly inelastic and will not likely be impacted by reduction in the demand for manure, as may be the case if the project activity results in a reduction of total manure applied. As such, the organic N rate at the aggregate level for the baseline and project scenario must be compared. If the aggregate's organic N rate for the project is smaller than the organic N rate for the baseline, secondary emissions from storage of manure that would have been applied in the absence of the project must be accounted for, according to Equation 5.20. It is conservatively assumed that all organic N applied is manure.

Equation 5.20. Project Emissions from Increased Manure Storage

$$\Delta MA = \sum_f (A_f \times (NR_{P,O,f} - NR_{B,O,f}))$$

In case $\Delta MA > 0$, then:

$$SE_{MS} = 0$$

In case $\Delta MA \leq 0$, then:

$$SE_{MS} = \Delta MN \times EF_{MS}$$

Where,

		Units
ΔMA	The total change in manure application across the project aggregate due to the project activities	kg N
A_f	The size of field f	ha
$NR_{B,O,f}$	Baseline N rate for total organic fertilizer for field f	kg N/ha
$NR_{P,O,f}$	Project N rate for total organic fertilizer for field f	kg N/ha
SE_{MS}	The secondary effect GHG emissions from increased manure storage (SSR 3)	Mg CO ₂ e
EF_{MS}	Emission factor for GHG emissions from manure storage	

⁷⁷California Air Resources Board (2007). OFFROAD2007. Mobile Source Emissions Inventory Program. Sacramento, CA.

(TBD: This emission factor will be based on IPCC and EPA GHG accounting guidelines and will be determined by Reserve staff and contractors during the public comment period. This factor will reflect the most conservative estimate of manure storage emissions)

5.5.3 Calculating GHG Emissions from Transport of Organic Fertilizer (SSR 6)

In the case the organic N fertilizer rate for the project is greater than the organic N fertilizer rate for the baseline at the aggregate level, secondary emissions from increased fuel use related to transport of organic N fertilizer between the manure production site and the project site must be accounted for.⁷⁸ See Equation 5.21 below.

Equation 5.21. Project Emissions from Increased Fuel Use Related to Transport of Manure

$$\Delta MA = \sum_f \left(A_f \times (NR_{P,O,f} - NR_{B,O,f}) \right)$$

In case $\Delta MA \leq 0$, then:
 $SE_{MT} = 0$

In case $\Delta MA > 0$, then:
 $SE_{MT} = EF_{MT} \times \frac{-0.454}{0.405} \times \sum_f \left(A_f \times \left(\sum_j (D_{B,j,f} \times MF_{B,O,j,f}) - \sum_j (D_{P,j,f} \times MF_{P,O,j,f}) \right) \right)$

Units

Where,

ΔMA	=	The total change in manure application across the project aggregate due to the project activities	kg N
A_f	=	The size of field f	ha
$NR_{B,O,f}$	=	Baseline N rate for total organic fertilizer for field f	kg N/ha
$NR_{P,O,f}$	=	Project N rate for total organic fertilizer for field f	kg N/ha
SE_{MT}	=	The secondary effect GHG emissions from increased manure transport (SSR 4)	Mg CO ₂ e
$D_{B,j,f}$	=	The distance between field f and the production site of baseline organic fertilizer j	miles
$D_{P,j,f}$	=	The distance between field f and the production site of project organic fertilizer j	miles

⁷⁸ Because increases in synthetic fertilizer use are not allowed per the applicability conditions in Section 5.1, increased emissions from transportation of synthetic fertilizer are not possible and can be excluded.

$MF_{B,j,f}$	=	The mass of baseline organic N-containing fertilizer j applied to field f	tons fertilizer/acre
$MF_{P,j,f}$	=	The mass of project organic N-containing fertilizer j applied to field f	tons fertilizer/acre
EF_{MT}	=	Emission factor for GHG emissions from manure transportation. (TBD: This emission factor is relative to the weight of the manure and will be based on IPCC and EPA emission factors for diesel fuel efficiency for an average size of a fully loaded manure transportation truck size. The emission factor will represent a two-way route between the facility where the manure originates and the farmer's field. The emission factor will be determined by Reserve staff and contractors during the public comment period)	Mg CO ₂ e/(kg organic N)/mile

5.5.45.4.2 GHG Emissions from the Shift of Shifting Crop Production Outside of Project Boundaries (Leakage) (SSR 7)

Econometric studies have reported considerable price elasticity for corn.⁷⁹ Therefore, it is assumed in this protocol that a statistically significant decrease in corn yields due to project activities would result in an increase of production outside of the project area. The increased emissions associated with this shift in production must be estimated if project related yield losses are statistically significant compared to historic and average yields.

In order to determine if crop yields have decreased across the project area during the cultivation cycle as a result of project activity, the annual yield from the project area must be compared to historical yields over the past five years from the same project area. Because yields fluctuate annually depending on numerous climatic drivers, for this evaluation, yields are normalized to average annual county yields using USDA NASS statistics,⁸⁰ according to the procedure below.

This normalization procedure must be followed for each cultivation cycle to demonstrate that the yields from the project area have not declined due to project activity. The following procedure is applicable for a single-field project. All aggregates must apply the following procedure to the entire project area, defined as the sum of individual fields included in verification activities:

1. For each year t in the historical look-back period (see Section 5.3, step 15.2), normalize the yield of the field by the county average for that year ($y_{norm,t}$). If the project is an aggregate, calculate ($y_{norm,t}$) for each of the historical years as the weighted average (by percent of field area) of all fields in the aggregate following Equation 5.22. Equation 5.19. The distribution of ($y_{norm,t}$) will have the same number data points as the number of eligible crop years in the historical look-back period (between 3 and 5 years).

⁷⁹ Haixiao, Huang, and Madhu Khanna. An Econometric Analysis of U.S. Crop Yield and Cropland Acreage: Implications for the Impact of Climate Change. Selected Paper prepared for presentation at the Agricultural & Applied Economics Association 2010 AAEA, CAES, & WAEA Joint Annual Meeting, Denver, Colorado, July 25-27, 2010.

⁸⁰ Available at <http://quickstats.nass.usda.gov>.

Equation 5.19 Normalized Yield for Each Year t in Case the Project is an Aggregate

For single-field projects: $y_{norm_t} = \frac{Y_{f,t}}{Y_{county,t}}$

For aggregate projects: $y_{norm_t} = \frac{\sum_f \left(A_f \times \frac{Y_{f,t}}{Y_{county,t}} \right)}{\sum_f A_f}$

Where,

		<u>Units</u>
A_f	= Size of field f	ha
$Y_{f,t}$	= Yield of field f in year t	Mg/ha
$Y_{county,t}$	= County average yield in year t	Mg/ha

If aggregates span multiple counties, $Y_{county,t}$ must correspond with the county in which field f is located.

- For the cultivation cycle for the present reporting period, normalize the yield of each field by the county average for the growing season for the year t , and, if the project is an aggregate, calculate the weighted average for all fields in the aggregate to get $\{y_{norm_{t_0}}\}$, using Equation 5.19 above and replacing t with t_0 , i.e. the year of the present reporting period.

- Take the standard deviation $\{s\}$ and mean of the y_{norm_t} distribution:

$$s = stdev(y_{norm_t})$$

$$\overline{y_{norm_t}} = average(y_{norm_t})$$

- Calculate the minimum yield threshold below which normalized yields are significantly smaller than the historical average. This shall be done as follows:

$$y_{min} = \overline{y_{norm_t}} - 2.132 \times s$$

Where 2.132 is the t-distribution value with 95 percent confidence for a one-tailed test with four degrees of freedom (i.e. n is 5),⁸¹ and s is the standard deviation of the y_{norm_t} distribution, as calculated in [stepStep 3](#).

- For every year of the crediting period, calculate $y_{norm_{t_0}}$ and compare this value to y_{min} . If $y_{norm_{t_0}}$ is smaller than y_{min} , it must be assumed that leakage occurred and emissions increased outside of the project area. The project must account for increased emissions as specified in [Equation 5.20](#) below:

⁸¹ The t-distribution value of 2.132 = $t(0.05, n - 1)$, where n is 5, and $n-1$ degrees of freedom is 4. If there are less than five data points (e.g. less than five eligible crop years in the historic look-back period), a different t-distribution value must be substituted for 2.132. Specifically, where $n=4$, $t\text{-value}=2.353$, and where $n=3$, $t\text{-value}=2.920$.

Equation 5.20. Increased Emissions Outside the Project Boundary

$$SE_{PS} = \left(1 - \frac{y_{norm_{t0}}}{y_{min}}\right) \times \sum_i [N_2O_{B,f} \times A_f]$$

Where,

Units

SE _{PS}	=	Total secondary effect GHG emissions from production shifting outside of the project boundary	Mg CO ₂ e/ha
y _{norm_{t0}}	=	Normalized project yield for field <i>f</i>	Mg/ha
y _{min}	=	Minimum yield threshold below which normalized yields are significantly smaller than the historical average for field <i>f</i>	Mg/ha ⁸²
N ₂ O _{B,f}	=	Total annual baseline N ₂ O for field <i>f</i> , see Section 0	Mg CO ₂ e/ha
A _f	=	Size of field <i>f</i>	ha

⁸² "Mg/ha" is indicated as required units for crop yield. Note, however, that units of y_{norm_{t0,i}} and y_{min_{t0,i}} cancel each other out. Therefore, other units can be used, as long as the units for y_{norm_{t0,i}} are the same as the units for y_{min_{t0,i}}.

6 Project Monitoring

The Reserve requires that Monitoring Plans and Reports be established for all monitoring and reporting activities associated with the project. Single-field projects must develop a monitoring plan in accordance with the guidance in Section 6.1. Aggregate projects must develop monitoring plans both at an aggregate-level and field-level in accordance with the guidance in Section 6.2.

6.1 Single-Field Project Monitoring Plan

Single-field projects must establish a Single-Field Monitoring Plan (SFMP). The SFMP, together with the Single-Field Report (SFR) outlined in Section 1.1, will serve as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and 7 are met for single-field projects, and that consistent, rigorous monitoring and recordkeeping is ongoing at the project field. The SFMP must be developed and maintained by the project developer. The SFMP must specify how required field data (Section 6.3) are collected, recorded, and managed at each field. The SFMP must also outline procedures for developing and submitting a complete Single-Field Report SFR in accordance with Section 1.1. It is the responsibility of the project developer to ensure that the SFMP meets all requirements specified, and is kept on file and up-to-date for verification.

The SFMP will outline the following procedures:

- How Procedures describing how the field perimeter GIS shape file and/or KML file will be created
- How Procedures describing how the crediting period, verification schedule, and quantification results will be tracked for that field
- How to ensure Procedures or methods for ensuring that the project developer holds title to the GHG emission reductions as required in Section 2.3
- Procedures that the project developer will follow to ascertain and demonstrate that the project field at all times passes the Legal Requirement Test and Regulatory Compliance (Sections 0 and 3.6 respectively)
- A plan for monitoring the field data outlined in Section 6.3, which includes a plan for detailed record keeping and maintenance that meet the requirements for minimum record keeping in Section 7.3.1
- The frequency of data acquisition
- ~~The frequency of sampling activities~~
- The role of individuals performing each specific activity, particularly N application, monitoring, and corn stalk sampling
- QA/QC provisions to ensure that data acquisition is carried out consistently and with precision

6.2 Monitoring Plans for Aggregates and Participating Fields

Aggregate projects must establish an Aggregate Monitoring Plan (AMP), according to the requirements of Section 6.2.1 below. It is also the responsibility of the aggregator to ensure that each of the project participants with fields enrolled in the aggregate develops a Field Monitoring Plan (FMP), according to) that meets at minimum the requirements specified in Section 6.2.2, and to ensure that aan up-to-date copy of each FMP is kept on file by the aggregator and up-to-date for verification.

6.2.1 Aggregate Monitoring Plan

Aggregate projects must establish an AMP, which will serve, together with the Aggregate Report outlined in Section 7.2.2, as the basis for verifiers to confirm that the aggregate tracking requirements have been and will continue to be met for each reporting period. The AMP must be developed and maintained by the aggregator. The AMP must outline procedures on how all of the data included in the annual Aggregate Report, the requirements of which are specified in Section 7.2.2, will be collected and managed, and must outline procedures for developing and submitting a complete Aggregate Report.

The AMP will outline the following procedures:

- How Procedures describing how the field perimeter GIS shape file and/or KML files will be created for each field
- How Procedures describing how the crediting period, verification schedule, and quantification results will be tracked for each field included in the aggregate
- How to ensure Procedures and methods for ensuring that the title to the GHG emission reductions has been conferred to the aggregator as required in Section ~~2.32.3~~ for each field in the aggregate
- Procedures that the aggregator will follow to ascertain and demonstrate that all fields in the aggregate at all times pass the Legal Requirement Test and Regulatory Compliance (Sections 0 and 3.6 ~~respectively~~ respectively); process should include review of permits (e.g. air, water, and land use permits), Notices of Violations (NOVs), and any administrative or legal consent orders relevant to project activities
- Procedures the aggregator will follow to track which fields have passed the performance standard and which are in a Grace Period with delayed crediting
- A plan for detailed record keeping and maintenance that meet the requirements for minimum record keeping in Section 0
- The role of individuals performing each specific activity-, particularly N application, monitoring, and corn stalk sampling
- QA/QC provisions to ensure that data collected from the field level, according to data acquisition requirements outlined in the Field Monitoring Plan (FMP) described below, is carried out consistently and with precision

6.2.2 Field Monitoring Plan for Project Participants in an Aggregate

The Field Monitoring Plan (FMP) will serve as the basis for verifiers to confirm that the monitoring and reporting requirements in Sections 6 and 7 are met at each field in an aggregate, and that consistent, rigorous monitoring and record keeping is ongoing at each field. The FMP must specify how required field data (Section 6.3) are collected, recorded and managed at each field.

One FMP must be developed for each project participant. If a project participant has multiple fields enrolled in the aggregate, only one FMP is required as long as it addresses the distinct monitoring requirements at each field. The FMP can be developed by the project participant or the aggregator, depending on the arrangement specified in contractual agreements. It is the responsibility of the aggregator to ensure that the FMP meets all requirements specified, and that an up-to-date copy of each FMP is kept on file by the aggregator and ~~up-to-date~~ for verification.

At a minimum the FMP shall stipulate:

- The frequency of data acquisition
- ~~The frequency of sampling activities~~
- The role of individuals performing each specific activity, particularly N application, monitoring, and corn stalk sampling activity
- A plan for monitoring the field data outlined in Section 6.3, including a detailed record keeping plan meeting the minimum record keeping requirements of ~~Section~~Sections 7.3.2.2- and 7.3.2.3
- QA/QC provisions to ensure that data acquisition is carried out consistently and with precision

6.3 Mandatory Field Data Monitoring Requirements

All field-level data and information specified in this Section must be collected and retained for verification purposes. Section 7.3 provides further guidance on specific record-keeping requirements.

6.3.1 General Field Tracking Data

- Either a GIS shape file or a KML file clearly defining the field perimeter
- The coordinates of the most north-westerly point of the field, reported in degrees to four decimal places⁸³ (to be used for creating field serial numbers)
- The serial number of the field, constructed as specified in Section 7.1.1.
- The start date of the field
- Disclosure of any material and immaterial regulatory violations, with copies of all Notices of Violations (NOVs) included in the report
- ~~A list of the project activities implemented on the field during the reporting period~~
- Field crop yield during the reporting period and for five years (or at least three eligible crop years) prior to the field start date for the eligible crop(s)

6.3.2 Field Management Data

The following management data must be collected and retained at each field for each cultivation cycle during the reporting period over the life of the project (e.g. both for eligible and ineligible crop years):

- Planting date
- ~~Type~~Whether irrigation was used, and if so the type of irrigation system used, justification of why it was necessary, irrigation dates and volumes (during the growing season and during post-harvest period). (It should be noted that irrigation is only permissible in eligible crop years in case of emergency irrigation needs)
- Begin and end date of harvesting on the field

6.3.3 Project Activity Data and Documentation

~~6.3.3.1 For eligible crop years:~~

6.3.3.1 Project Activity Data and Documentation: Eligible Crop Years

To corroborate field management assertions, each field must collect and retain the following documentation for all eligible crop years:

⁸³ Longitude reported in degrees to four decimal places provides a spatial resolution of about 11 meters, the resolution of the latitude is slightly less than that.

- Begin and end date of harvesting on the field
- Planting date
- Crop yield
- Fertilizer types ~~(both organic and synthetic)~~, amounts, (e.g. rates), and application dates, disaggregated by type for all sources of N (both synthetic and organic), including purchasing records and information on each type's N content, ascertained through laboratory test results, manufacturer specifications or fertilizer labeling concentration⁸⁴
- Fertilization amounts and application dates (disaggregated for organic and synthetic)
- All field monitoring parameters, as listed in Table 6.1
- Fertilizer application method and placement

6.3.3.2 For non-eligible crop year:

- Type of equipment used for fertilizer application
- Whether irrigation was used, and if so the type of irrigation system used, justification of why it was necessary, irrigation dates and volumes (during the growing season and during post-harvest period). (It should be noted that irrigation is only permissible in eligible crop years in case of emergency irrigation needs)

6.3.3.1.1 Implementation of a Corn Stalk Nitrate Test

As a monitoring requirement to help corroborate field management assertions, each field must implement at least one Corn Stalk Nitrate Test (CSNT) for each eligible corn crop toward the end of the reporting period, according to the sampling methodology developed by Iowa State University (ISU).⁸⁵

One CSNT sample is comprised of 15 segments taken from corn stalks across the field. If the project participant intends to use CSNT results as an adaptive management technique, each CSNT sample should cover no more than 20 acres. However, for the purposes of this protocol, one CSNT sample per 100 acres is allowable.

Sampling for the CSNT must follow the recommended methodology from ISU:

1. Sampling shall take place between one and three weeks after black layers have formed on about 80 percent of the kernels of most ears of corn.
2. The portion of each plant sampled is the 8-inch segment of stalk found between 6 and 14 inches above the soil.
3. Leaf sheaths should be removed from the segments.
4. Stalks severely damaged by disease or insects should not be used.
5. Fifteen 8-inch segments should be collected to form a single sample to be sent for analysis.

⁸⁴ Additional N concentration may be ascertained through laboratory test results, manufacturer specifications or fertilizer labeling. However, additional guidance on determining one's N content is provided in Section 5.2, and default look-up tables are available in Appendix A (to be provided), in Table A.2, for unlabeled or unprocessed fertilizers.

⁸⁵ Iowa State University Extension Service, "Cornstalk testing to evaluate nitrogen management," PM 1584, Revised August 1996, Prepared by: A. M. Blackmer and A. P. Mallarino, research agronomists, Department of Agronomy, Iowa State University, Available at: <http://www.extension.iastate.edu/Publications/PM1584.pdf>

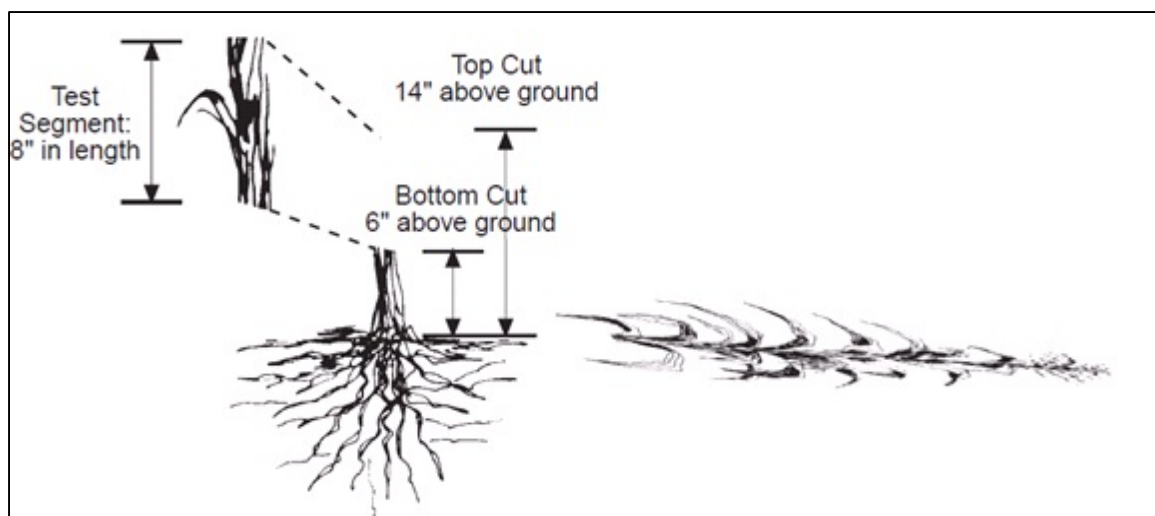


Figure 6.1. Diagram of How to Sample for Crop Stalk Nitrate Tests⁸⁵

Once CSNT samples are collected, they must be sent to a university extension service or other qualified laboratory for analysis as soon as possible after collection. Samples should be placed in paper (not plastic) bags to enable some drying and minimize growth of mold, and samples should be refrigerated (but not frozen) if stored for more than one day before mailing. The time required to mail samples to a laboratory should not be an issue.

Documentation of the lab results should be kept on file by both the project participant and aggregator. Verification bodies will use CSNT lab results to inform their verification site visit sampling for aggregates, as discussed in Section 8.3.1.

6.3.3.2 Project Activity Data and Documentation: Non-Eligible Crop Years

If the crop rotation on the project field includes ineligible crops (e.g. soy in a corn/soy rotation), the project field must report continuously on the field's management practices, even though the project field shall only receive credit for project activities implemented on eligible crops.

To corroborate field management assertions, each field must collect and retain the following documentation for all non-eligible crop years:

- ~~Fertilizer types (both organic~~Planting date
- ~~Begin and synthetic), amounts, and application dates~~end date of harvesting on the field
- ~~Total N applied for the current~~non-eligible crop year
- ~~Fertilizer type(s), amounts and application dates, and total N applied in each of the previous five crop years~~for the ~~past five years of the~~ same non-eligible crop grown on that field.

Though not required, the Reserve encourages project participants to keep detailed monitoring records for non-eligible crop years comparable to the records which must be kept for eligible crop years (e.g. Section 1.1.1.1).⁸⁶

6.3.4 Field Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.1⁷ below. Field monitoring parameters must be determined according to the data source and frequency specified for all eligible crop years. Table 6.1 specifies general monitoring parameters and requirements for “general input parameters,” which are those field monitoring parameters required for all project fields.

⁸⁶ Monitoring additional variables for the non-eligible crop year will ensure proper records have been kept in order to set an appropriate baseline and in the event that non-eligible crops are included in the NMPP in the future. See Section 6.4 for more information.

Table 6.1. Field Monitoring Parameters: ~~General Input Parameters~~

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
$NR_{f,e,t}$	Annual total nitrogen application rate (including organic and synthetic forms of N) on field f and crop c over time t	kg N/ha	ϵC	annual	Farmer records
$NR_{S,f}$	Annual N-rate of total synthetic fertilizer <u>nitrogen application rate</u> for field f	kg N/ha	ϵC	annual	Farmer records
$NR_{O,f}$	<u>Annual total organic nitrogen application rate for field f</u>	<u>kg N/ha</u>	<u>C</u>	<u>annual</u>	<u>Farmer records</u>
$NR_{DS,j,f}$	Annual N- <u>application</u> rate of dry synthetic fertilizer type j on field f	kg N/ha	ϵC	annual	Farmer records
$NR_{LS,j,f}$	Annual N- <u>application</u> rate of liquid synthetic fertilizer type j on field f	kg N/ha	ϵC	annual	Farmer records
$NR_{O,j,f}$	Annual N- <u>application</u> rate of total solid <u>organic fertilizer j on field f</u>	\hat{C} g N/ha	ϵC	annual	Farmer records
$NR_{LO,j,f}$	<u>Annual N- application rate of liquid organic fertilizer j on field f</u>	kg N/ha	ϵC	annual	Farmer records
$NR_{B,f,c}$	Baseline N-rate for field f , crop c	kg N/ha	ϵC	annual	Farmer records
$MF_{DS,i,f}$	<u>Mass of dry synthetic N-containing fertilizer j applied to field f</u>	<u>lbs fertilizer/acre</u>	<u>o</u>	<u>annual</u>	<u>Farmer records</u>
$NC_{DS,i}$	<u>Nitrogen concentration of dry synthetic fertilizer j</u>	<u>lbs N/(lbs fertilizer)</u>	<u>o, m, r</u>	<u>annual (unless unchanged)</u>	<u>Farmer records, Fertilizer N-content label or Laboratory tests preferable (Default reference data will be included in Appendix A)</u>
$MF_{LS,i}$	<u>Mass of liquid synthetic fertilizer j per gallon of fertilizer</u>	<u>lbs fertilizer/gallon</u>	<u>o</u>	<u>annual</u>	<u>Farmer records</u>
$VF_{LS,i,f}$	<u>Volume of liquid synthetic N-containing fertilizer j applied to field f</u>	<u>gallons/acre</u>	<u>o</u>	<u>annual</u>	<u>Farmer records</u>

<u>NC_{LS,j}</u>	<u>Nitrogen concentration of liquid synthetic fertilizer <i>j</i></u>	<u>gallons N/(gallons fertilizer)</u>	<u>o, m, r</u>	<u>annual (unless unchanged)</u>	<u>Farmer records, Fertilizer N-content label or Laboratory tests preferable (Default reference data will be included in Appendix A)</u>
<u>MF_{SO,i,f}</u>	<u>Mass of solid organic N-containing fertilizer <i>j</i> applied to field <i>f</i></u>	<u>tons fertilizer/acre</u>	<u>o</u>	<u>annual</u>	<u>Farmer records</u>
<u>NC_{SO,j}</u>	<u>Nitrogen concentration of solid organic fertilizer <i>j</i></u>	<u>lbs N/(lbs fertilizer)</u>	<u>o, m, r</u>	<u>annual (unless unchanged)</u>	<u>Farmer records, Fertilizer N-content label or Laboratory tests preferable (Default reference data will be included in Appendix A)</u>
<u>MF_{LO,i,f}</u>	<u>Mass of liquid organic N-containing fertilizer <i>j</i> applied to field <i>f</i></u>	<u>tons fertilizer/acre</u>	<u>o</u>	<u>annual</u>	<u>Farmer records</u>
<u>VF_{LS,i,f}</u>	<u>Volume of liquid organic N-containing fertilizer <i>j</i> applied to field <i>f</i></u>	<u>gallons/acre</u>	<u>o</u>	<u>annual</u>	<u>Farmer records</u>
<u>NC_{LO,j}</u>	<u>Nitrogen concentration of liquid organic fertilizer <i>j</i></u>	<u>lbs N/(lbs fertilizer)</u>	<u>o, m, r</u>	<u>annual (unless unchanged)</u>	<u>Farmer records, Fertilizer N-content label or Laboratory tests preferable (Default reference data will be included in Appendix A)</u>
<u>NR_{B,f}</u>	Baseline total N-rate determined for field <i>f</i>	kg N/ha	c	annual	Farmer records
<u>NR_{B,S,f}</u>	Baseline N-rate of total synthetic fertilizer for field <i>f</i>	kg N/ha	c	annual	Farmer records
<u>NR_{B,O,f}</u>	Baseline N-rate of total organic fertilizer for field <i>f</i>	kg N/ha	c	annual	Farmer records
<u>NR_{P,f}</u>	Project total N-rate for field <i>f</i>	kg N/ha	c	annual	Farmer records
<u>NR_{P,S,f}</u>	Project N-rate of total synthetic fertilizer for field <i>f</i>	kg N/ha	c	annual	Farmer records
<u>NR_{P,O,f}</u>	Project N-rate of total organic fertilizer for field <i>f</i>	kg N/ha	c	annual	Farmer records
<u>MF_{DS,j,f}</u>	<u>Mass of dry synthetic N-containing fertilizer <i>j</i> applied to field <i>f</i></u>	<u>lbs fertilizer/acre</u>	<u>e</u>	<u>annual</u>	<u>Farmer records</u>
<u>MF_{LS,j}</u>	<u>Mass of liquid synthetic fertilizer <i>j</i> per gallon of fertilizer</u>	<u>lbs fertilizer/gallon</u>	<u>e</u>	<u>annual</u>	<u>Farmer records</u>
<u>MF_{O,j,f}</u>	<u>Mass of organic N-containing fertilizer <i>j</i> applied to field <i>f</i></u>	<u>tons fertilizer/acre</u>	<u>e</u>	<u>annual</u>	<u>Farmer records</u>

$VF_{LS,j,f}$	Volume of liquid synthetic N-containing fertilizer j applied to field f	gallons/acre	e	annual	Farmer records
NC_j	Nitrogen content of fertilizer j (for each different fertilizer j)	lbs N/(lbs fertilizer)	e, m, f	annual (unless unchanged)	Farmer records, Fertilizer N content label or Laboratory tests preferable (Default reference data will be included in Appendix A)
$NC_{DS,j}$	Nitrogen content of dry synthetic fertilizer j	lbs N/(lbs fertilizer)	e, m, f	annual (unless unchanged)	Farmer records, Fertilizer N content label or Laboratory tests preferable (Default reference data will be included in Appendix A)
$NC_{LS,j}$	Nitrogen content of liquid synthetic fertilizer j	gallons N/(gallons fertilizer)	e, m, f	annual (unless unchanged)	Farmer records, Fertilizer N content label or Laboratory tests preferable (Default reference data will be included in Appendix A)
$NC_{O,j}$	Nitrogen content of organic fertilizer j	lbs N/(lbs fertilizer)	e, m, f	annual (unless unchanged)	Farmer records, Fertilizer N content label or Laboratory tests preferable (Default reference data will be included in Appendix A)
A_f	Size of field f	ha	o	annual	Farmer records
$Y_{f,e,t}$	Annual yield on field f and crop e over time t	unit/ha	o	annual	Farmer records
NC_e	Nitrogen content for crop e	kg N/unit	f	reference	Default reference data Appendix A, Table A.2
$RTA_{f,e,t}$	RTA calculated for field f and crop e over time t for purposes of the performance standard	ratio	c, o	annual	Calculated from farmer records
$RTA_{Hist,f,e}$	Historical RTA calculated for field f and crop e	ratio	e, o	pre-project	Calculated from historic farmer records
$N_2O_{B,f}$	Total annual baseline N_2O for field f	Mg CO_2e /ha	c	annual	
$N_2O_{Dir,B,f}$	Baseline direct N_2O emissions from field f	Mg CO_2e /ha	c	annual	
$N_2O_{LRVO,B,f}$	Baseline N_2O emissions from leaching, volatilization and runoff from field f	Mg CO_2e /ha	c	annual	
$N_2O_{P,f}$	Total annual project N_2O for field f	Mg CO_2e /ha	c	annual	
$N_2O_{Dir,P,f}$	Project direct N_2O emissions from field f	Mg CO_2e /ha	c	annual	
$N_2O_{LRVO,P,f}$	Project N_2O emissions from leaching, volatilization and runoff from field f	Mg CO_2e /ha	c	annual	

EF _{Dir,B,f}	Emission factor for baseline direct N ₂ O emissions from baseline N inputs	kg N ₂ O-N/(kg N input)	c		
EF _{Dir,P}	Emission factor for project direct N ₂ O emissions from project N inputs	kg N ₂ O-N/(kg N input)	c	annual	
PER	Primary effect GHG reductions over the entire project area	Mg CO ₂ e	c	annual	
μ _{struct,f}	Accuracy deduction for structural uncertainty for field <i>f</i>	value	c		
UNC _{PER,f}	Uncertainty in N ₂ O emissions reductions associated with a reduction in N-rate for field <i>f</i> relative to the average emission reduction value	%	c	annual	
nrFields	Number of fields included in the project area	No units	o	annual	Farmer records
SE _{FF,f}	Secondary effect of GHG emissions from increased cultivation equipment emissions due to fossil fuel combustion for field <i>f</i>	Mg CO ₂ e	c	annual	
SE _{PS}	Secondary effect of GHG emissions for the project aggregate from production shifting outside of the project boundary	Mg CO ₂ e	c	annual	
FF _{PR,j}	Total increase in fossil fuel combustion for field <i>f</i> during the reporting period, by fuel type <i>j</i>	Volume fossil fuel	o	annual	Farmer records, Fuel sales receipts

6.4 Supplemental Field Data Monitoring

In addition to the required field-level data and information specified in Section 6.3, project participants may choose to monitor and keep records of additional field data. Project participants are encouraged to monitor and retain supplemental records for all nitrogen management activities and all crops once a project is underway, including practices and crops not currently eligible for crediting at this time. Additional records may be of use in the event that quantification methodologies become available for currently ineligible practices and crops in future versions of this protocol. Further, while not required, supplemental data collected for eligible crop years may further assist project participants in successfully completing verification by providing verification bodies with additional information to corroborate project implementation activities and emission reductions from the project.

Supplemental monitoring parameters could include:

- A list of “enabling practices” (defined in Section 2.2.3) implemented on the field during the reporting period, as well as detailed records of dates and other aspects of management
- Additional data collected and/or test results from the implementation of any enabling or adaptive management practices (e.g. variable rate technology and the results of supplemental pre-plant or pre-sidedress soil nitrate tests, field-composite soil tests, and replicated strip trials)

7 Reporting and Record Keeping

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers.

7.1 Project Submittal Documentation

7.1.1 Single-Field Project Submittal Documentation

For each ~~single-field~~nitrogen management project, project developers/aggregators must provide the following documentation to the Reserve in order to submit ~~and register~~ a nitrogen management project for listing on the Reserve.

- ~~Single-Field~~ Project Submittal form
- ~~Signed Attestation of Title form~~
- ~~Signed Attestation of Regulatory Compliance form~~
- ~~Signed Attestation of Voluntary Implementation form~~
- ~~Verification Report~~
- ~~Verification Statement~~
- ~~Annual Single-Field Report (see Section Project Submittal *.csv file~~
- ~~The Project Submittal form will be the same for both single-field projects and aggregates. Both single-field and aggregate projects will also be required to submit a project submittal *.csv file, which shall include the initial "List of Enrolled Fields"; each field's serial number (according to Section 7.1.1-below for specific requirements)~~

~~Project developers must provide the following documentation each subsequent reporting period in order for the Reserve to issue CRTs for quantified GHG reductions.~~

- ~~Verification Report~~
- ~~Verification Statement~~
- ~~Annual Single-Field Report~~
- ~~Signed Attestation of Title form~~
- ~~Signed Attestation of Voluntary Implementation form~~
- ~~Signed Attestation of Regulatory Compliance form~~

~~With the exception of the Single-Field Report, at a minimum, the above project documentation will be available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available on a voluntary basis through the Reserve. below), county and state; and the names of project participants for each field. In the case of a single-field project, the List of Enrolled Fields will include only the single field. The List of Enrolled fields for aggregate projects shall include all fields enrolled in the aggregate at the time of submittal. Once verification commences, aggregate projects will be required to update the list to include all fields actually enrolled in the aggregate at that point (i.e. immediately prior to commencing the NOVA/COI process⁸⁷). The list must also be updated prior to each subsequent annual verification.~~

⁸⁷ See the Reserve Verification Program Manual at <http://www.climateactionreserve.org/how/program/program-manual/>.

Project submittal forms can be found at <http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/>.

7.1.1 Aggregate Submittal Determining Field Serial Numbers

The field serial number, which must be included in the List of Enrolled Fields, shall be determined by the following algorithm, with each element separated by a dash (-):

First letter of the County, followed by degrees of the most north-western point of the field (latitude then longitude, both reported to four decimal places), followed by the acreage of the field.⁸⁸ (Example: B-39.6123-121.5332-76 would be a 76 acre field in Butte County, CA)

7.1.27.2 Annual Reports and Documentation

For each ~~aggregate~~, ~~aggregators~~ Once a project has been listed on the Reserve, project developers must provide the following documentation to the Reserve in order to submit and register a nitrogen management ~~aggregate~~ with the Reserve. This documentation must be submitted to the Reserve within 12 months of the end of each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions.

The following documentation is required of both single-field projects and aggregates:

- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form ~~Aggregate Submittal form~~
 - ~~Includes the initial number of fields and the names of project participants for each individual enrolled field~~
- Signed (Aggregator) Attestation of Title form ⁸⁹
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form
- Annual Reports (as outlined in Sections 7.2.1 and 7.2.2)
- Verification Report
- Verification Statement
- Annual Aggregate Report (see Section 7.2.2 below for specific requirements)

~~Aggregators must provide the following documentation each subsequent reporting period in order for the Reserve to issue CRTs for quantified GHG reductions.~~

- ~~Verification Report~~
- ~~Verification Statement~~
- ~~Annual Aggregate Report~~
- ~~Signed Aggregator Attestation of Title form~~
- ~~Signed Attestation of Regulatory Compliance form~~

⁸⁸ Because all fields will be located in the United States, the latitude will always be positive (i.e. degrees north of the equator), and longitude will always be negative (i.e. degrees west of the Prime Meridian). Therefore, in the example serial number, the field in Butte County California is at +39.6123° latitude, and -121.5332° longitude.

⁸⁹ Although the single-field project will submit the general Attestation of Title form, aggregators will be required to submit an Aggregator Attestation of Title form, which will include language attesting to the fact that the aggregator has not and will not knowingly allow a third party (e.g. project participant) to provide false, fraudulent, or misleading data or statements.

~~▪ Signed Attestation of Voluntary Implementation form~~

With the exception of the ~~Aggregate Report, at a minimum, Annual Reports, outlined in Sections 7.2.1 and 7.2.2, all of~~ the above project documentation will be available to the public via the Reserve's online registry. Further disclosure (~~e.g. of the Annual Reports~~) and other documentation may be made available on a voluntary basis through the Reserve.

In the event that a project participant transfers from one aggregate to a different aggregate, the new aggregator is responsible for submitting a Field Management Transfer form, which will require the project participant's signature, to the Reserve prior to the beginning of the subsequent reporting period.

Project ~~submittal~~ forms can be found at <http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/>.

~~7.2 Annual Reports to be Submitted~~

~~7.2.1 Single-Field Report (Single-Field Projects Only)~~

For each cultivation cycle, the following information must be included in an annual report that will be submitted to the Reserve as a *.csv file:

- The field serial number, ~~(according to be determined by the following algorithm, with each element separated by a dash (-): Section 7.1.1)~~
 - ~~First letter of the County, followed by degrees of the most north-western point of the field, (latitude, then longitude, both reported to four decimal places), followed by the acreage of the field.⁹⁰ (Example: B-39.6123-121.5332-76 would be a 76 acre field in Butte County, CA)~~
- The acreage of the field (acres)
- Start date of the field
- Whether the field had previously been enrolled in an aggregate
 - If so, include the name of the aggregate ~~and~~, dates of enrollment, and a brief description of the circumstances for leaving the previous aggregate.
- The field's emission reduction calculation results for the current verified cultivation cycle (corrected for structural uncertainty) OR if a statement indicating that the field is in a non-eligible crop year.⁹¹
- Lab results of the Corn Stalk Nitrate Test

~~7.2.2 Aggregate Report~~

For each cultivation cycle, all aggregate-level monitoring information must be included in an annual Aggregate Report that will be submitted to the Reserve as a *.csv file, with accompanying documentation, at verification. The Aggregate Report must contain a list of all fields and the following information for each field:

⁹⁰ ~~Because all fields will be located in the United States, the latitude will always be positive (i.e. degrees north of the equator), and longitude will always be negative (i.e. degrees west of the Prime Meridian). Therefore, in the example serial number, the field in Butte County California is at +39.6123° latitude, and -121.5332° longitude.~~

⁹¹ Note that a single-field project must report continuously (e.g. submit a single-field report annually) even if that field is in a non-eligible crop year.

- The field serial number, (according to be determined by the following algorithm, with each element separated by a dash (-): Section 7.1.1)
 - ~~First letter of the County, followed by degrees of the most north-western point of the field, (latitude, then longitude, both reported to four decimal places), followed by the acreage of the field.~~⁶⁹ (Example: ~~B-39.6123-121.5332-76~~ would be a 76 acre field in Butte County, CA)
 - The acreage of the field (acres)
 - Start date of the field
 - ~~Date field enrolled in the aggregate~~
 - ~~Including, including~~ a flag specifying whether the field is a new addition to the aggregate ~~in the particular year for this reporting period~~
 - Current status of field (active, active but not in an eligible crop year, terminated, transferred to a different aggregate)
 - Name of project participant associated with the field
 - A flag ~~for which fields indicating whether the field~~ had a site visit or desktop ~~verificationsverification~~, or ~~werewas~~ unverified during the reporting period
 - The emission reduction calculation results for ~~eachthe~~ field (uncorrected for structural uncertainty)
 - The Lab results of the Corn Stalk Nitrate Test
- In addition to the above information, collected at the field-level, the Aggregate Report must include the total verified emission reductions for the aggregate ~~(, corrected for structural uncertainty and any deductions due to errors or misrepresentations at the verified fields),~~

7.2.3 Field Report

For each cultivation cycle, including those in which a non-eligible crop is grown, all fields within an aggregate must submit an annual Field Report to the aggregator. This report will not be submitted to the Reserve. Although the Reserve encourages participants to submit Field Reports in the form of a *.csv file, the format of the report will be at the discretion of the aggregator.

At a minimum, Field Reports will be required to include the following:

- A signed statement by the project participant attesting to the fact that all statements and data contained therein are true and accurate
- Current status of field (active, active but not in an eligible crop year), as well as a description of any notable changes in management control and/or management practices
- Field management data (as specified in Section 6.3.2)
- Project activity data (as specified in Section 6.3.3),

All fields must report continuously (e.g. submit a Field Report annually) even if that field is in a non-eligible crop. In a non-eligible crop year, the Field Report should include a statement indicating that the field is in a non-eligible crop year, as well as the information required by Section 6.3.3.2.

7.3 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the

information is generated or seven years after the last verification. This information will not be publicly available, but may be requested by the verifier or the Reserve.

7.3.1 Record Keeping for Single-Field Projects

The project developer should retain the following records and documentation, as well as documentation to substantiate the information in the annual Single-Field Report and all field-level data and calculations. These records include:

- Contractual arrangements with project developer, project participant and/or land owner (if applicable, e.g. if the project developer is not the field manager)
- Copies of letter of notification sent to land owner, including the date letter was sent
- GIS or KML shape file
- North-western latitude/longitude coordinates of field (to four decimal places)
- Serial number of field (according to the guidance in Section 7.1.1)
- ~~Data inputs for the calculation of the project emission reductions~~
- Copies of air, water, and land use permits relevant to project activities; Notices of Violations (NOVs) relevant to project activities; and any administrative or legal consent orders relevant to project
- Executed Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Voluntary Implementation forms
- ~~Field management data (as specified in Section 6.3.2)~~
- ~~Onsite fossil fuel use records~~
- Lab results of the Corn Stalk Nitrate Test
- Fertilizer purchase records
- Records demonstrating any material change (or lack thereof) in equipment type or usage (e.g. purchase or lease records for equipment, field-level fossil fuel use records, manufacturer's HP specifications, hours spent on N application)⁹²
- Data inputs for the calculation of the project emission reductions
- Field management data (as specified in Section 6.3.2)
- Project activity data (as specified in Section 6.3.3), including:
 1. ~~All time-stamped digital photographs of the fertilizer management activities~~
 2. ~~Farm management records, particularly pertaining to nitrogen management, and crop yields⁹³~~
 3. ~~All maintenance records~~ Records relevant to the farm equipment used for N-application and/or N-monitoring equipment (e.g. nutrient applicator, nutrient sprayer, chlorophyll meter, variable rate technologies)
- Results of CO₂e annual reduction calculations
- Initial and annual verification records and results

⁹² Records are required for both approaches to quantifying SSR 3. Fossil fuel-use records, broken down by field, are required for implementing Approach 2 (see Section 5.4.1). If the standard default is used (Approach 1), less extensive records are required, as equipment horsepower requirements may be looked up based on manufacturer specifications and operating hours spent on N-application may be estimated, but basic documentation corroborating the choice of default (e.g. proof the equipment or hours claimed are the equipment or hours used/spent) are still necessary.

⁹³ Project participants are encouraged to retain excellent records for all nitrogen management activities and crops once the project is underway, even those not currently eligible for crediting at this time, in the event that quantification methodologies become available at some point in the future and considered for inclusion in this protocol.

7.3.17.3.2 Record Keeping for ~~Aggregates~~Aggregate Projects

7.3.1.47.3.2.1 Aggregate-Level Record Keeping

The aggregator should retain the following records and documentation, as well as documentation required by Sections 6.2 to substantiate the information in the annual Aggregate Report. System information must be retained for each field, yet collected and managed at the aggregate level. These records include all:

- Contractual arrangements with project developer, each project participant and/or land owner
- Copies of letters of notification sent to land owners, including the dates letters were sent
- GIS or KML shape files for all fields in the aggregate
- North-western latitude/longitude coordinates for each field (to four decimal places)
- Serial numbers for each field (according to the guidance in Section 7.1.1)
- ~~▪ Data inputs for the calculation of the project emission reductions~~
- ~~▪ Copies of air, water, and land use permits relevant to project activities; Notices of Violations (NOVs) relevant to project activities; and any administrative or legal consent orders relevant to project activities~~
- Executed Aggregator Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Voluntary Implementation forms
- Data inputs for the calculation of the project emission reductions
- Results of CO₂e annual reduction calculations
- Initial and annual verification records and results

7.3.1.27.3.2.2 Aggregate Field-Level Record Keeping

The ~~project developer~~/aggregator should retain the following records and documentation, as well as documentation required in Section 6.3 for each field.

At each field, the following records should be retained for verification purposes:

- Field management data (as specified in Section 6.3.2)
- ~~▪ Onsite fossil fuel use records~~
- Lab results of the Corn Stalk Nitrate Test
- Fertilizer purchase records
- Records demonstrating any material change (or lack thereof) in equipment type or usage (e.g. purchase or lease records for equipment, field-level fossil fuel use records, manufacturer's HP specifications, hours spent on N application).⁹⁴
- Project activity data (as specified in Section 6.3.3), including:
 - ~~○ All time-stamped digital photographs of fertilizer management activities~~
 - Farm management records, particularly pertaining to nitrogen management and crop yield.⁹³

⁹⁴ Records are required for both approaches to quantifying SSR 3. Fossil fuel-use records, broken down by field, are required for implementing Approach 2 (see Section 5.4.1). If the standard default is used (Approach 1), less extensive records are required, as equipment horsepower requirements may be looked up based on manufacturer specifications and operating hours spent on N-application may be estimated, but basic documentation corroborating the choice of default (e.g. proof the equipment or hours claimed are the equipment or hours used/spent) are still necessary.

- All ~~maintenance~~ records relevant to the ~~farm~~ equipment used for N-application and/or N-monitoring equipment (e.g. chlorophyll meter, variable rate technologies)

7.3.2.3 Participant Field-Level Record Keeping

Project participants must retain the following documentation and be prepared to provide this documentation when requested by the aggregator and/or a verification body:

- Copies of air, water, and land use permits relevant to project activities; Notices of Violations (NOVs) relevant to project activities; and any administrative or legal consent orders relevant to project activities
- Records demonstrating any material change (or lack thereof) in equipment type or usage (e.g. purchase or lease records for equipment, field-level fossil fuel use records)

7.3.3 Supplemental Record Keeping

As noted in Section 6.4, project developers (of single-field projects) and project participants (who are part of an aggregate) are encouraged – but not required – to monitor and retain additional supplemental records for all nitrogen management activities and crops on their field once the project is underway, including nitrogen management activities and crops that are not eligible for crediting in the current protocol. Though this supplemental recordkeeping is not required, these additional records may help streamline verification activities and will be helpful for establishing a baseline in the event that additional quantification methodologies related to these practices and crops are included in future versions of the protocol. Supplemental records could include:

- A list of the “enabling practices” (see Section 2.2.3) implemented on the field during the reporting period
 - Additional data collected, due to enabling practices (e.g. variable rate technology and the results of supplemental pre-plant or pre-sidedress soil nitrate tests, field-composite soil tests, and replicated strip trials)
- Time-stamped digital photographs of fertilizer management activities
- Aerial images (demonstrating homogenous management and/or field boundaries)

7.4 Reporting Period and Verification Cycle

Project emission reductions must be quantified and verified on an annual basis, reflecting a reduction in annual N rate over a complete cultivation cycle. The length of time over which GHG emission reductions are quantified and verified is called the “reporting period-.” The reporting period must be uniformly defined for the aggregate, and shall be determined by the aggregator as an annual period most appropriate for aggregate, based on the cultivation cycles and respective start dates of fields within the aggregate. Individual fields within an aggregate may have cultivation cycles that start on different dates; however the cultivation cycles for all fields within an aggregate must be complete before the aggregate is able to undergo verification. To ensure that only emission reductions occurring during an aggregate’s fixed reporting period is credited during that reporting period, emission reductions from each field shall be prorated as discussed further below. For single-field projects, the reporting period shall be defined using the exact dates corresponding to the beginning and the end of the cultivation cycle for the particular field.

Both reporting periods and cultivation cycles must be contiguous; there can be no time gaps in reporting during the crediting period of an aggregate once the initial reporting period has

commenced.⁹⁵ If the crop rotation on the project field includes ineligible crops (e.g. soy in a corn/soy rotation), the project field must report continuously on the field's management practices, even though the project field shall only receive credit for project activities implemented on eligible crops.

Because a single reporting period must be uniformly defined for the aggregate, the aggregator must prorate the emissions reductions from each field in the aggregate, after the field has completed its respective cultivation cycle and total emission reductions for that field have been calculated. TheAll emission reductions from a complete cultivation cycle should be verified at one time. However, the aggregator shall divide total emission reductions from the reporting period by 365 days to calculate the average daily emission reductions associated with a given field, and multiply by the total days of the cultivation cycle falling within the aggregate's uniform reporting period currently undergoing verification. The remaining emission reductions from the complete cultivation cycle (applicable to the subsequent reporting period) may, should be verified along with the field's total emission reductions in thatfrom this cultivation cycle, but shall be credited under the subsequent aggregate reporting period.

For aggregates, no more than one reporting period can be verified at once, except during an aggregate's first verification, which may include historical emission reductions from prior years.

7.4.1 Additional Reporting and Verification Options for Single-Field Projects

For single-field projects, however, there are three verification options to choose from, which provide the project developer more flexibility and help manage verification costs associated with nitrogen management projects. The project developer may choose from these additional options after a project has completed its initial verification and registration.

A project developer may choose to use one option for the duration of a project's crediting period. Regardless of the option selected, reporting periods must be contiguous; there may be no time gaps in reporting during the crediting period of a project once the initial reporting period has commenced. Project participants must continue reporting during non-eligible crop years (see Section 6.3.3.2 for requirements). Non-eligible crop years do not require verification, and as such, do not count against the number of months included in a given verification period (see options below). Verifiers shall review N rate records for any interim non-eligible year(s) as a component of verifying eligibility in the subsequent eligible crop year (see Section 3.5.1.1).

If a single-field project joins an aggregate, that field will immediately be subject to the verification schedule of the aggregate moving forward (e.g. for the first reporting period that field is enrolled in the new aggregate).

If a field exits an aggregate to become a single-field project, that project is subject to the reporting and verification requirements of an initial reporting and verification period. In other words, that single-field project's first verification as a single-field project may not take advantage of Options 2 or 3, below.

7.4.1.1 Initial Reporting and Verification Period

The reporting period for projects undergoing their initial verification and registration cannot exceed one complete cultivation cycle, which may be slightly greater or less than 365 days. The

⁹⁵ An entire aggregate can willingly forfeit CRTs for an entire cultivation cycle in accordance with the Reserve's zero-crediting period policy, available at <http://www.climateactionreserve.org/how/program/program-manual/>.

one exception is for historic projects (e.g. fields with start dates on or after June 27, 2010), which are eligible to include multiple cultivation cycles in their first reporting period, so long as the project is submitted to the Reserve by June 27, 2013 (see Section 3.2 for additional guidance). Once a project is registered and has had at least one complete cultivation cycle of emission reductions verified, the project developer may choose one of the verification options below.

7.4.1.2 Option 1: Twelve-Month Maximum Verification Period

Under this option, the verification period may not exceed one complete cultivation cycle, which may be slightly greater or less than 365 days. Verification with a site visit is required for CRT issuance.

7.4.1.3 Option 2: Twelve-Month Verification Period with Desktop Verification

Under this option, the verification period cannot exceed one complete cultivation cycle.

However, CRTs may be issued upon successful completion of a desktop verification as long as:

(1) Site visit verifications occur at two-year intervals (e.g. every second eligible crop year), with a maximum of three non-eligible crop years between corn crops; and (2) The verification body has confirmed that there have been no significant changes in selected project activities, field management or ownership and/or management control of the field since the previous site visit. Desktop verifications must cover all other required verification activities (i.e. a full desktop verification of the Single-Field Report).

Desktop verifications are allowed only for a single 12-month verification period in between 12-month verification periods that are verified by a site visit.

7.4.1.4 Option 3: Twenty-Four Month Maximum Verification Period

Under this option, the verification period cannot exceed two complete cultivation cycles of eligible crops (approximately 730 days or 24 months) and the project monitoring plan and Single-Field Report must be submitted to the Reserve for the interim eligible crop's cultivation cycle's reporting period. The project monitoring plan and report must be submitted for projects that choose Option 3 in order to meet the annual documentation requirement of the Reserve program. They are meant to provide the Reserve with information and documentation on project operations and performance. They also demonstrate how the project monitoring plan was met over the course of the first half of the verification period. They are submitted via the Reserve online registry, but are not publicly available documents. The monitoring plan and report shall be submitted within 30 days of the end of the reporting period. In the case of a multi-crop rotation, a 24-month verification period that consists of two non-consecutive corn crop years is allowable, with no more than one interim non-eligible crop year (e.g. verification could cover 24 months of data within a 36-month timeframe).

Under this option, CRTs may be issued upon successful completion of a site visit verification for GHG reductions achieved over a maximum of 24 months. CRTs will not be issued based on the Reserve's review of project monitoring plans or reports. Project developers may choose to have a verification period shorter than 24 months.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions associated with the project activity. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities specifically related to nitrogen management projects.

Verification bodies trained to verify nitrogen management projects must be familiar with the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Nitrogen Management Project Protocol (NMPP)

The Reserve Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at <http://www.climateactionreserve.org>.

Only ISO-accredited verification bodies with lead verifiers trained by the Reserve for this project type are eligible to verify nitrogen management project reports. Verification bodies approved under other project protocol types are not permitted to verify nitrogen management projects. Information about verification body accreditation and Reserve project verification training can be found on the Reserve website at <http://www.climateactionreserve.org/how/verification/>.

In addition, all verification bodies must have ~~an accredited~~ a Certified Professional Agronomist, or Certified Crop Advisor ~~or similar agricultural specialist~~⁹⁶ on the verification team in order to verify nitrogen management projects. The agronomist or crop advisor must be present for all verification site visits, and will provide additional support and expertise with interpreting information, assessing field conditions, and interviewing project participants and any relevant staff, on-site

8.1 Preparing for Verification

The project developer is responsible for coordinating all aspects of the verification process, coordinating with the verification body, project participants (in the case of an aggregate), and the Reserve, and submitting all necessary documentation to the verification body and the Reserve.

The project developer is responsible for selecting a single verification body for the entire project or aggregate for each reporting period. The same verification body may be used up to six consecutive years (the number of consecutive years allowed, according the Reserve Verification Program Manual⁹⁷). Verification bodies, including the agronomist, must pass a conflict-of-interest review against the project developer, and in the case of aggregate projects, all project participants and the aggregator. Consequently, the submitted List of Enrolled Fields must be updated by the aggregator prior to the conflict of interest review.

⁹⁶ Certification of agronomists and crop advisors should be administered by the American Society of Agronomy (<https://www.agronomy.org>), or other comparable program.

⁹⁷ <http://www.climateactionreserve.org/how/verification/verification-program-manual/>

Each year, project developers of single-field projects must make the Single-Field Report, which is submitted to the Reserve annually, and the Single-Field Monitoring Plan available to the verification body. These documents must meet the requirements in Sections 6 and 7.

In ~~aggregates, each year~~ aggregate projects, project participants must annually submit a Field Report, all field data, and any reporting data from non-eligible crop years (where applicable, for fields completing an eligible crop year) to the aggregator according to the guidelines in Sections 6 and 7. Aggregators must make all Field Monitoring Plans (FMPs) ~~available to the verification body, as well as~~, Field Reports, reporting data from non-eligible crop years (for fields completing an eligible crop year), the Aggregate Monitoring Plan (AMP), and the Aggregate Report available to the verification body.

In all cases, the above documentation should be made available to the verification body after the NOVA/COI process is complete.

Aggregators may assist project participants in preparing documents for verification and in facilitating the verification process. The scope of these services is determined by the specific contract between project participants and the aggregator. However, the ultimate responsibility for monitoring reports and verification compliance is assigned to the aggregator.

For aggregates, a field is considered verified if it is in the pool of fields for which site visits or desktop verifications are conducted, even if not selected for either a site visit or desktop verification (see Section 8.3 for details on sampling for verification).

As a preliminary step in preparing for verification, the aggregator may choose to exclude fields from the pool of fields that may be selected for verification activities. Aggregators must report to the verification body all instances of field exclusion. The excluded fields shall be removed from the acreage totals and from field numbers used to determine field eligibility and verification sampling methodologies (in Section [8.3](#)) and are therefore not considered verified.

8.2 Verification Schedule for Single-Field Projects

Single-field projects are comprised of exactly one field, and as such, there is no sampling methodology to select the fields undergoing verification. The single-field project shall be verified according to the verification schedule outlined below.

This protocol provides project developers three verification options, Sections 8.2.1 to 8.2.3, for a single-field project after its initial verification and registration in order to provide flexibility and help manage verification costs associated with nitrogen management projects. For each option, verification bodies may need to confirm additional requirements specific to this protocol, and in some instances, utilize professional judgment on the appropriateness of the option selected.

All fields are required to perform a Corn Stalk Nitrate Test (CSNT) prior to the end of the reporting period for each eligible corn crop and provide the test results to the verification body, in preparation for verification. Unlike the case with aggregates, where CSNT results will directly inform risk-based sampling for verification site visits, the CSNT results for single-field projects are used to assess risk of whether the project activity has occurred. CSNT results that indicate

“excessive” N use (e.g. greater than 2000 ppm nitrate-N)⁹⁸ or other anomalous results (e.g. a large increase in ppm nitrate-N from previous), should be interpreted as having a higher risk of not having reduced their N rate over the reporting period.⁹⁹ Therefore fields with “excessive” CSNT results shall receive further follow up, in the form of site visits, interviews, additional information requests, etc, as necessary.

The actual requirements for performing a site visit verification and desktop verification are the same. A desktop verification is equivalent to a full verification, without the requirement to visit the site. A verification body has the discretion to visit any site in any reporting period if the verification body determines that the risks for that field warrant a site visit.

8.2.1 Option 1: Twelve-Month Maximum Verification Period

Option 1 does not require verification bodies to confirm any additional requirements beyond what is specified in the protocol. (See Section 7.4.1.2 for requirements)

8.2.2 Option 2: Twelve-Month Verification Period with Desktop Verification

Option 2 requires verification bodies to review the documentation specified in Section 7.4.1.3 in order to determine if a desktop verification is appropriate. The verifier shall use their professional judgment to assess any changes that have occurred related to project data management systems, equipment or personnel and determine whether a site visit should be required as part of verification activities in order to provide a reasonable level of assurance on the project verification. The documentation shall be reviewed prior to the NOVA/COI renewal submitted to the Reserve, and the verification body shall provide a summary of its assessment and decision on the appropriateness of a desktop verification when submitting the NOVA/COI renewal. The Reserve reserves the right to review the documentation provided by the project developer and the decision made by the verification body on whether a desktop verification is appropriate.

8.2.3 Option 3: Twenty-Four Month Maximum Verification Period

Under Option 3 (see Section 7.4.1.4), verification bodies shall look to the project monitoring report submitted by the project developer to the Reserve for the interim 12-month reporting period as a resource to inform its planned verification activities. While verification bodies are not expected to provide a reasonable level of assurance on the accuracy of the monitoring report as part of verification, the verification body shall list a summary of discrepancies between the monitoring report and what was ultimately verified in the List of Findings.

8.3 Verification Sampling and Schedule for Aggregates

Guidelines for verification sampling of the aggregate and the aggregate’s verification schedule are different for “small aggregates,” “large single-participant aggregates,” and “large multi-

⁹⁸ Iowa State University Extension Service, “Cornstalk testing to evaluate nitrogen management,” PM 1584, Revised August 1996, Prepared by: A. M. Blackmer and A. P. Mallarino, research agronomists, Department of Agronomy, Iowa State University, Available at: <http://www.extension.iastate.edu/Publications/PM1584.pdf>

⁹⁹ It is important to note that many factors influence N availability and a field’s corn stalks may vary in their nitrate-N concentration from year to year. Consequently, an “excessive” result by the CSNT does not necessarily mean that a field has not reduced its N rate against its baseline, but it is a good indication of which fields have the highest probability of application above the N demand for the crop, and therefore are at highest risk of not having reduced their N rate over the reporting period.

participant aggregates.” This approach allows a consistent application of verification requirements across all aggregates regardless of size or number of participants.

In all cases, the verification schedule shall be established by the verification body using a combination of risk-based and random sampling, according to the verification schedule and sampling methodologies outlined in Sections 8.3.2, 8.3.3, and 8.3.4. These sampling methodologies establish ~~the~~a minimum and a range of verification frequencies; as well as guidance on circumstances in which the verification body ~~may at any time~~is encouraged to add fields beyond the minimum ~~number~~percentage of fields required for site visit and/or desktop verification ~~and~~. The verifier may use ~~verifier~~professional judgment to determine the number of additional fields and method for selecting fields if a risk-based review indicates a high probability of non-compliance. The verification sampling requirements are mandatory regardless of the mix of entry dates represented by the group of fields in the aggregate.

The initial site visit verification schedule for a given year shall be established after the completion of the NOVA/COI process ~~and prior to~~. The schedule should be established as soon as possible after the commencement of ~~any~~ verification activities, once the verifier has received CSNT results and the Aggregate Report, at a minimum, so as to include both risk-based and random sampling for the selection of site visited fields. This is meant to allow for the aggregator and verification body to work together to develop a cost-effective and efficient site visit schedule. Specifically, once the sample fields designated for a site visit have been determined, the verification body shall document all fields selected for planned site visit verification and provide a list of project participants and fields receiving a visit to the aggregator and the Reserve. The aggregator shall be responsible for informing project participants of their selection for a planned site visit. Following this notification, the aggregator shall supply the verification body with all the required documentation to demonstrate field-level conformance to the protocol. When a verification body determines that additional sampling is necessary, due to suspected non-compliance, however, a similar level of advance notice may not be possible.

Though significant advance notice of a field’s selection for a site visit is required, aggregators and project participants shall not be given advance notice of which fields’ data will be subject to desktop verification in a given year. A field shall be prepared for desktop verification during every reporting period, so long as the field’s FMP is implemented and up-to-date, the Field Report submitted to the aggregator, and all record-keeping requirements of this protocol are followed.

Regardless of the size of an aggregate, if the aggregate contains any fields that did not pass site visit verification the year before and wish to re-enter the aggregate, those fields must have a full verification with site visit for the subsequent reporting period. These fields must be site visited *in addition* to the verification sampling methodology and requirements outlined below in Sections 8.3.2, 8.3.3, and 8.3.4.

For the purposes of verification, a “small aggregate” is defined as an aggregate comprised of 4020 or fewer fields, regardless of the number of project participants. Small aggregates will meet fixed site visit and desktop verification frequency requirements based on a verification schedule determined by the verifier, in compliance with Section 8.3.2 of this protocol.

A “large single-participant aggregate” is defined as an aggregate comprised of more than 4020 distinct fields all managed by one single project participant. For large single-participant aggregates, fields will be randomly selected for site visit and desktop verification, according to

the sampling method in Section 8.3.3, which is based on a non-linear scale where the relative fraction of fields undergoing verification activities gets smaller as the aggregate size gets larger.

A “large multi-participant aggregate” is defined as an aggregate comprised of more than 4020 fields and more than one project participant. For large multi-participant aggregates, participants and their fields will be randomly selected for site visit and desktop verification, according to the risk-based and random sampling method in Section 8.3.4, which is based on a non-linear scale where the relative fraction of participantsfields undergoing verification activities gets smaller as the aggregate size, in terms of number of participants, gets larger.

In all cases, when determining the sample size for site visits and desktop verifications, the verification body shall round up to the nearest whole number.

The actual requirements for performing a site visit verification and desktop verification are the same. A desktop verification is equivalent to a full verification, without the requirement to visit the site. A verification body has the discretion to visit any site in any reporting period if the verification body determines that the risks for that field warrant a site visit.

8.3.1 Informing Site Visit Sampling with Corn Stalk Nitrate Test Results

All fields are required to perform a Corn Stalk Nitrate Test (CSNT) prior to the end of the reporting period for each eligible corn crop and provide the test results to the verification body, in preparation for verification. Verifiers must review the results of the CSNTs for all fields to inform their risk-based sampling. Verifiers shall prioritize selection of fields for site visits, based on CSNT results that indicate “excessive” N use (e.g. greater than 2000 ppm nitrate-N)¹⁰⁰ or other anomalous results for site visit verification by sampling (e.g. a large increase in ppm nitrate-N from previous CSNT results, even if not excessive).

It is important to note that many factors influence N availability and a field’s corn stalks may vary in their nitrate-N concentration from year to year. Consequently, an “excessive” result by the CSNT does not necessarily mean that a field has not reduced its N rate against its baseline, but it is a good indication of which fields within the aggregate have the highest probability of application above the N demand for the crop, and therefore are at highest risk of not having reduced their N rate over the reporting period. As such, fields with “excessive” CSNT results shall receive further follow up, in the form of site visits, interviews, additional information requests, etc, as necessary.

<u>Category</u>	<u>Nitrate-N Concentration</u>	<u>Interpretation</u>
<u>Excessive</u>	<u>>2000 ppm</u>	<u>High probability that N availability was greater than N demand</u>
<u>Optimal</u>	<u>700-2000 ppm</u>	<u>High probability that N availability was within the optimal range needed to maximize profitability for the producer</u>
<u>Marginal</u>	<u>250 – 700 ppm</u>	<u>Indicated that N availability was very close to the minimal crop demand</u>
<u>Low</u>	<u><250 ppm</u>	<u>High probability that greater N availability would have resulted in increased yields</u>

Source: Iowa State University Extension Service¹⁰⁰

¹⁰⁰ Iowa State University Extension Service, “Cornstalk testing to evaluate nitrogen management,” PM 1584, Revised August 1996, Prepared by: A. M. Blackmer and A. P. Mallarino, research agronomists, Department of Agronomy, Iowa State University, Available at: <http://www.extension.iastate.edu/Publications/PM1584.pdf>

8.3.18.3.2 Verification Schedule for Small Aggregates

8.3.1.18.3.2.1 Site Visit Verification Schedule for Small Aggregates

~~Each field in a small aggregate shall undergo initial site visit verification within the first two cultivation cycles for each crediting period. In the first year of the aggregate or in subsequent years when new fields enter the aggregate, a minimum of 30 percent of the newly enrolled fields shall complete the initial site visit verification in their first year of enrollment.~~

~~In addition, site~~Site visit verifications must be conducted on a schedule such that:

1. Each field in the aggregate must successfully complete a minimum of ~~two~~one site visit ~~verifications~~verification per crediting period ~~(e.g. the initial site verification in addition to one more).~~
2. A minimum of 20 percent of the fields in the aggregate shall be site verified in any given year, selected at random first by a risk-based approach informed by CSNT results, and then selected at random, until 20 percent has been reached.

8.3.1.28.3.2.2 Desktop Verification Schedule for Small Aggregates

In any given year, a number of desktop verifications of field data must be conducted, with the number inversely related to the number of fields undergoing a site visit that year. Specifically, the number of desktop verifications ~~(D)~~, shall equal 50 percent of the number of fields ~~(n)~~, in the aggregate that will not receive a site visit that year, rounding up in the case of an uneven number of fields. In other words,

$D = \frac{(n - S)}{2}$ <p>Where,</p> <p>n = Number of fields in the aggregate</p> <p>S = Number of site visits</p> <p>D = Number of desktop verifications</p>

Fields shall not be selected for a desktop verification in years that the field is undergoing a site visit. If a site visit is planned for a field randomly selected for a desktop verification, the verification body will continue randomly drawing additional fields until the total number selected for a desktop verification reaches the value of ~~(D)~~ per the equation above.

8.3.28.3.3 Verification Schedule for Large Single-Participant Aggregates

In contrast to small aggregates, it is possible that a field in a large aggregate is never verified, either via site visit or desktop verification, during its entire crediting period. Therefore, a combination of risk-based and random sampling is a particularly important component of enforcement.

8.3.2.18.3.3.1 Sampling for Site Visit Verification for Large Single-Participant Aggregates

The verification body determines the number of enrolled fields that must be ~~randomly~~selected for site visit verification in a given year. The required number of site visits ~~(S)~~, shall equal the square root of the total number of eligible fields ~~(n)~~ (e.g. those growing an eligible crop over the reporting period), enrolled in the large single-participant aggregate that year (i.e. $S = \sqrt{n}$ rounded up to the nearest whole number).- Verifiers shall select fields for site visits first through

the risk-based approach informed by CSNT results, and then by selecting additional fields at random, until the required number of site visits (S) has been reached.

8.3.2.28.3.3.2 Sampling for Desktop Verification for Large Single-Participant Aggregates

In addition to site visit verifications, verification bodies shall randomly select a sample of fields to undergo a desktop verification ~~(D)~~, equal to two times the square root of the total number of fields in the aggregate.

Fields shall not be selected for a desktop verification in years that the field is undergoing a site visit. If a site visit is planned for a field randomly selected for a desktop verification, the verification body will continue randomly drawing additional fields until the total number selected for a desktop verification reaches the square root of the total number of fields in the aggregate.

8.3.38.3.4 Verification Schedule for Large Multi-Participant Aggregates

~~The random sampling methodology shall be applied first at the project participant level and then at the field level. A random sampling methodology will be applied for site visit and desktop verification selection. However, the verification body shall select fields for site visits first as described in Section 8.3.3.1 and desktop verifications second as described in Section 8.3.3.2.~~

In contrast to small aggregates, it is possible that a field in a large aggregate is never verified, either via site visit or desktop verification, during its entire crediting period. Therefore, a combination of risk-based and random sampling is a particularly important component of the enforcement mechanism. The sampling methodology for large multi-participant aggregates shall take place in three steps. Site visit sampling shall be informed in step one by a risk-based sampling approach and in step two by random sampling. The third step shall inform desktop verification based on random sampling.

A minimum of five percent of the total number of eligible fields in the aggregate (e.g. only fields growing eligible crops in the reporting period to be verified) must be site visited. The verification body shall be allowed to vary the number of site visits performed, based on levels of perceived risk identified during verification, up to a maximum of fifteen percent of eligible fields in a given year. Specific risks identified during the verification could include: the incidence of CSNT results within the “excessive” range, fields generating large proportions of the emission reductions of the aggregate, and/or demonstrated poor communication of N-reduction strategies and implementation between aggregators and participants

Each verification report must contain a description of the sampling methodology, number of site visits, and justification for higher levels of sampling (e.g. due to higher levels of risk)

8.3.3.18.3.4.1 Sampling for Site Visit Verification for Large Multi-Participant Aggregates

~~The verification body~~

- ~~1. First, verifiers shall determine~~select fields for site visits first through a risk-based approach informed by CSNT results
- ~~1. Once the number of project participants that must be randomly~~verifier has selected for a site visit in a given year, as follows:

$$S = \left(1 + \left(\frac{P}{500} \right) \right) \times \sqrt{P}$$

~~Where,~~

S	=	Number of site visits required (rounded up to the nearest whole number)
P	=	Number of project participants in the aggregate

~~2. The verification body fields for site visits through the risk-based approach, additional fields shall randomly select (S) project participants to receive site visits that year.~~

~~3. by selected at random. The verification body shall randomly select which fields of the selected project participants will receive a site visit. For project participants with six enrolled fields or fewer, the verification body shall site visit at least 50 percent of the fields, selected at random. For project participants with more than six additional fields enrolled in the aggregate, the verification body shall site visit at least 33.3 percent of the fields, selected at random.~~

~~4.2. A minimum of the square root of the total number of fields in the aggregate must be site visited. If this number is not met after following Steps 1 to 3, then the verification body shall randomly select one additional project participant and the sample of fields, according to Step 2 and 3 above, and repeat this until the number of site visits meets this minimum requirement. Note that Step 3 must be completed in full and therefore could result in a greater number of fields selected for site visits than the minimum requirement. of at least five percent (or the verifier's chosen percentage, based on higher risk)~~

8.3.3.28.3.4.2 Sampling for Desktop Verification for Large Multi-Participant Aggregates

In addition to site visit verifications, each year verification bodies shall also randomly select fields to undergo a desktop verification of their field data. Verification bodies shall randomly select a sample of fields to undergo a desktop verification equal to two times the square root of the total number of fields in the aggregate (rounded up to the next whole number).

Fields shall not be selected for a desk-audit in years that the field is undergoing a site visit. If a site visit is planned for a field randomly selected for a desktop verification, the verification body will continue randomly drawing additional fields until the total number selected for a desktop verification reaches the square root of the total number of fields in the aggregate.

8.4 Standard of Verification

The Reserve's standard of verification for nitrogen management projects is the Nitrogen Management Project Protocol (this document) and the Reserve Program Manual and Verification Program Manual. To verify a nitrogen management aggregate, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.5 Monitoring Plan

The Aggregate Monitoring Plan (AMP) and Field Monitoring Plan (FMP) serve as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and recordkeeping is ongoing by the aggregator and all enrolled fields. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1 are collected and recorded.

8.5.1 Annual Reports

The single-field project's project developer must annually submit field data for single-field projects to the Reserve. The Single-Field Report will consist of a *.csv file and attachments, as described in Section 7.2.1. Verification bodies must review the Single-Field Report to confirm project information and data collected according to the SFMP.

The aggregate must annually submit an Aggregate Report to the Reserve. The report will consist of a *.csv file and attachments, as described in Section 7.2.2. Verification bodies must review the Aggregate Report to confirm project information and data collected according to the AMP.

The verification body will need to review field data during desktop verifications of randomly selected fields in an aggregate. The field data must be made available to the verification body in order to confirm field-level information collected according to the FMP.

8.6 Verifying Eligibility at the Field Level

Verification bodies must affirm each project field's eligibility during site visit and/or desktop verifications according to the rules described in this protocol. The table below outlines the eligibility criteria for each project field. This table does not present all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.3.

Table 8.1. Summary of Eligibility Criteria for a Nitrogen Management Project

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	The first day of the cultivation cycle, which begins immediately after completion of the previous crop's harvest, in which the approved project activity is adopted at the field. For 12 months following the Effective Date of this protocol, a pre-existing field with a start date on or after June 27, 2010 may be submitted for listing; after this 12 month period, projects must be submitted for listing within six months of the project start date	Once during first verification
Location and Crop Type	The field is located in an approved area of the U.S. and U.S. tribal areas and contains a corresponding eligible crop, according to Table 3.1	Every verification
Performance Standard	The field passes the Performance Standard Test for its respective state-crop combination— <u>according to Section 3.5.1.1</u> . (Fields previously in a non-eligible year must also demonstrate that N loading has not occurred since the last verification to pass the Performance Standard Test)	Every verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test	Every verification
Legal Title to CRTs	Aggregator Attestation of Title to CRTs	Every verification
Regulatory Compliance	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verification body; project must be in material compliance with all applicable laws. In particular, no violations to the Safe Drinking Water Act or Clean Water Act, due to agricultural discharges.	Every verification
Applicability Conditions	<ul style="list-style-type: none"> • Verify that the total OSN values in the project are within the range allowable, as calculated in all applicability conditions to Section 5.3, Step 5 • Verify that no fields have histosol soils • Verify that only eligible N fertilizers¹ have been used met. 	Every verification

8.7 Core Verification Activities

The NMPP provides explicit requirements and guidance for quantifying the GHG reductions associated with the implementation of approved nitrogen management practice changes on project fields. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a nitrogen management project, but verification bodies must also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emission sources, sinks, and reservoirs (SSRs)
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs for each field

The verification body reviews for completeness the sources, sinks, and reservoirs identified for a single-field project or aggregate, ensuring that all relevant secondary effect SSRs for each field are identified.

Reviewing GHG management systems and estimation methodologies at the field level

The verification body reviews and assesses the appropriateness of the methodologies and management systems that are used to gather data and calculate baseline and project emissions for each field.

Reviewing GHG management systems and estimation methodologies at the aggregate level

The verification body reviews and assesses the appropriateness of the methodologies and management systems that the project aggregator uses to gather data and calculate baseline and project emissions on the aggregate level.

Verifying emission reduction estimates at the field level

The verification body further investigates areas that have the greatest potential for material misstatements and confirms whether or not material misstatements have occurred for all fields undergoing verification. This involves site visits to a random sample of project fields, according to the sampling methodology outlined in Section 8.3.3.1, to ensure systems on the ground correspond to and are consistent with data provided to the verification body, combined with a random sample of desktop verifications of remaining project fields according to Section [8.3.3.2](#). In addition, the verification body recalculates a representative sample of the performance or emissions data from fields for comparison with data reported by the project aggregator in order to confirm calculations of GHG emission reductions.

Verifying emission reduction estimates at the aggregate level

The verification body further investigates areas that have the greatest potential for material misstatements at the aggregate level, including whether the appropriate structural uncertainty factors (Section [5.4.4](#)) and yield-loss statistical tests (Section 1.1.1) have been performed for the aggregate.

8.8 Project Type Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a nitrogen management project. The tables include references to the section in the protocol where requirements are further specified. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. Supplemental monitoring data and records (noted in Sections 6.4 and 7.3.3) are not included in the tables below. However, any supplemental information made available to the verifier by the project participant may be used to raise the verifier's level of assurance that the project activity occurred.

For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to nitrogen management projects that must be addressed during verification.

8.8.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for nitrogen management aggregates. These requirements determine if the aggregate is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any one requirement is not met, either for one or more fields, then the entire aggregate may be determined ineligible or the GHG reductions from the reporting period may be ineligible for issuance of CRTs, as specified in Section 3.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2	Verify that all verified fields meet the definition of a nitrogen management project	No
<u>2.3</u>	Verify ownership of the reductions by reviewing Aggregator Attestation of Title	No
<u>2.3</u>	Verify ownership of the reductions by reviewing Letters of Notification and contracts between aggregators, project participants, and land owners	No
3.2	Verify the project start date for all fields	No
3.2	Verify accuracy of project start date for all verified fields based on operational records	Yes
3.3	Verify that each field is within the 14 <u>10</u> -year crediting period and seven <u>five</u> eligible crop years within that crediting period.	No
3.5.1	Verify that each field meets the Performance Standard Test	No
<u>3.5.1</u>	<u>Verify that each field previously in a non-eligible year applied no more than the permissible N rate range over the non-eligible crop year</u>	<u>Yes</u>
3.5.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test	No
3.5.3	Verify that any ecosystem service payment or credit received for activities on a project field has been disclosed and is allowed to be stacked	No
3.6	Verify that the project activities at all verified fields comply with applicable laws, particularly water quality laws, by reviewing any instances of non-compliance provided by the aggregator and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
5.1	Verify that all applicability conditions have been met for the project activity, including that no histosol soils are present in a field's project area, that the OSN has been consistent in the project and baseline, and that only eligible N fertilizers have been used.	No
6.1, 6.2, 6.2.2	Verify that the project Monitoring Plan contains a mechanism for ascertaining and demonstrating that all fields pass the Legal Requirement Test at all times	No
6.1, 6.2.2, 6.3	Verify that field-level and aggregate-level monitoring meets the requirements of the protocol. If it does not, verify that a variance has	No

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
	been approved for monitoring variations	

8.8.2 Quantification

Table 8.3 lists the items that verification bodies shall include in their risk assessment and re-calculation of the GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the aggregate GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that all SSRs in the GHG Assessment Boundary are accounted for	No
5.1	For each field, ensure that the baseline and project N rate have been determined correctly	No
0	For each field, verify that input parameters for both the baseline and the project are represented by the appropriate data and the calculations are accurate for the baseline and the project emissions calculations	Yes
5.4.4	For the aggregate, verify that all field emission reductions are summed correctly, and that the structural uncertainty factor is properly applied	No
5.5.1	Verify that the aggregator correctly monitored, quantified and aggregated fossil fuel and electricity use changes	Yes
1.1.1	For the aggregate, verify that the statistical test for reduced yield is properly performed, and that increased emissions outside the project boundary are properly quantified for significant yield losses	No

8.8.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that all contractors are qualified to perform the duties expected. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
6.1, 6.2, 6.2.2	Verify that the project has documented and implemented the Single-Field Monitoring Plan or Aggregate Monitoring Plan, and all necessary Field Monitoring Plans	No
6.1, 6.2, 6.2.2	Verify that the project monitoring plans are sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6.3	Verify that appropriate monitoring data is measured or referenced accurately	No
6, 7	Verify that the individual or team responsible for managing and reporting	Yes

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
	project activities are qualified to perform this function	
6, 7	Verify that appropriate training was provided to personnel assigned to GHG reporting duties	Yes
7.2	Verify that the Single-Field Report or Aggregate Report was uploaded to the Reserve software	No
7.2, 7.3	Verify that field data has been gathered by project participants and made available to the aggregator	No
7.3	Verify that all required records have been retained by the project developer	No

8.9 Successful and Unsuccessful Verifications

Successful verification of each field in the sample of fields selected for site visit and desktop verifications results in the crediting of all fields participating in the entire aggregate, as calculated by the aggregator according to the quantification methodology in Section 5.

Verification may uncover any number of material and immaterial errors at the field, project participant or aggregate level, and the extent to which an error was propagated through the aggregate can affect whether a verification is determined to be “unsuccessful.”

8.9.1 Field-Level and Project Participant-Level Errors

If material issues arise during verification of a participating field, verification bodies shall issue Corrective Action Requests, as needed. The aggregator will need to work with the project participant to independently address the issues and required corrective actions using the same process taken with standalone projects. These are described in the verification guidance of this protocol and the Reserve Verification Program Manual. If the error can be corrected at the field level and is the type of error which will not be propagated across an individual participant’s fields or the entire aggregate, then the error shall be corrected and the field verification shall be considered successful. Errors shall be considered immaterial at the field level if they result in a discrepancy that is less than five percent of the total emission reductions quantified for that field.

If verification of a field reveals material non-compliance with the protocol, and no corrective action is possible, that field shall receive a negative verification and no CRTs shall be issued for that field, effectively removing the field from the aggregate for that year. When verification is unsuccessful for a participating field, the verification body must verify additional fields until the total number of successful verifications reaches the required number (as described in Section [8.2](#)), starting with fields managed by the same participant, as follows. If the project participant managing the unsuccessfully verified field also manages other fields enrolled in the aggregate, the verification body shall site visit a minimum of two additional fields or 50 percent of the remaining unverified fields, whichever is larger, that are managed by that project participant. If the verification of the additional fields is also unsuccessful, no CRTs shall be issued for any of the fields managed by the project participant.

Deliberate non-compliance may result in disqualification of the project participant including all of their enrolled fields. Additionally, if the project participant failing verification and their negatively verified fields re-enter the aggregate the following year, each of the fields that failed verification the previous year shall be required to undergo a site visit, in addition to the minimum sampling requirements in Section [8.2](#).

Whenever a project participant receives a negative verification for all of their enrolled fields, the verification body shall use their professional judgment and a risk-based assessment to determine whether sampling additional project participants for site visit verification, beyond the minimum requirements of this protocol, is necessary to verify the entire aggregate to a reasonable level of assurance.

8.9.1.1 Cumulative Field-Level Error of Sampled Fields

Total errors and/or non-compliance shall be determined for the sampled fields and the offset issuance for those fields corrected, as required, by the Verification Program Manual. Should the aggregated error and/or non-compliance rate for the sampled fields be less than five percent, CRT issuance for fields not subjected to site visit or desktop verification shall be equal to the amount reported by the aggregator. However, if the aggregated percent error and/or non-compliance rate (i.e. the percentage of verified fields failing verification) for sampled fields is greater than five percent, CRT issuance for fields not subjected to site visit or desktop verification shall be reduced by the total amount of aggregated percent error or non-compliance rate.

8.9.2 Aggregate-Level Errors

If verification reveals a potential systemic error, which may be propagated out to the aggregate level (e.g. a qualitative error with regard to the input parameters or a quantitative error repeated in multiple field-level calculations), the verification body shall use their professional judgment to sample additional fields, as necessary, to determine whether the error is truly systemic. Systemic errors must be corrected at the aggregate level.

8.10 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Accredited verifier	A verification firm approved by the Climate Action Reserve to provide verification services for project developers.
Additionality	Project activities that are above and beyond business-as-usual operation, exceed the baseline characterization, and are not mandated by regulation.
Aggregate	<u>A project comprised of two or more fields. An aggregate does not need to be comprised of contiguous fields, and can encompass fields located on one farming operation or distributed amongst different farms and/or producers. See Section 2.4 for further definition.</u>
Aggregator	<u>A project developer who represents one or more fields participating in a project (e.g. an aggregate). See Sections 2.3 and 2.4 for further definition.</u>
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e. fossil fuel destruction, deforestation, etc.).
Biogenic CO ₂ emissions	CO ₂ emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Carbon dioxide (CO ₂)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO ₂ equivalent (CO ₂ e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
<u>Cultivation cycle</u>	<u>The period starting immediately after harvest of one primary crop and ending after the next primary planted crop is harvested the following calendar year (e.g. 365 days). See Section 2.2.2 for further definition.</u>
Direct emissions	Greenhouse gas emissions from sources that are owned or controlled by the reporting entity.
Effective Date	The date of adoption of this protocol by the Reserve Board.
Eligible crop year	A creditable year of the crediting period, in which an eligible crop (see Table 3.1) is grown. Eligible crop years are not required to be consecutive.
Emission factor (EF)	A unique value for determining an amount of a GHG emitted for a given quantity of activity data (e.g. metric tons of carbon dioxide emitted per barrel of fossil fuel burned).

Field	<u>The project site, upon which the project activity is implemented. The field must be under the direct management control of a single entity, continuous, with homogenous management within the field boundary. See Section 2.2.1 for additional specifications.</u>
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Carbon dioxide (CO ₂), methane (CH ₄), nitrous oxide (N ₂ O), sulfur hexafluoride (SF ₆), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
GHG reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.
GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.
Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO ₂ .
Indirect emissions	Reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants.
Metric ton or “tonne” (MT)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Methane (CH ₄)	A potent GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.
MMBtu	One million British thermal units.
Mobile combustion	Emissions from the transportation of materials, products, waste, and employees resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g. cars, trucks, tractors, dozers, etc.).
Primary crop	<u>Defined as the main production crop grown on a field in a given year (e.g. corn is a primary crop and may be grown on its own or with a cover crop).</u>
Project baseline	A “business as usual” GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project developer	An entity that undertakes a GHG project, as identified in this protocol, Section 2.3.

Project participant	<u>An individual (e.g. a farmer) who has the authority to make cultivation management decisions on their fields and enrolls in an aggregate.</u>
Stationary combustion source	A stationary source of emissions from the production of electricity, heat, or steam, resulting from combustion of fuels in boilers, furnaces, turbines, kilns, and other facility equipment.
Verification	The process used to ensure that a given participant's GHG emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	A Reserve-approved firm that is able to render a verification statement and provide verification services for operators subject to reporting under this protocol.

10 References

[Partial List]

Bierman, P., Rosen, C., Venterea, R.T., & Lamb, J. (2011). Survey of Nitrogen Fertilizer Use on Corn in Minnesota. *Minnesota Department of Agriculture*.

Bouwman, A.F., & Boumans, L.J.M. (2002). Modeling global annual N₂O and NO emissions from fertilized fields. *Global Biogeochemical Cycles*, 16, 1080.

Clean Water Act (Federal Water Pollution Control Act). Available at <http://www.epa.gov/agriculture/lcwa.html>

Coalition on Agricultural Greenhouse Gases. (May 2011). C-AGG Executive Summary: Uncertainty in Models and Agricultural Offset Protocols. *Version 1*. Discussion Draft, February 2012, available at <http://www.c-agg.org/resources.html>.

Conservation Stewardship Program (CSP), Code of Federal Regulations, Title 7, §1470.37.

Cooley, D., & Olander, L. (September 2011). Stacking Ecosystem Services Payments: Risk and Solutions. *Nicholas Institute for Environmental Policy Solutions, Duke University, NI WP 11-04*. Available at <http://nicholasinstitute.duke.edu/ecosystem/land/stacking-ecosystem-services-payments/>

Davidson, E.A. (2009). The contribution of manure and fertilizer nitrogen to atmospheric nitrous oxide since 1860. *Nature Geoscience*, 2, 659-662.

Eagle, A.J., Olander, L.P., Lucy R. Henry, Karen Haugen-Kozyra, Neville Millar, and G. Philip Robertson. (January 2012). Greenhouse Gas Mitigation Potential of Agricultural Land Management in the United States: A Synthesis of the Literature (Third Edition). *Technical Working Group on Agricultural Greenhouse Gases*. Available at <http://nicholasinstitute.duke.edu/ecosystem/land/TAGGDLitRev>

Environmental Quality Incentives Program (EQIP), Code of Federal Regulations, Title 7, §1466.36.

Fixen, P. (2010). A Preliminary Nutrient Use Geographic Information System (NuGIS) for the U.S. International Plant Nutrition Institute. *IPNI Publication No. 30-3270*.

Huang, H., & Khanna, M. (2010). An Econometric Analysis of U.S. Crop Yield and Cropland Acreage: Implications for the Impact of Climate Change. Selected Paper prepared for presentation at the *Agricultural & Applied Economics Association 2010 AAEA, CAES, & WAEA Joint Annual Meeting*. Denver, Colorado. July 25-27, 2010.

IPCC Fourth Assessment Report, Climate Change 2007. Available at http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#1

IPCC Guidelines for National Greenhouse Gas Inventories. (2006). *Volume 4: Agriculture, Forestry and Other Land Use*. Available at <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>

Janzen, R., Baumann, T., Dyer, L., Hardly, P., & Reed, D. (2012). Additionality in Agricultural Offset Protocols. *Climate Check*.

Ladha, J.K., Pathak, H., J Krupnik, T., Six, J., & van Kessel, C. (2005). Efficiency of fertilizer nitrogen in cereal production: retrospects and prospects. *Advances in Agronomy*, 87, 85-156.

Millar, N., Robertson, G.P., Grace, P.R., Gehl, R.J., & Hoben, J.P. (2010). Nitrogen fertilizer management for nitrous oxide (N₂O) mitigation in intensive corn (Maize) production: an emissions reduction protocol for U.S. Midwest agriculture. *Mitigation and Adaptation Strategies for Global Change*, 15, 185-204.

Millar, N., Robertson, P., & Diamant, A. (2012). Quantifying N₂O Emissions Reductions in U.S. Agricultural Crops through Nitrogen Fertilizer Rate Reduction. Developed by *Michigan State University and Electric Power Research Institute*, Version 1.4.6, January 25, 2012. Undergoing 2nd Assessment with Verified Carbon Standard.

Natural Resources Conservation Service, U.S. Department of Agriculture. (December 2011) Conservation Practice Standard Nutrient Management, Code 590.

Parkin, T.B., & Venterea, R.T. (2010). Sampling Protocols. Chapter 3, Chamber-Based Trace Gas Flux Measurements. IN Sampling Protocols. R.F. Follett, editor. p. 3-1 to 3-39. Available at www.ars.usda.gov/research/GRACEnet

Ribaudo, M., Delgado, J., Hansen, L., Livingston, M., Mosheim, R., & Williamson, J. (2011). Nitrogen in Agricultural Systems: Implications for Conservation Policy. *U.S. Department of Agriculture, Economic Research Service, ERR-127*.

Rosenstock, T., Liptzin, D., Six, J., & Tomich, T. (In Review). The paradox of nitrogen fertilizer use in California: Simultaneous increases in agronomic efficiency and pollution potential.

Sawyer, J.E., Nafziger, E., Randall, G., Bundy, L., Rehm, G., & Joern, B. (2006). Concepts and rationale for regional nitrogen rate guidelines for corn. *Iowa State University, University Extension*.

Snyder, C.S., Fixen, P., & Johnston, A. (2011). Reducing Nitrous Oxide Emissions Through Improved Nitrogen Stewardship: Balancing Crop Production Management and Environmental Protection. *Soil Science Society of America Annual Meeting*. San Antonio, TX.

U.S. Environmental Protection Agency, Watershed Assessment, Tracking & Environmental Results. Available at http://iaspub.epa.gov/waters10/attains_nation_cy.control?p_report_type=T

U.S. Environmental Protection Agency. (2011). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009. *EPA 430-R-11-005*. Washington, D.C. Available at http://www.epa.gov/climatechange/emissions/usgginv_archive.html

World Business Council on Sustainable Development / World Resources Institute. (2005). The Greenhouse Gas Protocol for Project Accounting. *World Resources Institute*. Washington, DC. Available at <http://www.ghgprotocol.org>

Appendix A Summary of Performance Standard Development

~~A.1 Practices and Data Availability~~

This appendix summarizes performance standard development and research into industry trends in nitrogen management practices in crop cultivation that have the potential to reduce nitrous oxide emissions. This appendix primarily lays out the background and rationale for the Performance Standard Test for the approved project activity of reducing nitrogen application rate (N rate), which was identified in other methodologies ~~([Millar et al., 2010](#))¹⁰¹~~ and by the Reserve's Science Advisory Committee (SAC, see Appendix B) as a practice with consistent N₂O emission reduction potential.

A.1 Practices and Data Availability

~~While nine N₂O mitigation practices were prioritized for consideration in the NMPP, the lack of comprehensive datasets on "business as usual" nitrogen management practices hindered the development of performance standards for a number of these practices, as shown in [Table A.1](#).¹⁰² ~~Where available,~~ [Table A.1](#).¹⁰³~~

USDA ARMS datasets, discussed further below, were used to analyze common practice nitrogen management, and where sufficient data were available, research outcomes informed development of a performance standard. The only complete performance standard currently included in the NMPP is for N rate reduction projects for corn in the North Central Region ~~and, as such,~~ this appendix primarily addresses that performance standard and its development.

Section A.7 ~~of this appendix also~~ summarizes the preliminary performance standard research done on other priority nitrogen management practices for which data were available, namely switching from fall to spring application and using nitrification inhibitors (or using both nitrification and urease inhibitors), which may be included as approved project activities under a future version of this protocol. Section A.7 ~~also~~⁶ summarizes the preliminary performance standard research done on N rate reduction projects for other crops and regions, which also may be included under a future version of this protocol.

¹⁰¹ [Millar et al., 2010](#)

¹⁰² ~~The Background Paper on Quantification of N₂O Mitigation Options, prepared by Terra Global Capital for the Climate Action Reserve provides an extensive review of datasets considered for use in developing the performance standard. Only the most promising and comprehensive of datasets are discussed here.~~

¹⁰³ [The Background Paper on Quantification of N₂O Mitigation Options, prepared by Terra Global Capital for the Climate Action Reserve provides an extensive review of datasets considered for use in developing the performance standard. Only the most promising and comprehensive of datasets are discussed here.](#)

Table A.1. Priority List of Practices and Data Availability

Priority List of Practices to Include in NMPP (Based on SAC Report)	Are comprehensive data available to develop performance standard (USDA ARMS)?
Reduce N Applied w/out Going Below N Demand	Yes
Use of Nitrification and Urease Inhibitors	Yes ¹⁰⁴
Use of Nitrification Inhibitors (only)	Yes
Switch from Anhydrous Ammonia to Urea	No
Switch from Fall to Spring Application	Yes
Change to Slow Release Fertilizer	No
Change to Fertigation	No
Apply N Closer to Roots	No ¹⁰⁵
Add N Scavenging Cover Crops	No

A.2 Nitrogen Cycling and Nitrogen Use Efficiency

Metrics to set a performance standard threshold must be simple and consistent. Though the annual N fertilization rate may seem like a straightforward metric for setting a performance threshold, particularly for practices that reduce nitrogen rates, it is not a consistent metric. More specifically, fields that receive an equal amount of N fertilizer can vary drastically in terms of yield, how much N crops take up, how much N is lost, and how much residual N remains after crop uptake, all of which influence the quantity of N available for processes that lead to N₂O emissions. This difference in efficiency across sites can be understood if one considers the nitrogen cycle.

Nitrogen cycles through cropland systems in a way that is influenced by a wide range of site-specific variables such as soil type, climate, cropping system and previous and current N

¹⁰⁴ The USDA- ARMS data includes only penetration data for nitrification inhibitors, not urease inhibitors. This data set may still potentially be used to inform penetration rates for this practice, as the subset of farmers using both types of inhibitors will be smaller than those using just nitrification inhibitors, and as such, the penetration rate will also be lower.

¹⁰⁵ Though some N placement data is available through ARMS, the Reserve does not believe this data is sufficient to develop a performance standard for changing N placement, at this time.

management. A simplified diagram of the N cycle is depicted in **Figure A.1**

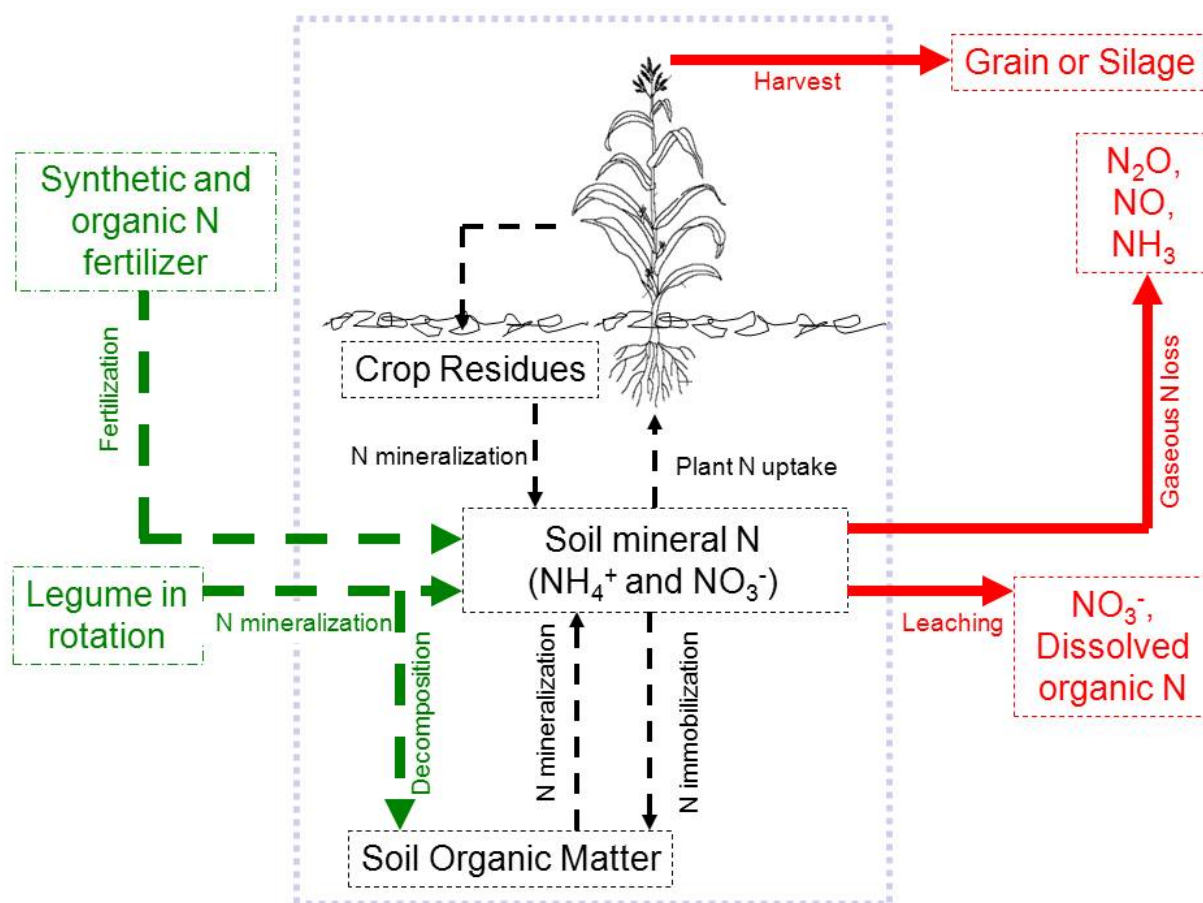
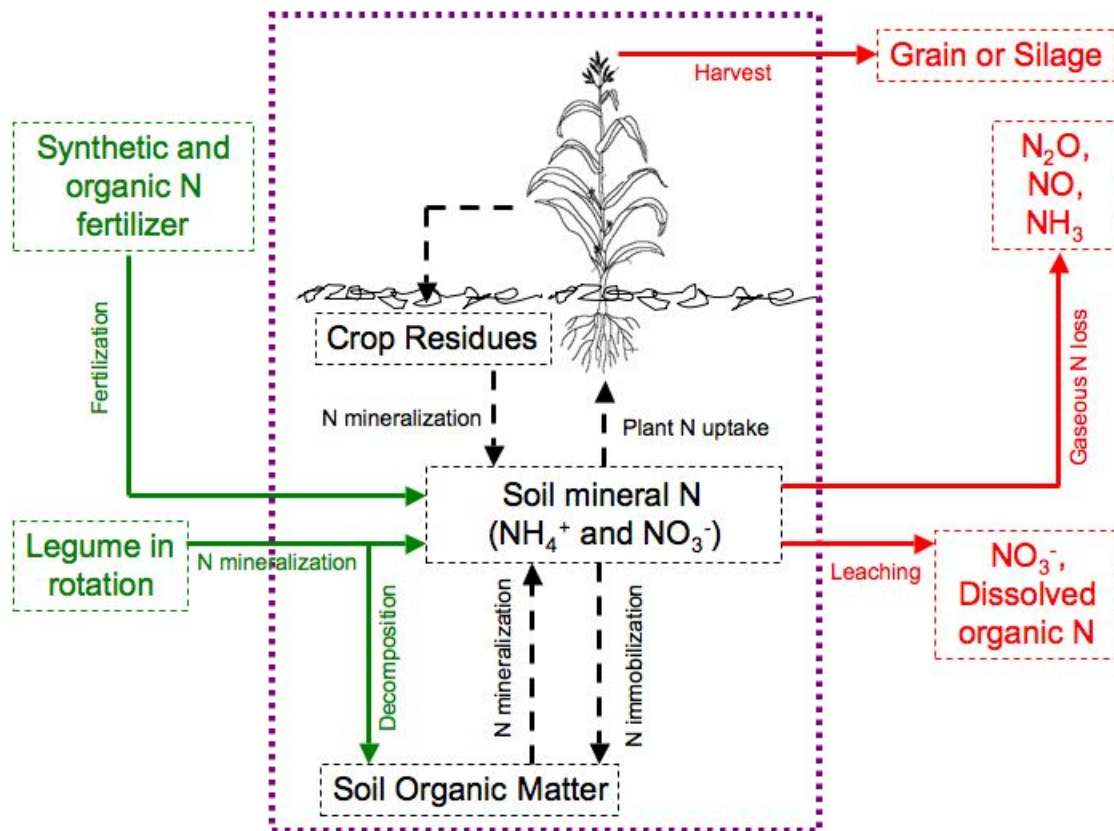


Figure A.1 below. N inputs in most agricultural systems consist of synthetic N fertilizer (e.g. anhydrous ammonia or urea), organic fertilizer (e.g. manure, compost, or sewage sludge), or carryover from legumes in the rotation. N can also become available through mineralization of organic matter or residual soil N carried over from one season to the next. Major N losses include leaching, NH_3 volatilization or emission of NO , N_2O or N_2 . Finally, N is also removed from the system through harvest, with the amount of N removed by harvest depending on the crop type and crop usage (e.g. corn for grain versus silage). As a consequence, the most appropriate N rate for a given field will vary drastically across and within cropping systems and regions, due to differences in climates, soil types and crop physiologies.



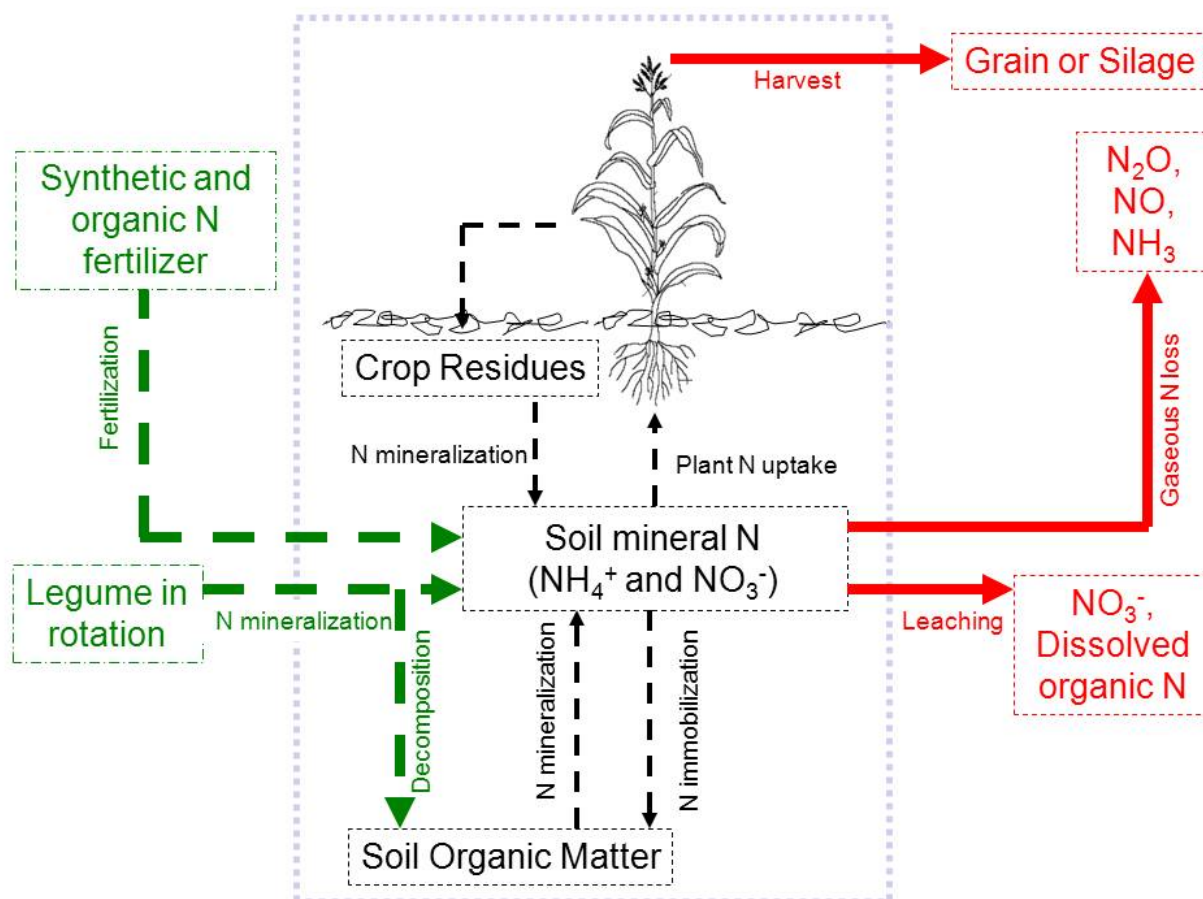


Figure A.1. Nitrogen Sources, Cycling, and Losses in Agricultural Systems

Red/Wide red arrows represent losses from the system, wide dashed green arrows external inputs and narrow dashed arrows internal recycling. The purple dotted line marks the accounting boundary-.] (Drawing of corn plant was obtained from www.inra.fr-www.inra.fr with N Cycle added.)

The most comprehensive evaluations of N budgets and N cycling in the system take into account all N inputs, losses and internal N cycling. A commonly used metric in the industry to characterize N budgets of cropland systems is Nitrogen Use Efficiency nitrogen use efficiency (NUE). The NUE takes the form of a ratio that considers an output (e.g. crop biomass at harvest or economic yield) as the numerator and input (N supply) as the denominator-(Ladha et al., 2005)-¹⁰⁶. The crop biomass at harvest (i.e. the “biological yield”) can include either total aboveground plant dry matter or total plant N, whereas the economic yield includes either grain yield or total grain N-(Ladha et al., 2005)-¹⁰⁶. The N supply can be from soil (N mineralization, carryover of residual N, N credit from legumes), fertilizer (organic or inorganic), or soil plus fertilizer-(Ladha et al., 2005)-¹⁰⁶. Consequently, various working definitions and methodologies to measure and calculate NUE are in circulation, each of which find their use in answering particular agronomic, ecological or economic questions. NUE can be used at various geographic scales, from studying and fine-tuning the N budget of a single field to evaluating nitrogen balances at a watershed or landscape scale. In a recent USDA report on N use

¹⁰⁶ Ladha JK, Pathak H, Krupnik TJ, et al. 2005. Efficiency of fertilizer nitrogen in cereal production: Retrospects and prospects. *Advances in Agronomy*, 87:85-156

(Ribaudo et al., 2011),¹⁰⁷ BMP N rates for a particular field were defined as N rates applied at less than 40 percent excess of N removed by harvest. At a landscape scale, NUE has been used by the International Plant Nutrition Institute (IPNI, (e.g. NuGIS, Fixen 2010)),¹⁰⁸ the Agricultural Sustainability Institute (ASI) at UC Davis, and other entities as an important indicator to evaluate the sustainability and performance of various agricultural regions and cropping systems (Fixen, 2010; Ladha et al., 2005; Rosenstock et al., In Review).¹⁰⁹ Regardless of the definition used for NUE, higher values for NUE generally reflect improved utilization of N by the crop, often decreasing the risk for harmful loss of N to the environment, such as N₂O emissions.

A performance standard threshold that is solely based on N fertilizer rates will be insufficient to deduce performance consistently across sites, due to the inability to account for site-specific factors. A high N rate threshold may be appropriate for high-yielding fields, but not for marginal fields within the same geographic region. A performance metric based on [nutrientnitrogen](#) use efficiency rather than absolute N rate can overcome this issue. NUE-based performance metrics reflect N management that limits N losses and maximizes N use by crops.

A.3 Ratio of Removed to Available Nitrogen (RTA) as Performance Standard Threshold

In the previous section, it was explained how a performance threshold for reducing N rates shall be based on some measure of NUE. Ideally, all inputs, losses (including N removed by harvest), and internal recycling should be considered when characterizing cropland NUE. However, in practice, such data is lacking, both in terms of regional data sets needed to set a threshold, as well as site-specific data that would be needed to compare a field's performance against the threshold. The only data readily available to assess these respective NUE values and set NUE thresholds is limited to synthetic and organic fertilizer N inputs and cropping yields, which can be used to calculate the N removed by harvest. Though more comprehensive NUE metrics, which include many additional variables, may approximate NUE more accurately in theory, these more comprehensive metrics can become rather complicated and opaque, making their use less desirable in the context of an offset protocol. For testing additionality, the focus should be on metrics for which sufficient data is available to define the common practice and that can be calculated for individual fields using historic data that is readily available to the grower. Metrics that reflect the system's N budget to its fullest extent will require additional data gathering and field sampling that are likely prohibitive to conduct at a field scale due to practical and financial constraints.

This protocol uses a simplified NUE metric, defined as the "ratio of removed to applied N" (RTA). The terminology "RTA" rather than "NUE" was selected to avoid confusion with more complicated definitions of NUE used in the industry and to acknowledge that RTA as it is used in the protocol does not necessarily provide the most precise quantification of the cropping system's N balance. The RTA metric is calculated in Equation 3.1 as the ratio of N removed by harvest to N applied, where N removed by harvest is determined by multiplying yield by a crop-specific default factor for N [content, found in Table A.2.concentration.](#)¹¹⁰ Therefore, RTA values increase when yield increases or N rate decreases. If a large number of producers in a specific state apply relatively low N rates because they account for potential residual N at the beginning

¹⁰⁷ Ribaudo et al., 2011

¹⁰⁸ NuGIS, Fixen 2010

¹⁰⁹ Fixen, 2010; Ladha et al., 2005; Rosenstock et al., In Review

¹¹⁰ Default N concentrations for corn are derived from Ribaudo et al., 2011

of the growing season or legume N credits, the state-average RTA will be relatively large. Vice versa, if the selection of an appropriate N rate is not commonly discounted for residual N or N credit from legumes, the state-average RTA will be relatively large. Therefore, simple state-average RTA values implicitly take into account the adoption of best management practices with respect to N rate, and state-specific threshold values can be used to ensure additionality and promote environmental integrity.

It should be noted that the RTA is a kind of intensity-based metric that normalizes N rates by using cropping yields. However, it is important to note that while the performance standard is based on an intensity-based approach, quantification of N₂O emission reductions in the NMPP is not intensity-based, but rather based on total reductions quantified for a given project area.

The RTA equation (~~Equation 3.1~~)¹¹¹ is used to calculate average state-level RTAs for developing performance standard thresholds (see ~~Sections~~Section A.5 and A.6), as well as used to determine baseline and project RTAs, based on project participants' crop production management records as described in Section 3.5.1.1.

Calculation of the RTA, both at the project-level and for the regional threshold, relies on the use of default values for N ~~content~~concentration of crops, as ~~listed~~included in ~~Table A.2 below~~Equation 3.1, which are adopted from the USDA N use report (~~Ribaudo et al., 2011~~).¹¹² Default values for N ~~content~~concentration are used to allow for a more straightforward comparison of state-specific and field-specific RTAs, particularly because data on field-specific crop N ~~contents~~concentrations are not typically collected and doing so can be somewhat cost-prohibitive. The average N concentration in corn grain may decrease in future years as more N-efficient corn hybrids are developed. The Reserve will monitor changes in average N concentration of crops over time and plans to update default values as appropriate.

In theory, the ratio of N removed by harvest to available N is expected to be close to ~~4~~one if a system is in balance. However, because the simplified RTA calculated in this protocol only considers applied N and does not take into account all available N sources, RTAs above ~~4~~one may be observed. Specifically, in cases where an N credit from leguminous crops in the rotation or from residual soil N contribute to the total plant N requirements and are taken into account by the growers, RTA values will likely be higher than ~~4~~one. In addition, RTA as defined in this protocol is sensitive to uncertainty around crop N ~~content~~concentration as well as the uncertainty around manure N ~~content~~concentration. Actual crop N ~~content~~concentration can be affected by various variables including weather, agronomic practices and crop hybrid, and overestimation of crop N ~~content~~concentration will lead to overestimation of the RTA. Likewise, while standard N ~~contents~~concentrations for different sources of manure were used to calculate N application rates from manure, actual manure N ~~contents~~concentrations can vary significantly even within a specific manure source. Given these assumptions and limitations associated with RTA calculations, RTA values larger than one do not necessarily indicate soil N mining. Moreover, while it is possible that some corn cropping systems in the NCR mine soil N, it is unlikely that reducing N rate will cause a drastic increase in N mining if yields are maintained. Significant N mining would have a strong impact on yields.

¹¹¹ The equation used to calculate the state average RTAs included in Table A.7 is identical to Equation 3.1, with the exception that the yield and N rate values are state average values from a given survey year.

¹¹² Ribaudo et al., 2011

Table A.2. Default Values for Average N-Content Fertilizer N Concentration and Fertilizer Weights

Crop-Type	Yield-Units	N-Content	Synthetic fertilizer N contents and weights	N-Content-Units
Corn for grain	Fertilizer type	Bushels/acre	0.8% N*	lb N/bushel/Weight ^a (lbs gallon ⁻¹)
Ammonia		dry/liquid	80	n.a.
ammonium superphosphate		dry	12-17	--
Ammonium metaphosphate		dry	12	--
ammonium nitrate		dry	32-34	--
ammonium phosphate		dry	11-18	--
ammonium phosphate nitrate		dry	27-30	--
ammonium phosphate sulfate (APS)		dry	13-16	--
ammonium polyphosphate (APP)		liquid	10-11	11.65
ammonium polysulfide (Ammonium sulfate)		liquid	20-21	n.a.
ammonium sulfate nitrate		dry	20-30	--
ammonium thiosulfate solution		liquid	12	11.00
anhydrous ammonia		liquid/gas	82	n.a.
aqua ammonia (ammonium hydroxide)		liquid	16-25	n.a.
bone meal		dry	0-2	--
calcium nitrate		dry	15-16	--
diammonium phosphate sulfur		dry	15-16	--
diammonium phosphate (DAP)		dry	16-21	--
monoammonium phosphate (MAP)		dry	11-13	--
natralene		dry/liquid	40	n.a.
Corn for silage		Tons/acre/liquid	7.09-58	lb N/ton 7-21-7: 11.00 9-18-9: 11.11 12-0-0: 11.00
nitric phosphate		dry	12-17	--
Winter wheat		Bushels/acre		
potassium nitrate		dry	4-13	lb N/bushel--
potassium sodium nitrate		dry	15	--
sodium nitrate (nitrate of soda)		dry	15-16	--
urea		dry	45-46	--
urea, sulfur coated		dry	36-38	--
urea ammonium phosphate		dry	25-58	--
urea ammonium nitrate (UAN)		liquid	28-32	28%: 11.66 32%: 11.06
urea phosphate		dry	17	--
Spring wheat	Bushels/acre	4.39		lb N/bushel
Durum wheat	Manure type	Bushels/acre	4.29	lb N/bushel/Weight (ton gallon-1)
Beef cattle			8.5	8.5
Dairy cattle			6.1	8.4
Hogs			11.3	8.4

Poultry**26.9****8.3**

Source: Ribaudo et al., 2011.

Source: Synthetic fertilizer N contents, fertilizer weights, and unit conversion factors are adopted from USDA NRCS Minnesota, Planning – Nutrient Management, Conversion Factors and Tables, Factors and Tables Useful When Planning. Available at <http://www.mn.nrcs.usda.gov/technical/ecs/nutrient/planning/planning.htm>. Organic fertilizer weights per unit of volume are adopted from: Lorimor, J., A. Sutton, and W. Powers. 2004. Manure Characteristics. MWPS-18. Section 1. Second Edition. Ames, IA: Midwest Plan Service. Default manure N contents are consistent with Edmonds et al. (2003) cited in U.S. Environmental Protection Agency. (2011). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009. EPA 430-R-11-005. Washington, D.C.

A.4 Analysis of Grower Decision-Making to Determine N Rates

This section summarizes research into how farmers decide on the N application rate, as further background to the performance standard threshold. In particular, the use of recommended N rates as a proxy for common practice was investigated for corn cropping systems in selected states in the North Central Region. More information is available in a background paper prepared for the Reserve by Terra Global Capital,¹¹³ which evaluated a regional N rate calculator using the “maximum return to N” (MRTN) approach and N application rates based on N use surveys; the analysis of those methods will be discussed further below.

In the Background Paper analysis, recommended N rates were determined using the Iowa State University Corn Nitrogen Rate Calculator¹¹⁴ (Sawyer et al., 2006). This calculator provides a regional (corn belt) approach to N rate guidelines and finds the MRTN, which is the N rate where the economic net return to N application is greatest given current prices for fertilizer N and projected corn grain prices. The calculator was calibrated for several states and for specific regions within some of the states, using corn yield data from N response trials (Sawyer et al., 2006). The MRTN approach to decide on N fertilizer rate is more commonly used today than the yield-goal approach,¹¹⁵ which was the dominant approach to determine N rates for corn throughout the last four decades. MRTN-based recommended N rates are often lower than yield-goal based N rates. To assess the suitability of MRTN as a proxy for common practice, MRTN-based recommended N rates for selected N-to-corn grain price ratios were compared with state-average N rates from USDA ARMS (Table A.3). Price ratios were selected assuming that 50 percent of fertilizer use consists of urea and 50 percent consists of anhydrous ammonia, and based on the observation that price ratios fluctuated between 0.07 and 0.14 with an average of 0.10 over the period 1999-2011.¹¹⁶

¹¹³ Background Paper: Quantification of Emission Reductions (December 22, 2011). Available on the Reserve website: <http://www.climateactionreserve.org/how/protocols/agriculture/nitrogen-management/>

¹¹⁴ <http://extension.agron.iastate.edu/soilfertility/nrate.aspx>

¹¹⁵ The yield-goal approach recommends that N rates be determined by multiplying the expected yield by a factor that expresses N requirements in function of expected yields.

¹¹⁶ See NMPP background paper for more details.

Table A.3. Actual and Recommended N Rates for Corn in Selected States in the North Central Region

States	Actual Corn N Fertilization Rate		Region Within State	Recommended N Rate - MRTNs at Different Price Ratios [lbs N/acre]					
	[lbs N/acre]			Average Price Ratio (0.10)		Low Price Ratio ~2010 (0.07)		High Price Ratio ~2005 (0.14)	
	2005	2010		SC	CC	SC	CC	SC	CC
Illinois	146	167	North	145	185	157	201	132	167
			Central	168	185	183	200	152	169
			South	172	188	190	205	155	171
Indiana	147	178	West & Northwest	169	NA	177	NA	156	NA
			East and Central	202	NA	214	NA	191	NA
			Remainder	176	NA	189	NA	161	NA
Iowa	141	142	State	133	190	145	199	120	176
Michigan	128	122	State	131	NA	141	NA	122	NA
Minnesota	139	125	State	109	148	120	154	103	144
Ohio	161	141	State	175	197	190	214	158	182
Wisconsin	107	92	VH/HYP	125	151	131	160	107	139
			M/LYP	94	109	107	118	89	94
			Irr. Sands	209	209	209	209	197	197
			Non-irr. Sands	130	130	130	130	122	122

Red cells indicate MRTN N rates that are greater than the actual corn N fertilization rate at a specific year. Green cells indicate MRTN N rates that are less than the actual corn fertilization rate at a specific year. SC = Soy-corn rotation, CC = Continuous corn, NA = not available, VH/HYP = very high and high yield potential, M/LYP = medium to low yield potential, Irr. = irrigate, Non-irr. = non-irrigated

For continuous corn systems, the recommended MRTN rates were generally greater than the actual corn N fertilization rates at average and low price ratios. However, the N rate did fluctuate somewhat based on the price ratio. When the price ratio was small, as in 2010, the actual N fertilization rate tended to be lower than the recommended rates for soybean-corn systems in more states compared to when the price ratio was large, as in 2005. Consequently, whether the actual N rate is above or below the recommended N rate depends greatly on the crop rotation and price ratio. In agreement with Snyder et al. (2011), the outcomes of the comparison suggest that the average farmer in leading corn-producing states does not commonly apply more N than the recommended N rate based on the corn N rate calculator. Because the recommended N rate does not always compare well with the state-averaged N rates and does not capture potential variability in N rates between farmers within a state or geographic region, the Reserve deemed recommended N rates unsuitable as a proxy for common practice in this protocol. This is further supported by the low percentage of farmers (17.3 percent in 2005) reporting that the cost of nitrogen and/or expected commodity price was the driving factor in determining their N rates, as reported in a recent USDA N use report by Ribaud et al. (2011) and presented in Table A.4, below.

Lastly, the suitability of historic or “routine practice” N rates (e.g. simply basing this year’s N rate decision on previous years’ historic N rates) as a proxy for common practice was investigated. A historic N rate has the advantage of taking into account site-specific variables that influence growers’ management decisions, including soil fertility, soil N retention and previous management. Furthermore, survey data presented by Ribaud et al. (2011) indicate that over

70 percent of growers base N rates on their routine practice (Table A.4). Consequently, historic or routine practice N rate is likely a sensible proxy for common practice on a particular site. As such, the Reserve determined that historic N rate shall be used to set the project's baseline under this protocol.

Table A.4. Factors Influencing Farmers' N Rate Decision

Application Used	2001	2005
	<i>Percent of Farmers</i>	
Soil or tissue test	18.8	27.0*
Crop consultant recommendation	13	17.6*
Fertilizer dealer recommendation	28.7	41.2*
Extension service recommendation	3.2	4.6*
Cost of nitrogen and/or expected commodity price	11.4	17.3*
Routine practice	70.9	71.7*
	<i>Number</i>	
Observations	1,646	1,344

* Statistically different from 2001 at the 1-percent level, based on pair-wise two-tailed delete-a-group Jackknife t-test (Dubman, 2000).

Source: [USDA, Economic Research Service using data from USDA's 2001 and 2005 Agricultural Resource Management Survey, Phase II, Cost of Production and Costs Report](#).
Source: [Adopted/Adapted](#) from Ribaudo et al., 2011.

In most cases, recommended N rates are underpinned by results from N response trials, where the relationship between N rate and yield is assessed. Recommended N rates are designed to maximize yield or profit, but are not specifically optimized to minimize harmful N losses (Ribaudo, 2011).¹¹⁷ Similarly, an N rate survey in Minnesota indicated that average N fertilizer use by Minnesota corn farmers was generally consistent with University of Minnesota Extension N management guidelines (Bierman et al., 2011).¹¹⁸

A.5 Historic Trends and Distributions of State RTAs

A.5 Setting the Performance Standard RTA Threshold

This section examines the current and historic trends of state RTAs and justifies the setting of an RTA threshold above which fields implementing N rate reduction projects are additional. ~~The purpose of the RTA threshold is to provide a minimum nitrogen efficiency level above which credits can be generated.~~ The RTA metric is used as a proxy for nitrogen use efficiency. The nitrogen use efficiency is different per crop and state, and consequently the calculated average RTA, both in a given year and over time, varies across crops and states, as well. ~~While ideally, the average state RTA itself is crucial to informing RTA thresholds, it is imperative to estimate the distribution of RTAs would be calculated by calculating the RTA across a large number of individual fields across within a state for a and cropping system and averaging these field-specific cropping system, to understand how many fields are excluded for a specific RTA threshold. The distribution of RTAs can therefore inform the decision of a threshold RTA by evaluating the distribution of RTAs around the mean, taking into account the proportion of fields that are above and below the chosen threshold. This section aims at estimating the distribution of RTAs. Setting the RTA threshold is included in the following section.~~

¹¹⁷ Ribaudo et al, 2011

¹¹⁸ Bierman et al., 2011

RTAs. Unfortunately, ~~very limited~~insufficient data are publically available to calculate the ~~distribution of~~ RTA values of individual fields, and, hence, the true distribution of RTAs within a state and cropping system. ~~Though the state in a robust manner. Therefore, the~~ average RTAs RTA per state were calculated ~~based on state average N rates and yields from using readily available data in~~ USDA ARMS and NASS datasets, ~~these datasets do not provide sufficient data to approximate the distribution of RTAs within those states, as is discussed further below. Based on confidential stakeholder data, the Reserve approximated the distribution of RTAs for corn within one of the NCR states, and it is assumed that this state's corn RTA distribution can be extended to other states and cropping systems with sufficient accuracy if the average N rates and yields of the distribution are adjusted to the state and crop specific N rates and yields.~~

~~A few basic assumptions are required to determine the distribution of RTAs across fields within a state. Since the RTA is the ratio of N rate and N removed from harvest, the distribution of the RTA is dependent on the distribution of N rates and yields. Various models have been proposed for cropping yield distributions.¹⁴⁹. Often the distribution of yields is right or left skewed, and the distribution is highly dependent on the crop type and the year. However, the deviations from normality are usually fairly minor and for the purpose of calculating the RTA distribution, we believe a normal distribution of the yields suffices. Confidential stakeholder data indicate that N rates and yields RTAs may be adequately represented by a normal distribution, as well. Since both the N rate and the yield follow near normal distributions separately, it is safe to assume that N rates and yields follow a bivariate normal distribution together. It is obvious that yields will be, to some extent, correlated with N rates: higher N rates are more likely associated with higher yields, and vice versa, as is demonstrated in a wide range of experiments. Once the combined distribution of the N rates and yields is available, one can calculate the distribution of the RTA, which is simply the ratio of N rates and yields. Unfortunately, there is no analytical form for the ratio of two normally distributed distributions. As a consequence, the distribution of the RTA must be approximated through numerical methods.~~

~~If it can be assumed that N rate and yields follow a bivariate normal distribution, the following five properties are required to develop this distribution:~~

- ~~1. Average N rate~~
- ~~2. Average yield~~
- ~~3. Variance (or standard deviation) of the N rates~~
- ~~4. Variance (or standard deviation) of yields~~
- ~~5. Covariance (or correlation) between N rates and yields~~

~~Each of these properties is discussed below.~~

Average N Rates and Yields

Statewide. More specifically, statewide crop-specific average yields are available from survey and census data from the NASS/USDA. Statewide average N rates from processed fertilizers (e.g. synthetic N, as well as some processed organics) for selected crops and states are available from ARMS/USDA. Note that the calculation of the RTA requires total N rates, including synthetic and all organic N. Therefore, the N input from unprocessed organics, such as manure, must be added to the synthetic N rates. Quantities of unprocessed manure inputs are available from ARMS/USDA. Estimates of the manure N inputs were based on quantities of unprocessed manure applied per treated acre, the percentage of corn acres treated with

¹⁴⁹ Ramirez et al., 2001. Available at: http://www.aacc.ttu.edu/Publications/AAEA/ramirez_misira_field.pdf

manure, the total number of acres planted with corn, and the animal source of the manure, consistent with the USDA N use report.¹²⁰

Variance of the N Rates

Knowledge on distributions of N rates is essential to assess the suitability of state- and crop-specific average N rates as proxies for common practice and to predict the percentage of fields that exceeds a given threshold. The distribution of N rates is often quantified by standard errors and/or standard deviations. While the relative standard error (RSE), or the standard error for that matter, is a useful measure to investigate the spread of average N rates among crops, years and geographic regions, the parameter does not provide much information about the spread of N rates on individual fields within a crop-state-year combination.¹²¹ RSE of the N rate for selected major commodities and selected states (the largest producers of those commodities) are available from USDA ARMS for selected years,¹²² in addition to state- and crop-specific average N application rates. However, standard deviations of N rates were not available from USDA ARMS. Though the standard deviation might be calculated using the RSE and the number of observations, the number of observations is not available for the ARMS data, due to privacy concerns. However, insight on typical distributions of N rates of individual fields was gained through confidential communication with stakeholders. The following figure (Figure A.3) depicts a plausible distribution of N fertilization rates for corn in the NCR, in which a large range of N rates is observed within a geographic region. The N rates, however, appear to be symmetrically and even normally distributed around the average.

The Coefficient of Variation (CV) is the ratio of the standard deviation to the average of N rates. It is basically a relative statistic that expresses the degree of spread of a certain variable. In many distributions of the same variable in different areas, such as N rates within different states, the CV will remain constant even though the average can be quite different. Therefore, the CV is a robust measure to investigate the spread of N rates and extrapolate the spread from one state to a different state. The CV of the N rate was provided confidentially from a stakeholder and assumed to be representative for all states in the NCR. It is assumed that this range in CV of N rates is typical for most states and crops.

Variance of Yields

Yields can vary significantly across fields within a state and for a particular cropping season. Under controlled experimental conditions, the CV varies typically between 20 to 50 percent as measured on smaller subplots within a larger field. The range in CVs is strongly dependent on the weather of a particular season. No consistent dataset was available to estimate the variance, CV, or standard deviation of field-level cropping yields in the U.S. One reference point was obtained from Agriculture and Agri-Food Canada (AAFC); this organization reported CVs for field-level corn yields within Ontario and Quebec of 21 percent and 29 percent, respectively.¹²³ As an alternative strategy, the sensitivity of the distribution of the RTAs to the yield CV was investigated for different values of the yield CV that were in proximity to the values reported in Canada (Figure A.3). It can be observed that the yield CV has a significant impact

¹²⁰ Ribaud et al, 2011.

¹²¹ Because the RSE and the standard error are estimators of the spread of the average N rates, they are well suited to test whether average N rates are significantly different among crops, states, and years. However, to investigate where the N rate from an individual field is located within the distribution of N rates of a specific crop, state, and year, one has to employ the standard deviation. The standard error differs from the standard deviation by a factor that is equal to the inverse of the square root of the number of observations.

¹²² <http://www.ers.usda.gov/Data/ARMS/CropOverview.htm>

¹²³ <http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1181067473911>

on the distribution of RTAs. Greater CVs lead to greater RTA values at a given percentile for percentiles that are above 0.5. Therefore, when using percentiles to set RTA thresholds, assuming greater CVs will lead to more conservative thresholds.

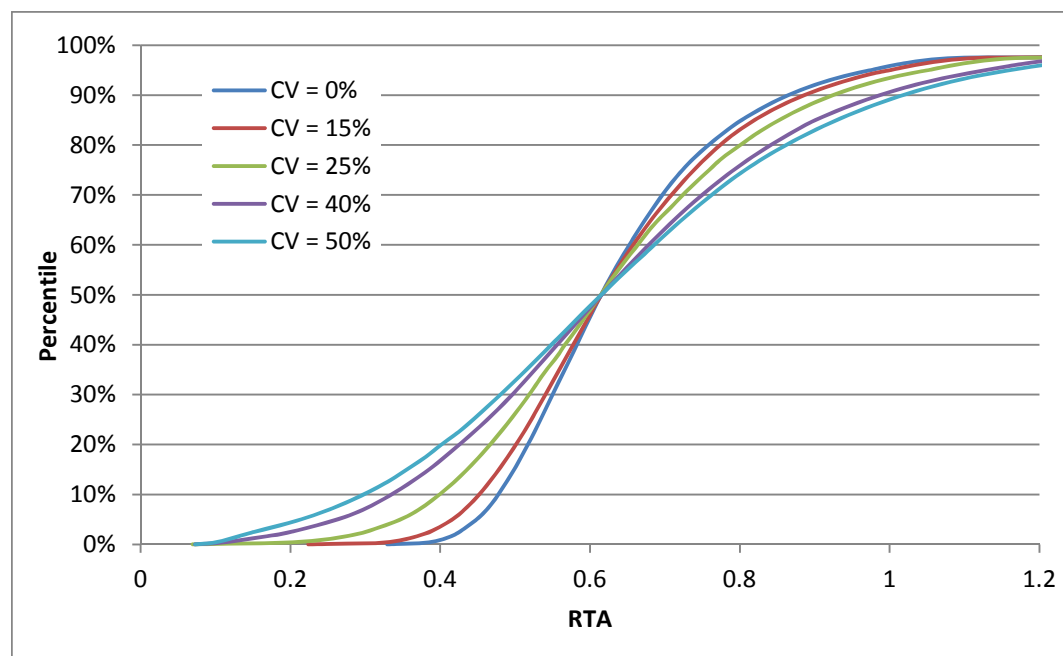


Figure A.2. Simulated Distribution of the RTA in a Typical Region for different values of the RTA to the Coefficient of Variation (CV) of Yields

Correlation between N Rates and Yields

Even though yields are obviously correlated with N rates, it is surprisingly challenging to find correlation coefficients between yields and N rates across a wide range of soils and other conditions that are present within a state. No direct data source was found that contained a robust estimate of this correlation. Even though studies have reported high correlation coefficients (>0.50) between yields and N rate in controlled experiments where effects of soil and climate are minimal, or when state-wide average yields are related to state-wide N rates, it can be expected that the correlation on individual fields within a state is substantially smaller than 0.50 differences in soil and climate. However, the impact of the correlation on the distribution of the RTA is fairly minimal within the most plausible range of the correlation (0.1 to 0.3), as shown in Figure A.4, below. Therefore, given that the impact of the correlation coefficient is minimal, we assumed a correlation coefficient of 0.15 in all subsequent calculations.

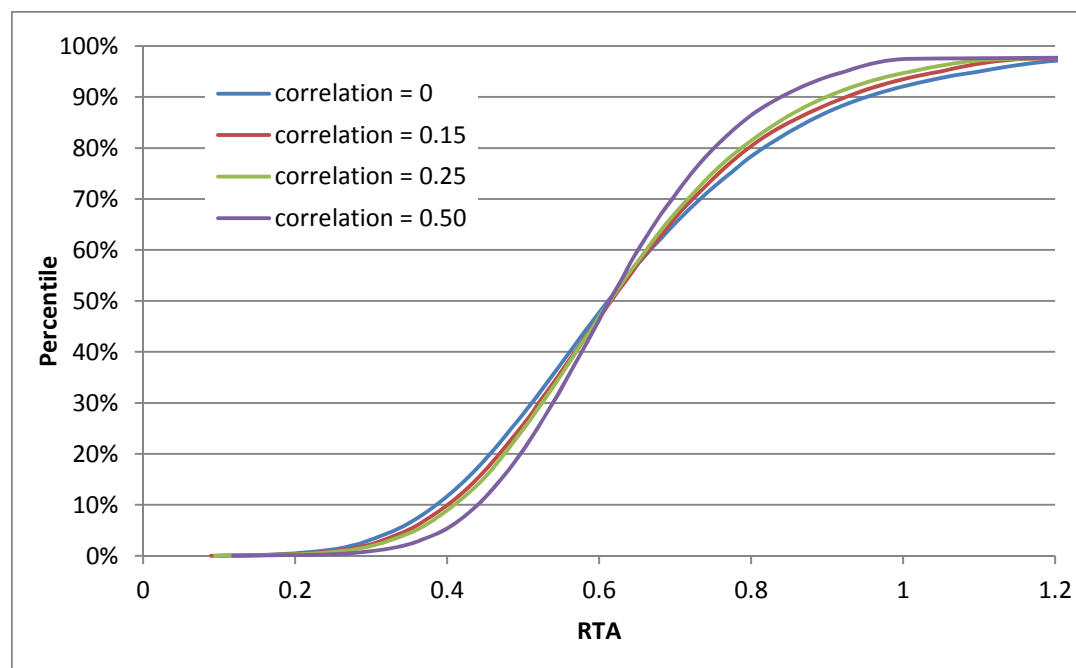
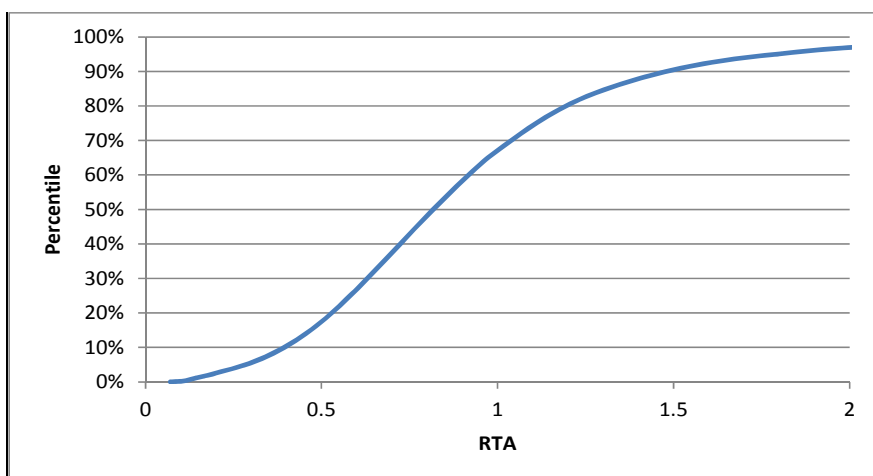


Figure A.3. Simulated Distribution of the RTA in a Typical Region for Different Values of the Correlation Between N Rates and Cropping Yields

As an example, a typical distribution of RTA values was constructed for the state of Michigan, see Figure A.5 below, using typical N rates (e.g. Michigan's N rate average), the representative CV of the N rates, a conservative CV of yields, and the correlation between yield and N rate discussed above. Figure A.5 indicates that the distribution of the RTAs is slightly right-skewed, which is not surprising as the ratio of two normal distributions is not necessarily normally distributed as well. This particular distribution indicates that, the median RTA is 0.82 with a standard deviation of 0.66.



Percentile	RTA
10%	0.39
20%	0.53
25%	0.58
30%	0.63
40%	0.72
50%	0.82
60%	0.92
70%	1.04
75%	1.11
80%	1.20
90%	1.48

Figure A.4. Example Distribution of the RTA for corn fields in Michigan (left) and RTA Values for Different Percentile Levels (right)

Taking the above RTA distribution analysis, as shown in Figure A.5, a step further, the table in Figure A.5 includes the RTA values at different percentiles. This table informs setting a specific RTA threshold. For example, the 75th percentile of the field level RTA value is 1.11, which becomes the RTA performance threshold for the state of Michigan. The RTA performance threshold of the other NCR states is available in Table A.8.

A.6 Setting the Performance Standard RTA Threshold

As a first step in setting RTA threshold values for use in the performance standard test, average state RTA values were computed and state trends in RTA values over time were assessed. Table A.8,

After collecting the state average yields and N rates for a number of years, average state RTA values were computed and trends in average state RTA values over time were assessed. In case RTA values would be upward trending, it is assumed likely that increasing nitrogen use efficiency will occur to some extent in the future in the absence of a carbon market. Conversely, if no significant trend in RTA over time exists, the rationale is that because NUE has remained constant over time, the chances are that it will remain constant into the future. As a consequence, the presence of strong trends of the RTA would justify setting the RTA at a different value than the current average to reflect future values of RTA values. A summary of the historic RTA and N rate trends for each NCR state is included in Table A.5 and Table A.6, respectively, below. Notably, only Missouri had a significant increasing trend for RTA, and only Missouri and Kansas had significant decreasing trends for N rate. In all of these cases, the trend, albeit significant, was either minor or caused by spikes in yields and N rates during a specific year, and hence not robust (Figure A.2). As a consequence, it was decided to set the RTA threshold for all states at the state-average RTA.

Table A.7 below summarizes state N rate averages and RTAs for a number of variations of corn rotations in the NCR, while Tables A.12 and A.13 (at the end of Appendix A) show. The table shows more complete state RTA and N rate averages for a number of variations of corn rotations in all states for which ARMS data is available. A summary of the historic RTA and N rate trends for each NCR state is included in Tables A.6 and A.7, respectively, below. These trends in RTAs and N rates over time were assessed to complement the evaluation of additionality of “reducing N rate,” and were used in adjusting the RTA thresholds in circumstances where the trend was for increasing RTA over time, as will be discussed further below. If no significant trend in RTA over time exists, the rationale is that because NUE has remained constant over time, the chances are that it will remain constant into the future. If the RTA increased over time, it is assumed likely that increasing nutrient use efficiency will occur to some extent in the future in the absence of a carbon market, and shall serve as the look-up table for the RTA performance threshold (Section 3.5.1.1).

Table A.5. Summary of State RTA Trends Over Time based on USDA-ARMS Data

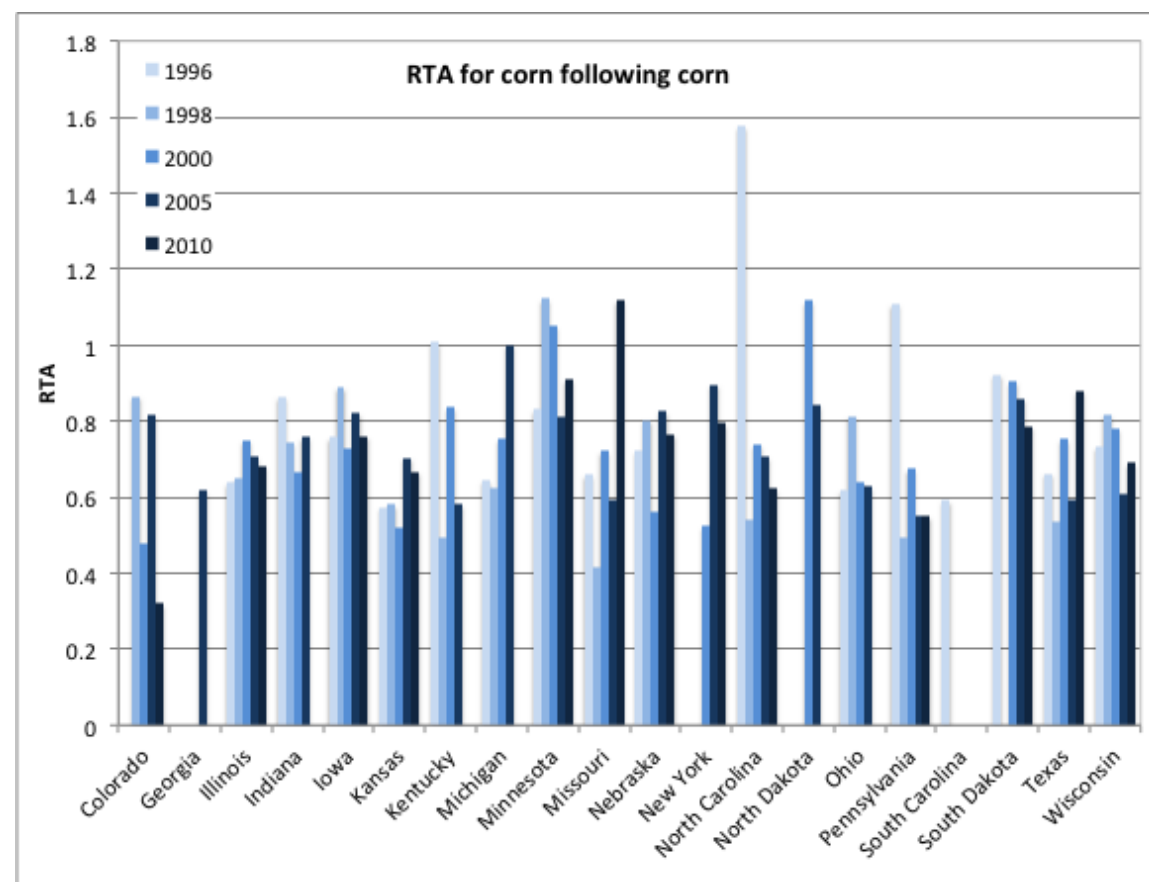
State	Trends in RTA Over Time	
	Corn Grain	Corn Silage
Illinois	no significant trend over time	no significant trend over time
Indiana	no significant trend over time	no significant trend over time
Iowa	no significant trend over time	no significant trend over time
Kansas	no significant trend over time	no significant trend over time
Michigan	no significant trend over time	no significant trend over time
Minnesota	no significant trend over time	no significant trend over time

Missouri	significant increase over time	significant increase over time
Nebraska	no significant trend over time	no significant trend over time
North Dakota	no significant trend over time	no significant trend over time
Ohio	no significant trend over time	no significant trend over time
South Dakota	no significant trend over time	no significant trend over time
Wisconsin	no significant trend over time	no significant trend over time

Table A.6. Summary of State N Rate Trends Over Time [based on USDA-ARMS data](#)

State	Trends in N Rate Over Time	
	Corn Grain	Corn Silage
Illinois	no significant trend over time	no significant trend over time
Indiana	no significant trend over time	no significant trend over time
Iowa	no significant trend over time	no significant trend over time
Kansas	significant decrease over time	significant decrease over time
Michigan	no significant trend over time	no significant trend over time
Minnesota	significant increase over time	significant increase over time
Missouri	significant decrease over time	significant decrease over time
Nebraska	no significant trend over time	no significant trend over time
North Dakota	no significant trend over time	no significant trend over time
Ohio	no significant trend over time	no significant trend over time
South Dakota	no significant trend over time	no significant trend over time
Wisconsin	significant increase over time	significant increase over time

The trends in RTA over time for corn following corn is also shown in the graph in Figure A.62 below.



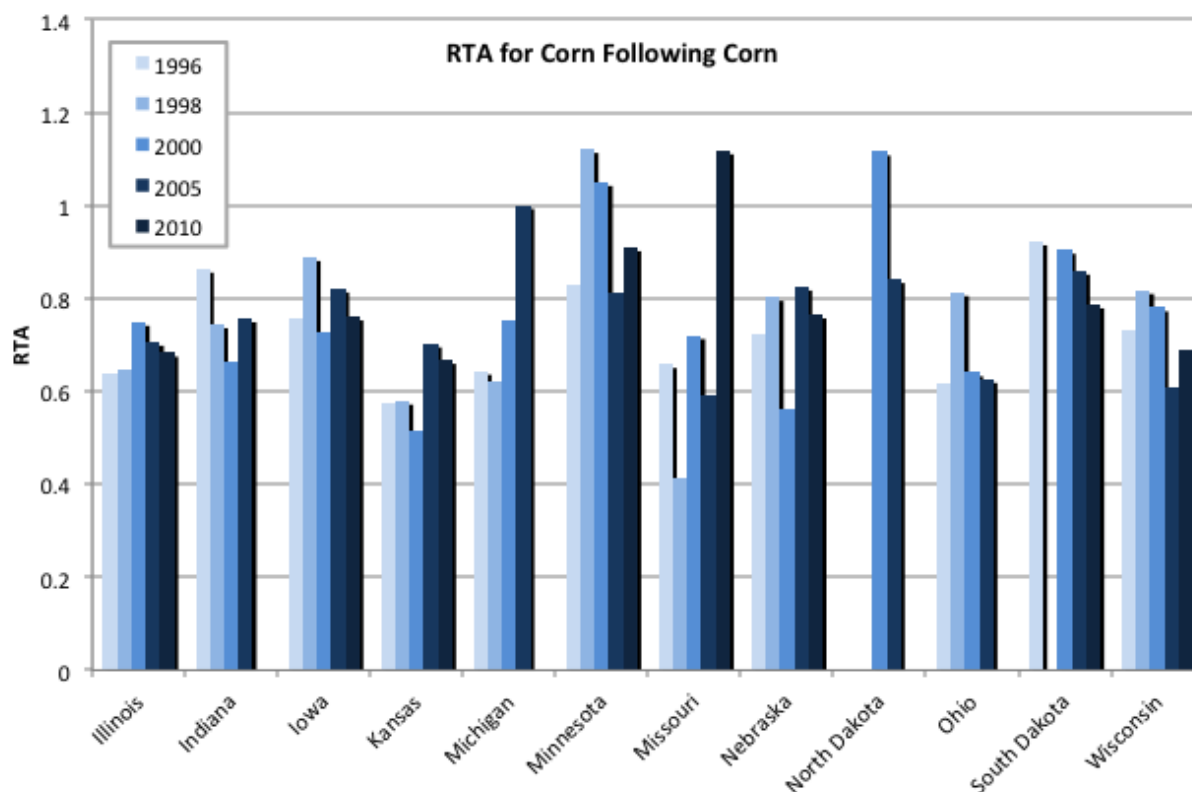


Figure A.2. RTA for Corn Following Corn in the North Central Region, based on USDA-ARMS data

Table A.7. State N Rate and RTA Data for Corn in the North Central Region¹²⁴ — Based on USDA-ARMS Data and Yield Data from USDA-NASS¹²⁵

State	Crop	Previous Crop	Most Recent Survey Year	Average N Rate (lbs/acre)	Average Yield (bushels/acre for grain; tons/acre for silage)	Average RTA
Illinois	corn grain	corn	2010	184	157	0.68
		soybean	2010	179		0.7
	corn silage	corn	2010	184	18	0.69
		soybean	2010	179		0.71
Indiana	corn grain	corn	2005	163	154 (for 2005)	0.75
		soybean	2010	165	157 (for 2010)	0.76
	corn silage	corn	2005	163	20 (for 2005)	0.87
		soybean	2010	165	21 (for 2010)	0.9
Iowa	corn grain	corn	2010	173	165	0.76
		soybean	2010	162		0.82

¹²⁴ Table A.8 includes average N rates, average RTA and RTA threshold values for both corn grain and corn silage, following cultivation of both corn, following cultivation of both corn, soybeans, respectively). Asterisks (*) indicate that RTA significantly increases over time and that the RTA threshold may be set at a higher percentile, as examined in Table A.9, below. A plus (+) flags states whose RTA threshold will be above 1 at the 75th percentile.

¹²⁵ No yield data were available from USDA NASS to distinguish yields between corn systems following cultivation of corn, and corn systems following cultivation of soybeans. In case the survey year for N rates for corn systems following cultivation of corn was different from the survey year for N rates for corn systems following cultivation of soybeans, yields for both survey years were included.

	corn silage	corn	2010	173	21.5	0.88
		soybean	2010	162		0.94
Kansas	corn grain	corn	2010	150	125	0.67
		soybean	2010	136		0.74
	corn silage	corn	2010	150	14	0.66
		soybean	2010	136		0.73
Michigan	corn grain	corn	2005	114	143 (for 2005)	1
		soybean	2010	148	150 (for 2010)	0.81
	corn silage	corn	2005	114	17.5 (for 2005)	1.09
		soybean	2010	148	18.5 (for 2010)	0.89
Minnesota	corn grain	corn	2010	156	177	0.91
		soybean	2010	155		0.91
	corn silage	corn	2010	156	20	0.91
		soybean	2010	155		0.91
Missouri	corn grain	corn	2010	88	123	1.12
		soybean	2010	130		0.76
	corn silage	corn	2010	88	15	1.21
		soybean	2010	130		0.82
Nebraska	corn grain	corn	2010	173	166	0.77
		soybean	2010	156		0.85
	corn silage	corn	2010	173	18.5	0.76
		soybean	2010	156		0.84
North Dakota	corn grain	corn	2005	123	129 (for 2005)	0.84
		soybean	2010	142	132 (for 2010)	0.74
	corn silage	corn	2005	123	11 (for 2005)	0.63
		soybean	2010	142	14 (for 2010)	0.7
Ohio	corn grain	corn	2005	183	143 (for 2005)	0.62
		soybean	2010	158	163 (for 2010)	0.82
	corn silage	corn	2005	183	17	0.66
		soybean	2010	158		0.76
-South Dakota	corn grain	corn	2010	137	135	0.79
		soybean	2010	143		0.75
	corn silage	corn	2010	137	13.5	0.7
		soybean	2010	143		0.67
Wisconsin	corn grain	corn	2010	188	162	0.69
		soybean	2010	202		0.64
	corn silage	corn	2010	188	19	0.72
		soybean	2010	202		0.67

Table A.9 below shall serve as the look-up table for both the RTA performance threshold (Section 3.5.1.1) and for the quantification methodology, when a default RTA is used to set the N-rate baseline (Section 5.3).

Table A.8. State RTA Performance Thresholds and Default Baseline RTAs for Corn in the North Central Region

State	Crop	Previous Crop	RTA Performance Threshold	Default RTA ¹²⁶ (to calculate baseline)
-------	------	---------------	---------------------------	--

¹²⁶ The "default RTA" used in baseline calculations for Section 5.3 refers to the state average RTAs for all states, but for two exceptions: Kansas and Missouri, which are marked with an (*). Decreasing trends in N rates over time were observed in both states, while an increasing RTA trend was observed in Missouri. As such, to ensure additionality of projects implemented in those states where a trend toward reducing N rate was observed, the default baseline shall be set at the 60th percentile of RTAs for the states and respective crops.

Illinois	corn-grain	corn	0.93	0.68
		soybean	0.96	0.7
	corn-silage	corn	0.95	0.69
		soybean	0.97	0.71
Indiana	corn-grain	corn	1.02	0.75
		soybean	1.03	0.76
	corn-silage	corn	1.18	0.87
		soybean	1.23	0.9
Iowa	corn-grain	corn	1.04	0.76
		soybean	1.11	0.82
	corn-silage	corn	1.2	0.88
		soybean	1.28	0.94
Kansas*	corn-grain	corn	0.91	0.75
		soybean	1	0.83
	corn-silage	corn	0.9	0.74
		soybean	1	0.82
Michigan	corn-grain	corn	1.37	1
		soybean	1.1	0.81
	corn-silage	corn	1.49	1.09
		soybean	1.21	0.89
Minnesota	corn-grain	corn	1.24	0.91
		soybean	1.24	0.91
	corn-silage	corn	1.24	0.91
		soybean	1.24	0.91
Missouri*	corn-grain	corn	1.52	1.26
		soybean	1.03	0.85
	corn-silage	corn	1.64	1.36
		soybean	1.11	0.92
Nebraska	corn-grain	corn	1.04	0.77
		soybean	1.16	0.85
	corn-silage	corn	1.04	0.76
		soybean	1.14	0.84
North Dakota	corn-grain	corn	1.14	0.84
		soybean	1.01	0.74
	corn-silage	corn	0.86	0.63
		soybean	0.95	0.7
Ohio	corn-grain	corn	0.85	0.62
		soybean	1.12	0.82
	corn-silage	corn	0.9	0.66
		soybean	1.04	0.76
South Dakota	corn-grain	corn	1.08	0.79

		soybean	1.02	0.75
	corn-silage	corn	0.95	0.7
		soybean	0.91	0.67
Wisconsin	corn-grain	corn	0.94	0.69
		soybean	0.87	0.64
	corn-silage	corn	0.97	0.72
		soybean	0.9	0.67

A.7A.6 Discussion of Performance Standard Research for N Rate Reductions in Other Regions

A.6.1 Preliminary Work on RTAs for Other Crops and Regions

Average RTA values have been developed for corn cropping systems outside of the North Central Region where USDA-ARMS data on N-rates for synthetic fertilizer and manure were available. Note that data distributions for N-rate are not available. Therefore, only state-average RTA values could be investigated for performance standard tests. For calculating RTAs, crop yield data are required in addition to N rates. Crop yield data are not available from the USDA ARMS survey, but can be downloaded from USDA/NASS Quickstats.¹²⁷ Yield data for a large variety of crops are available at the state level. Within some state, agricultural district or county-averaged crop yields are available. No standard errors or distributions are available for yield data.

~~In the draft NMPP, which goes before the Board for approval, we will include an additional brief summary of work done with ARMS data for other crops and regions here.~~

Table A.8. State N Rate and RTA Data for Corn Outside the North Central Region Based on USDA-ARMS Data¹²⁸

<u>State</u>	<u>Crop</u>	<u>Previous Crop</u>	<u>Most Recent Survey Year</u>	<u>Average N Rate¹²⁹ (lbs/acre)</u>	<u>Average Yield (bushels/acre for grain; tons/acre for silage)</u>	<u>Average RTA</u>
<u>Colorado</u>	<u>corn grain</u>	<u>corn</u>	<u>2010</u>	<u>378</u>	<u>151</u>	<u>0.32</u>
		<u>soybean</u>	<u>2010</u>	<u>NA</u>		<u>NA</u>
	<u>corn silage</u>	<u>corn</u>	<u>2010</u>	<u>378</u>	<u>24.5</u>	<u>0.46</u>
		<u>soybean</u>	<u>2010</u>	<u>NA</u>		<u>NA</u>
<u>Georgia</u>	<u>corn grain</u>	<u>corn</u>	<u>2005</u>	<u>166</u>	<u>128</u>	<u>0.62</u>
		<u>soybean</u>	<u>2005</u>	<u>115</u>		<u>0.89</u>
	<u>corn silage</u>	<u>corn</u>	<u>2005</u>	<u>166</u>	<u>19</u>	<u>0.81</u>
		<u>soybean</u>	<u>2005</u>	<u>115</u>		<u>1.17</u>
<u>Kentucky</u>	<u>corn grain</u>	<u>corn</u>	<u>2005</u>	<u>182</u>	<u>132 (for 2005) 124 (for 2010)</u>	<u>0.58</u>
		<u>soybean</u>	<u>2010</u>	<u>159</u>		<u>0.63</u>
	<u>corn silage</u>	<u>corn</u>	<u>2005</u>	<u>182</u>	<u>15 (for 2005)</u>	<u>0.58</u>

¹²⁷ <http://quickstats.nass.usda.gov/>

¹²⁸ No data was available to distinguish yields between corn systems following cultivation of corn, and corn systems following cultivation of soybeans. In case the survey year for N rates for corn systems following cultivation of corn was different from the survey year for N rates for corn systems following cultivation of soybeans, yields for both survey years were included.

¹²⁹ Includes synthetic and manure N. N rates are based on USDA ARMS data on synthetic N application per acre, manure N applied per treated acre, total corn acreage and the percentage of corn acreage receiving manure inputs.

		soybean	2010	159	18.5 (for 2010)	0.83
New York	corn grain	corn	2010	151	150	0.79
		soybean	2010	154		0.78
	corn silage	corn	2010	151	19	0.89
		soybean	2010	154		0.87
North Carolina	corn grain	corn	2010	117	91	0.62
		soybean	2010	149		0.49
	corn silage	corn	2010	117	13	0.79
		soybean	2010	149		0.62
Pennsylvania	corn grain	corn	2010	186	128 (for 2005) 122 (for 2010)	0.55
		soybean	2005	181		0.54
	corn silage	corn	2010	186	18	0.68
		soybean	2005	181		0.70
South Carolina	corn grain	corn	1996	107	79	0.59
		soybean	1996	122		0.52
	corn silage	corn	1996	107	12.5	0.83
		soybean	1996	122		0.73
Texas	corn grain	corn	2010	132	145 (for 2005) 100 (for 2010)	0.88
		soybean	1998	103		0.78
	corn silage	corn	2010	132	18 (for 2005) 19 (for 2010)	0.97
		soybean	1998	103		1.31

Average RTA values will be determined for other crops as well. Table A.9 summarizes states and crops for which N-rate data is available with the most recent data collection in 2000 or later.

Table A.9. States and Crops for which USDA-ARMS Data on N Rate are Available with Data Collected in 2000 or More Recent

	Apples	Cotton	Soybeans	Durum wheat	Spring wheat	Winter wheat	Peanuts	Sugarbeets	Oats	Barley	Sorghum
Alabama	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Arizona	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Arkansas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
California	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Colorado	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Florida	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Georgia	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Idaho	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Illinois											
Indiana											
Iowa											
Kansas											
Kentucky											
Louisiana											
Maryland											
Michigan											
Minnesota											
Mississippi											
New York											
Missouri											
Montana											
Nebraska											
North Carolina											
North Dakota											
Ohio											
Oklahoma											
Oregon											
Pennsylvania											
South Carolina											
South Dakota											
Tennessee											
Texas											
Virginia											
Washington											
Wisconsin											
Wyoming											

A.6.2 Preliminary Work on California RTAs

~~The state of California is included in the ARMS data survey for some crops, such as wheat. The state of California is included in the ARMS data survey for some crops, such as wheat.~~

However, due to the large variety of crops grown in California, most of which are specialty crops, the ARMS data are not particularly helpful. However, N rates and yields for various cropping systems in California can be found in the forthcoming California Nitrogen Assessment (CNA) performed by the Agricultural Sustainability Institute at UC Davis. This is likely the most comprehensive resource on N management in California. N rates reported in the CNA are derived from expert opinions taken from the most recent UC ARE Cost and Return Studies (2000 to present)¹³⁰ and from growers surveys included in the USDA Chemical Usage Reports between 1999 and 2009. Grower survey data is the preferred data source for developing performance standard tests, especially given that experts likely overestimate N application rates

¹³⁰ <http://coststudies.ucdavis.edu/current.php>

| ~~(Rosenstock et al., In Review).~~¹³¹ However, some crops are not included in the USDA Chemical Usage Reports.¹³² Adoption rates for other N management practices are currently not publicly available. Surveys of extension specialists could be considered for developing performance standard test for eligible project activities.

| ¹³¹ [Rosenstock et al., in review](#)

| ¹³² USDA, NASS, Agricultural Chemical Usage Program,
<http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1561>

Table A.10. N Rates for Selected Crops in California

Commodity	Acreage ¹	Yield (lbs./acre) ¹	% moisture ²	% N content ²	Nitrogen application rates (lbs./acre)	
					USDA ³	UCD cost study ⁴
Almond	580000	1882	4.42	3.34	NA	200
Avocado	61820	6592	72.56	1.23	116	153
Broccoli	123600	14900	89.70	5.65	216	135
Carrot	71620	32040	88.00	1.51	180	70
Celery	25740	71300	94.55	2.42	344	226
Corn - grain	146000	9544	13.52	1.64	NA	230
Cotton ⁵	404000	1397	9.00	0.20	123	250
Grapes - wine	477800	13388	80.28	0.57	33	100
Lemons	45000	34772	87.20	1.51	152	130
Lettuce - head	130600	37000	94.80	3.81	200	150
Melons - honeydew	17360	20900	88.33	0.91	58	150
Oranges	183100	23238	86.81	1.25	85	110
Peach - freestone	36400	22364	87.83	0.95	122	151
Pepper - bell	20700	36500	92.50	2.18	283	342
Plums - dried	67800	3596	85.20	0.85	130	150
Potato	43020	35720	77.20	1.61	NA	250
Rice	535800	7912	11.33	1.39	124	120
Strawberry	33680	60600	91.28	1.25	215	180
Tomato - processing	279400	75328	94.00	2.56	188	178
Walnut	215200	3116	3.65	2.37	NA	200

¹Data is the average of 2003 -2007 from historical NASS data archive. (http://www.nass.usda.gov/Statistics_by_State/California/Historical_Data/index.asp)

²Nitrogen content data from USDA crop nutrient tool (<http://npk.nrcs.usda.gov/>).

³USDA application rates are from the most recent USDA chemical usage reports (<http://usda.mannlib.cornell.edu/MannUsda/search.do>).

⁴UCD cost study application rates are from the UC Davis Cost Studies published by the Agricultural and Resource Economics Department (<http://coststudies.ucdavis.edu>)

⁵Moisture and nitrogen content values are for lint.

Crop	Average N Rate (lbs/acre) ¹³³	Average Yield (lbs/acre)	% moisture	% N content	Average RTA ¹³⁴
Almond	NA	1882	4.42	3.34	NA
Avocado	116	6592	72.56	1.23	0.19
Broccoli	216	14900	89.7	5.65	0.40
Carrot	180	32040	88	1.51	0.32
Celery	344	71300	94.55	2.42	0.27
Corn-grain	NA	9544	13.52	1.64	NA
Cotton	123	1397	9	0.2	0.02
Grapes-wine	33	13388	80.28	0.57	0.46
Lemons	152	34772	87.2	1.51	0.44
Lettuce-head	200	37000	94.8	3.81	0.37
Melons-honeydew	58	20900	88.33	0.91	0.38
Oranges	85	23238	86.81	1.25	0.45

¹³³ Survey data from USDA Chemical Usage Reports

¹³⁴ RTA is calculated as in Equation 3.1. Because available N content data for crops in Table A.10 is expressed on a dry matter basis, yield needs to be corrected for moisture content before multiplying with the N content: $RTA = (yield * (100 - \%moisture)/100 * \%N/100) / N_rate$.

<u>Peach-freestone</u>	<u>122</u>	<u>22364</u>	<u>87.83</u>	<u>0.98</u>	<u>0.22</u>
<u>Pepper-bell</u>	<u>283</u>	<u>36500</u>	<u>92.5</u>	<u>2.18</u>	<u>0.21</u>
<u>Plums-dried</u>	<u>130</u>	<u>3596</u>	<u>85.2</u>	<u>0.85</u>	<u>0.03</u>
<u>Potato</u>	<u>NA</u>	<u>35720</u>	<u>77.2</u>	<u>1.61</u>	<u>NA</u>
<u>Rice</u>	<u>124</u>	<u>7912</u>	<u>11.33</u>	<u>1.39</u>	<u>0.79</u>
<u>Strawberry</u>	<u>215</u>	<u>60600</u>	<u>91.28</u>	<u>1.24</u>	<u>0.30</u>
<u>Tomato-processing</u>	<u>188</u>	<u>75328</u>	<u>94</u>	<u>2.56</u>	<u>0.62</u>
<u>Walnut</u>	<u>NA</u>	<u>3116</u>	<u>3.65</u>	<u>2.37</u>	<u>NA</u>

Source: California Nitrogen Assessment (<http://asi.ucdavis.edu/research/nitrogen/n-science/nitrogen-use-efficiency>).

A.87 Discussion of Performance Standard Research for Other Practices

Preliminary performance standard research for other practices has been undertaken by the Reserve, with the aim of eventually developing practice-based positive lists. The Reserve is looking at both absolute levels of and temporal trends in penetration rates of project activities as a decision criterion for including project activities on a positive list (i.e. activities on the positive list are automatically considered additional). Preliminary data for the project activities “changing N timing” and “use of N inhibitors,” the only two priority practices for which USDA ARMS datasets are available, are presented in Sections [A.8.2](#) and [A.8.3](#) of this appendix, respectively. If quantification methodologies for these practices become available, the Reserve will complete work on the positive list, with the hopes of expanding the protocol to include these new practices. The Reserve will also continue to evaluate, on an ongoing basis, additional datasets for the other priority practices, to determine whether there may be enough data for those practices to develop a performance standard, as discussed further below.

A.87.1 Data Available Using the USDA ARMS Dataset

~~The most comprehensive data source for developing robust and widely applicable performance standard tests for this NMPP protocol is the USDA Agricultural Resources and Management Survey (ARMS).¹³⁵ This survey includes three phases, Phase II of which includes surveys conducted to obtain physical and economic data on production inputs, management practices (including a fertilizer management survey), and commodity cost of production. Averages and relative standard errors (RSE) around survey data on crop production practices for selected major field crops and their respective top producing states can be downloaded from the USDA ARMS website.¹³⁶ The crop practice categories and crops for which data is readily downloadable are listed in Table A.11. Note that only a selected subset of the survey data is available to download. Also, for data that is characterized by continuous variables (e.g. N rate), data distributions are not available. This provides a major limitation for developing robust performance standard tests. For calculating RTAs, crop yield data are required in addition to N rates. Crop yield data are not available from the USDA ARMS survey, but can be downloaded from USDA/NASS Quickstats.¹³⁷ Yield data for a large variety of crops are available at the state level. Within some state, agricultural district or county averaged crop yields are available. No standard errors or distributions are available for yield data.~~ Crop practice categories and crops

¹³⁵ General documentation on ARMS can be found at <http://www.ers.usda.gov/Data/ARMS/GlobalDocumentation.htm>

¹³⁶ Go to <http://www.ers.usda.gov/Data/ARMS/CropOverview.htm> and select “tailored reports”.

¹³⁷ <http://quickstats.nass.usda.gov/>

for which data is readily downloadable from the USDA ARMS dataset are listed in Table A.11. Note that only a selected subset of the survey data is available to download.

Table A.11. Crops and Crop Practices ~~for which Available from~~ USDA ARMS Data ~~is Readily Downloadable~~¹³⁸

Crops	Subgroups	Manure Table
corn soybean cotton rice spring wheat sorghum oats peanuts barley feed barley malt	farm production region irrigation system highly erodible land previous crop harvested tillage system ownership status	manure type manure application method manure application timing distance to manure production site tillage system ownership status
Nutrient Use and Management	Nutrient Use by Application Method	Synthetic N Application Timing
N rate manure applied compost applied soil and/or plant tissue N test nitrification inhibitor used	no N broadcast all N broadcast with incorporation all N broadcast without incorporation mixed N application method, with incorporation mixed N application method, without incorporation	N in fall before planting N in spring before planting N at planting N after planting

A.87.2 Preliminary Analysis for N Timing (Switching from Fall to Spring Application)

Survey data on ~~penetration~~ rates for ~~those who already do not apply N in fall~~ ~~N application~~ in corn cropping systems was obtained from USDA ARMS to evaluate the trends in switching from Fall to Spring. Both penetration rates and trends in penetration rate over time differ across states (~~Figure A.7, Table A.12~~). (Figure A.3, Table A.12). For a large number of states, not enough data are available for trend analysis. In states where enough data were available, no trends over time were observed. Across all states and years, the ~~smallest~~~~greatest~~ observed penetration rate was ~~29~~~~8~~ percent (Kentucky 2010) and the ~~largest~~~~64~~~~lowest~~ ~~36~~ percent (Iowa 2010).

¹³⁸ The state and year combinations for which the data is available can be found at <http://www.ers.usda.gov/Data/ARMS/GlobalDocumentation.htm>

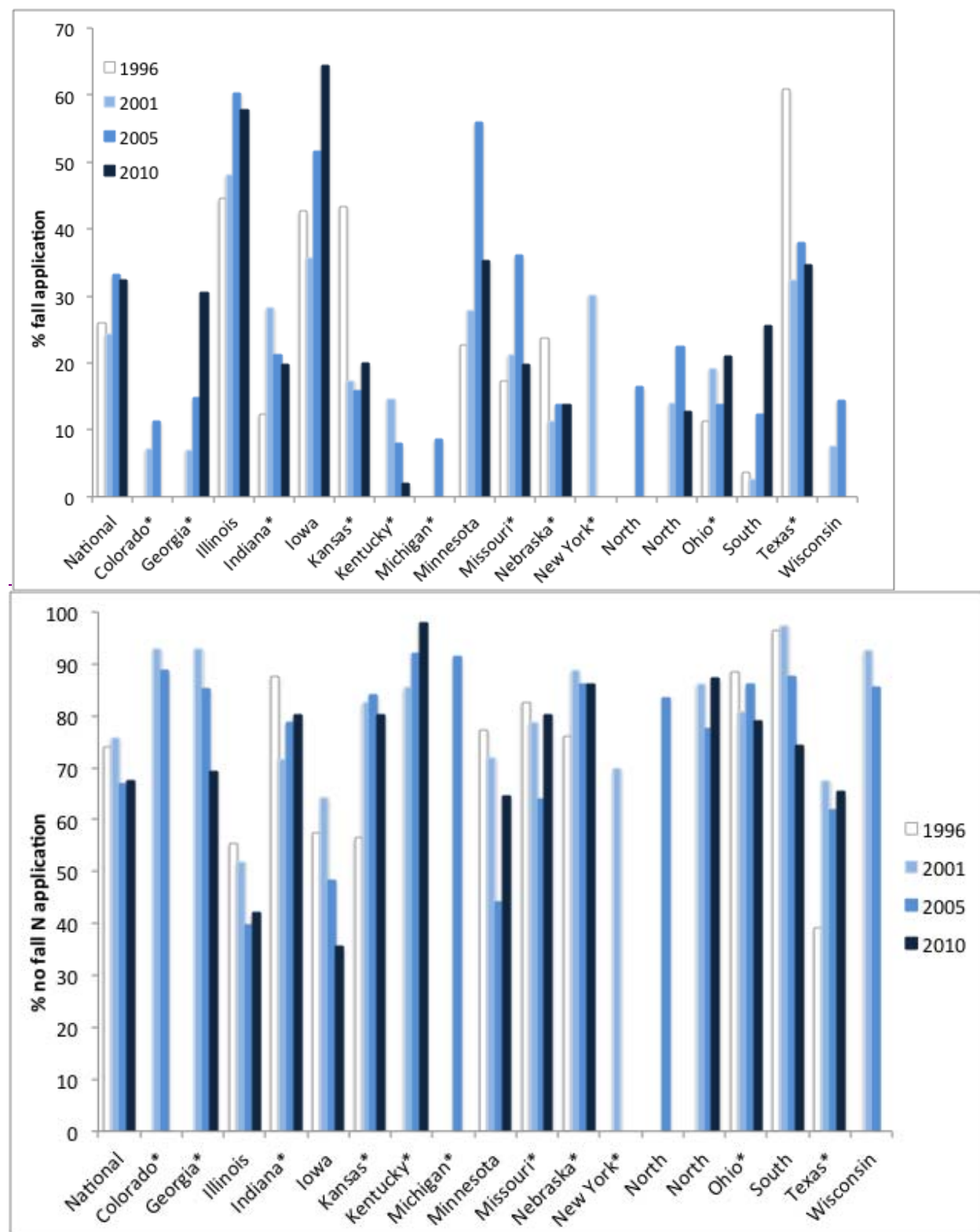


Figure A.3. Penetration Rate of those Not Applying N in Fall N-Application for Corn

Table A.9.12. Trends in Penetration Rate of those Not Applying N in Fall N-Application Over Time

State	CaseTrend
Colorado	Case 5- Insufficient data and no recent data
Georgia	Case 3- Insufficient data but recent data is available
Georgia	Case 3- Insufficient data but recent data is available
Illinois	Case 1- no significant trend over time
Indiana	Case 1- no significant trend over time
Iowa	Case 1- no significant trend over time
Kansas	Case 1- no significant trend over time
Kentucky	Case 5- Insufficient data and no recent data
Michigan	Case 5- Insufficient data and no recent data
Minnesota	Case 1- no significant trend over time
Missouri	Case 5- Insufficient data and no recent data
Nebraska	Case 5- Insufficient data and no recent data
North Carolina	Case 5- Insufficient data and no recent data
North Dakota	Case 5- Insufficient data and no recent data
Ohio	Case 5- Insufficient data and no recent data
Pennsylvania	Case 5- Insufficient data and no recent data
South Dakota	Case 5- Insufficient data and no recent data
Texas	Case 1- no significant trend over time
Wisconsin	Case 5- Insufficient data and no recent data
New York	Case 5- Insufficient data and no recent data

A.87.3 Preliminary Results for the Use of N Inhibitors

Data on adoption of N inhibitors in corn cropping systems was also obtained from USDA ARMS. It should be noted that 'N inhibitor' as defined in the USDA ARMS survey includes nitrification inhibitors, urease inhibitors and chemical coated (controlled release) fertilizers. Only aggregated data on penetration rates for N inhibitors are publicly available. However, the survey question was phrased in a manner that disaggregation per N inhibitor type should theoretically be possible. ~~Consequently Because of the aggregation~~, penetration rates presented in ~~Figure A.8~~ Figure A.4 should be interpreted with caution ~~but are conservative, as the penetration of one particular type of N inhibitor will be lower than the penetration of the umbrella group of N inhibitors~~. Both penetration rates and trends in penetration rate of N inhibitors over time differ across states (~~Figure A.8,~~ Figure A.4 ~~and~~ Table A.13). For a large number of states, not enough data are available for trend analysis. In states where enough data were available, no trends over time were observed. Across all states and years, the smallest observed penetration rate was two percent (Missouri and Nebraska 2001) and the largest rate 44 percent (Indiana 2010). Penetration rates in 2010 were lower than 10 percent in Minnesota, Nebraska and Ohio.

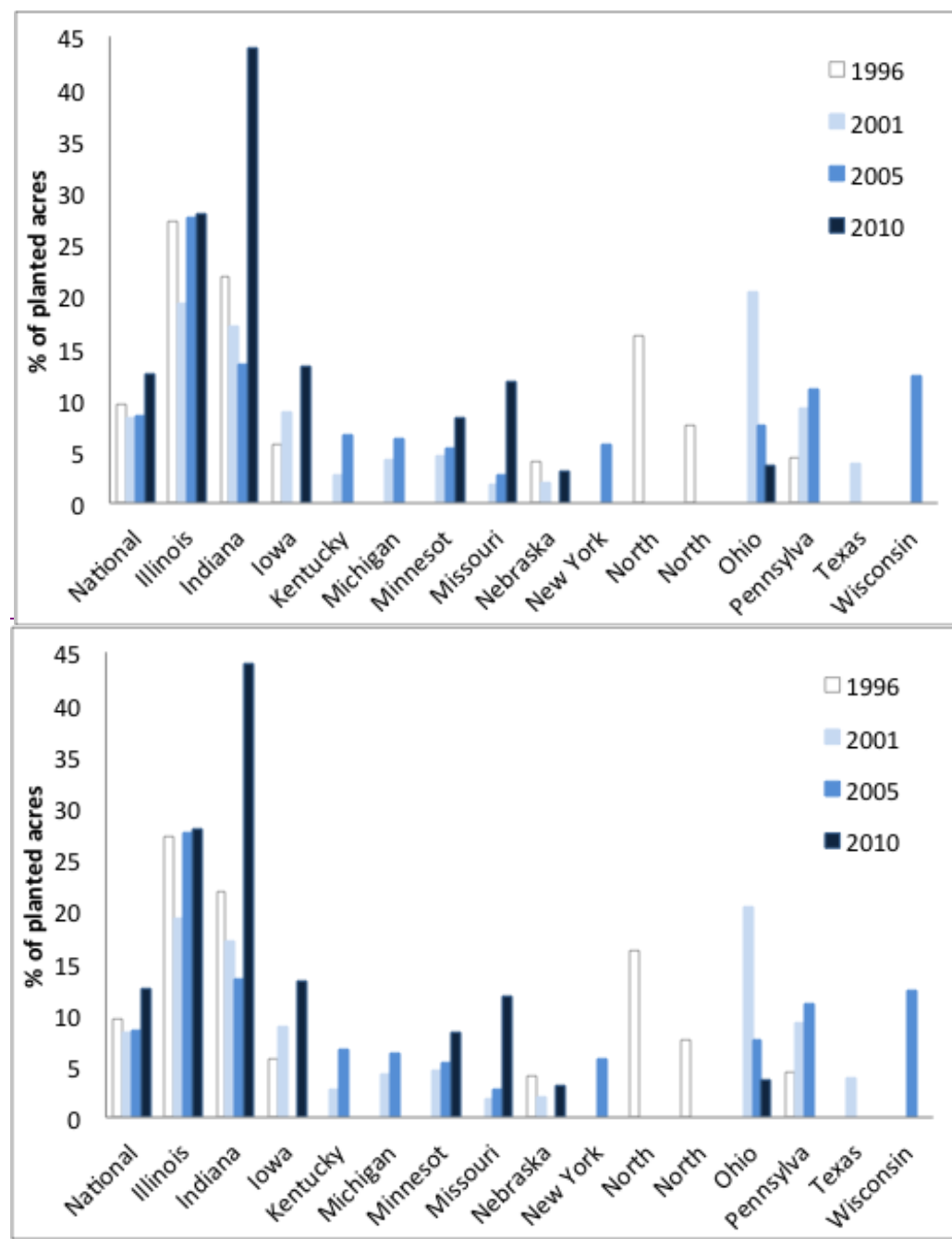


Figure A.4. Penetration Rate of Use of N Inhibitors for Corn

Table A.10.13. Trends in Penetration Rate of Use of N Inhibitors Over Time

State	CaseTrend
Iowa	Case 4 : no significant trend over time
Illinois	Case 4 : no significant trend over time
Indiana	Case 4 : no significant trend over time
Kentucky	Case 4 : no significant trend over time
Michigan	Case 5 : Insufficient data and no recent data
Minnesota	Case 4 : no significant trend over time
Missouri	Case 4 : no significant trend over time
Nebraska	Case 4 : no significant trend over time
New York	Case 5 : Insufficient data and no recent data
Ohio	Case 4 : no significant trend over time
Pennsylvania	Case 4 : no significant trend over time
South Dakota	Case 5 : Insufficient data and no recent data
Texas	Case 5 : Insufficient data and no recent data
Wisconsin	Case 4 : no significant trend over time

~~A.9 Complete RTA and N Rate Historic Trend Tables for All States with ARMS Data for Corn~~

Table A.11. Low, Average, and High State and Crop Specific RTA Values and Trends Over Time

n.s. = not statistically significant ($p < 0.5$), * = not enough data was available for trend analysis, positive = the trend in RTA over time was statistically significant and positive ($p < 0.05$)

Crop	Previous Crop	State	nrObs	Lowest Historic RTA	Average Historic RTA	Highest Historic RTA	Trend
corn-grain	corn-grain	Colorado	6	0.60	0.79	1.15	n.s.
corn-grain	corn-grain	Georgia	2	0.62	0.81	1.00	*
corn-grain	corn-grain	Iowa	8	0.75	0.92	1.39	n.s.
corn-grain	corn-grain	Illinois	8	0.62	0.70	0.77	n.s.
corn-grain	corn-grain	Indiana	7	0.58	0.75	0.89	n.s.
corn-grain	corn-grain	Kansas	7	0.52	0.62	0.70	n.s.
corn-grain	corn-grain	Kentucky	6	0.50	0.72	1.01	n.s.
corn-grain	corn-grain	Michigan	7	0.68	0.87	1.18	n.s.
corn-grain	corn-grain	Minnesota	8	0.98	1.17	1.42	n.s.
corn-grain	corn-grain	Missouri	8	0.42	0.68	1.12	positive
corn-grain	corn-grain	North Carolina	7	0.52	0.83	1.58	n.s.
corn-grain	corn-grain	North Dakota	3	0.84	0.94	1.12	n.s.
corn-grain	corn-grain	Nebraska	8	0.57	0.74	0.84	n.s.
corn-grain	corn-grain	New York	4	1.05	1.51	1.95	n.s.
corn-grain	corn-grain	Ohio	7	0.64	0.74	0.87	n.s.
corn-grain	corn-grain	Pennsylvania	6	0.76	1.09	1.40	n.s.

corn-grain	corn-grain	-South Carolina	4	0.59	0.59	0.59	*
corn-grain	corn-grain	-South Dakota	6	0.67	0.87	1.02	n.s.
corn-grain	corn-grain	-Texas	7	0.54	0.69	0.88	n.s.
corn-grain	corn-grain	-Wisconsin	8	1.10	1.31	1.46	n.s.
corn-grain	soybean	-Georgia	4	0.89	0.89	0.89	*
corn-grain	soybean	-Iowa	8	0.84	0.93	0.99	n.s.
corn-grain	soybean	-Illinois	8	0.65	0.74	0.80	n.s.
corn-grain	soybean	-Indiana	8	0.67	0.76	0.89	n.s.
corn-grain	soybean	-Kansas	7	0.70	0.82	1.02	n.s.
corn-grain	soybean	-Kentucky	7	0.45	0.58	0.67	n.s.
corn-grain	soybean	-Michigan	8	0.58	0.77	1.02	n.s.
corn-grain	soybean	-Minnesota	8	0.87	0.96	1.10	positive
corn-grain	soybean	-Missouri	8	0.49	0.65	0.78	n.s.
corn-grain	soybean	-North Carolina	7	0.37	0.61	0.79	n.s.
corn-grain	soybean	-North Dakota	4	0.63	0.76	0.87	n.s.
corn-grain	soybean	-Nebraska	8	0.81	0.94	1.06	n.s.
corn-grain	soybean	-New York	4	1.74	1.74	1.74	*
corn-grain	soybean	-Ohio	8	0.59	0.69	0.86	positive
corn-grain	soybean	-Pennsylvania	5	0.78	1.03	1.50	n.s.
corn-grain	soybean	-South Carolina	4	0.52	0.52	0.52	*
corn-grain	soybean	-South Dakota	8	0.77	0.87	1.05	n.s.
corn-grain	soybean	-Texas	4	0.78	0.78	0.78	*
corn-grain	soybean	-Wisconsin	8	0.70	1.01	1.19	n.s.
corn-silage	corn silage	-Colorado	6	0.89	1.15	1.69	n.s.
corn-silage	corn silage	-Georgia	2	0.81	1.00	1.20	*
corn-silage	corn silage	-Iowa	8	0.80	1.00	1.56	n.s.
corn-silage	corn silage	-Illinois	8	0.59	0.69	0.78	n.s.
corn-silage	corn silage	-Indiana	7	0.67	0.86	1.13	n.s.
corn-silage	corn silage	-Kansas	7	0.49	0.63	0.74	n.s.
corn-silage	corn silage	-Kentucky	6	0.59	0.83	1.19	n.s.
corn-silage	corn silage	-Michigan	7	0.68	0.95	1.28	n.s.
corn-silage	corn silage	-Minnesota	8	0.80	1.11	1.43	n.s.
corn-silage	corn silage	-Missouri	8	0.40	0.69	1.21	positive

corn-silage	corn silage	-North Carolina	7	0.63	1.03	1.91	n.s.
corn-silage	corn silage	-North Dakota	3	0.64	0.78	0.97	n.s.
corn-silage	corn silage	-Nebraska	8	0.56	0.74	0.84	n.s.
corn-silage	corn silage	-New York	4	1.33	1.84	2.37	n.s.
corn-silage	corn silage	-Ohio	7	0.64	0.80	0.93	n.s.
corn-silage	corn silage	Pennsylvania	6	0.97	1.41	1.66	n.s.
corn-silage	corn silage	-South Carolina	4	0.83	0.83	0.83	*
corn-silage	corn silage	-South Dakota	6	0.57	0.75	0.84	n.s.
corn-silage	corn silage	-Texas	7	0.84	0.94	1.07	n.s.
corn-silage	corn silage	-Wisconsin	8	1.14	1.35	1.49	n.s.
corn-silage	soybean	-Georgia	4	1.17	1.17	1.17	*
corn-silage	soybean	-Iowa	8	0.91	1.00	1.10	n.s.
corn-silage	soybean	-Illinois	8	0.59	0.72	0.78	n.s.
corn-silage	soybean	-Indiana	8	0.72	0.87	1.00	n.s.
corn-silage	soybean	-Kansas	7	0.69	0.83	1.16	n.s.
corn-silage	soybean	-Kentucky	7	0.47	0.68	0.82	n.s.
corn-silage	soybean	-Michigan	8	0.68	0.84	1.02	n.s.
corn-silage	soybean	-Minnesota	8	0.81	0.91	1.10	n.s.
corn-silage	soybean	-Missouri	8	0.43	0.66	0.82	n.s.
corn-silage	soybean	-North Carolina	7	0.42	0.76	1.00	n.s.
corn-silage	soybean	-North Dakota	4	0.55	0.65	0.70	n.s.
corn-silage	soybean	-Nebraska	8	0.79	0.94	1.10	n.s.
corn-silage	soybean	-New York	4	1.95	1.95	1.95	*
corn-silage	soybean	-Ohio	8	0.66	0.73	0.79	n.s.
corn-silage	soybean	Pennsylvania	5	1.02	1.33	1.78	n.s.
corn-silage	soybean	-South Carolina	4	0.73	0.73	0.73	*
corn-silage	soybean	-South Dakota	8	0.60	0.74	0.81	n.s.
corn-silage	soybean	-Texas	4	1.31	1.31	1.31	*
corn-silage	soybean	-Wisconsin	8	0.71	1.05	1.32	n.s.
spring-wheat	NA	national	4	0.67	0.75	0.80	n.s.
spring-wheat	NA	Colorado	4	1.57	1.57	1.57	*
spring-wheat	NA	Idaho	3	0.92	0.97	1.04	n.s.
spring-wheat	NA	Minnesota	4	0.67	0.74	0.80	n.s.
spring-wheat	NA	Montana	4	0.62	0.74	0.88	n.s.
spring-wheat	NA	North Dakota	4	0.61	0.71	0.86	positive

spring-wheat	NA	Oregon	3	0.84	1.00	1.14	n.s.
spring-wheat	NA	South-Dakota	4	0.70	0.79	0.84	n.s.
spring-wheat	NA	Washington	3	0.59	0.77	0.92	n.s.
winter-wheat	NA	national	4	0.72	0.76	0.80	n.s.
winter-wheat	NA	Arkansas	1	0.60	0.60	0.60	*
winter-wheat	NA	California	1	0.85	0.85	0.85	*
winter-wheat	NA	Colorado	4	0.82	0.95	1.25	n.s.
winter-wheat	NA	Georgia	1	0.50	0.50	0.50	*
winter-wheat	NA	Idaho	4	0.77	0.86	0.94	n.s.
winter-wheat	NA	Illinois	4	0.56	0.64	0.75	n.s.
winter-wheat	NA	Kansas	4	0.67	0.80	0.92	n.s.
winter-wheat	NA	Kentucky	1	0.66	0.66	0.66	*
winter-wheat	NA	Louisiana	1	0.49	0.49	0.49	*
winter-wheat	NA	Michigan	2	0.74	0.80	0.88	*
winter-wheat	NA	Minnesota	1	0.76	0.76	0.76	*
winter-wheat	NA	Mississippi	1	0.37	0.37	0.37	*
winter-wheat	NA	Missouri	4	0.50	0.57	0.68	n.s.
winter-wheat	NA	Montana	4	0.62	0.81	1.01	n.s.
winter-wheat	NA	Nebraska	4	0.83	0.97	1.19	n.s.
winter-wheat	NA	North Carolina	2	0.46	0.47	0.48	*
winter-wheat	NA	North-Dakota	1	0.58	0.58	0.58	*
winter-wheat	NA	Ohio	4	0.77	0.80	0.82	n.s.
winter-wheat	NA	Oklahoma	4	0.44	0.57	0.72	n.s.
winter-wheat	NA	Oregon	4	0.96	1.08	1.17	n.s.
winter-wheat	NA	South-Dakota	4	0.66	0.81	0.95	n.s.
winter-wheat	NA	Texas	4	0.40	0.52	0.60	n.s.
winter-wheat	NA	Washington	4	0.87	1.08	1.37	n.s.
durum wheat	NA	National	4	0.64	0.77	0.94	n.s.
durum wheat	NA	California	1	0.54	0.54	0.54	*
durum wheat	NA	Idaho	1	0.64	0.64	0.64	*
durum wheat	NA	Montana	2	0.72	0.76	0.80	*
durum wheat	NA	North-Dakota	4	0.56	0.68	0.81	n.s.

Table A.12. Low, Average, and High State and Crop Specific N Rates and Trends Over Time

n.s. = not statistically significant ($p < 0.5$), * = not enough data was available for trend analysis, positive = the trend in N rate over time was statistically significant and positive ($p < 0.05$), negative = the trend in N rate over time was statistically significant and negative ($p < 0.05$)

Crop	Previous Crop	State	nrObs	Lowest Historic N-Rate	Average Historic N-Rate	Highest Historic N-Rate	trend
corn-grain	corn-grain	-Colorado	6	101	150	195	n.s.
corn-grain	corn-grain	-Georgia	2	107	136	166	*
corn-grain	corn-grain	-Iowa	8	84	134	159	n.s.
corn-grain	corn-grain	-Illinois	8	155	164	172	n.s.
corn-grain	corn-grain	-Indiana	7	113	150	175	n.s.
corn-grain	corn-grain	-Kansas	7	150	178	206	negative
corn-grain	corn-grain	-Kentucky	6	99	145	186	n.s.
corn-grain	corn-grain	-Michigan	7	97	110	130	n.s.
corn-grain	corn-grain	-Minnesota	8	75	103	142	positive
corn-grain	corn-grain	-Missouri	8	88	154	219	negative
corn-grain	corn-grain	-North Carolina	7	48	106	135	n.s.
corn-grain	corn-grain	-North Dakota	3	80	103	123	n.s.
corn-grain	corn-grain	-Nebraska	8	144	156	177	n.s.
corn-grain	corn-grain	-New York	4	51	65	75	n.s.
corn-grain	corn-grain	-Ohio	7	130	148	177	n.s.
corn-grain	corn-grain	-Pennsylvania	6	70	89	117	n.s.
corn-grain	corn-grain	-South Carolina	4	107	107	107	*
corn-grain	corn-grain	-South Dakota	6	78	105	131	n.s.
corn-grain	corn-grain	-Texas	7	132	141	154	n.s.
corn-grain	corn-grain	-Wisconsin	8	70	84	105	positive
corn-grain	soybean	-Georgia	4	115	115	115	*
corn-grain	soybean	-Iowa	8	120	129	140	positive
corn-grain	soybean	-Illinois	8	146	156	167	n.s.
corn-grain	soybean	-Indiana	8	140	149	164	n.s.
corn-grain	soybean	-Kansas	7	116	135	154	n.s.
corn-grain	soybean	-Kentucky	7	159	172	188	n.s.
corn-grain	soybean	-Michigan	8	87	128	143	n.s.
corn-grain	soybean	-Minnesota	8	114	123	134	n.s.
corn-grain	soybean	-Missouri	8	129	150	173	n.s.
corn-grain	soybean	-North Carolina	7	98	133	153	n.s.
corn-grain	soybean	-North Dakota	4	113	129	142	n.s.
corn-grain	soybean	-Nebraska	8	109	123	140	positive
corn-grain	soybean	-New York	4	69	69	69	*
corn-grain	soybean	-Ohio	8	150	160	174	n.s.
corn-grain	soybean	-Pennsylvania	5	68	94	122	n.s.

corn-grain	soybean	-South Carolina	4	122	122	122	*
corn-grain	soybean	-South Dakota	8	89	105	133	positive
corn-grain	soybean	-Texas	4	103	103	103	*
corn-grain	soybean	-Wisconsin	8	89	111	146	n.s.
corn-silage	corn-silage	-Colorado	6	101	150	195	n.s.
corn-silage	corn-silage	-Georgia	2	107	136	166	*
corn-silage	corn-silage	-Iowa	8	84	134	159	n.s.
corn-silage	corn-silage	-Illinois	8	155	164	172	n.s.
corn-silage	corn-silage	-Indiana	7	113	150	175	n.s.
corn-silage	corn-silage	-Kansas	7	150	178	206	negative
corn-silage	corn-silage	-Kentucky	6	99	145	186	n.s.
corn-silage	corn-silage	-Michigan	7	97	110	130	n.s.
corn-silage	corn-silage	-Minnesota	8	75	103	142	positive
corn-silage	corn-silage	-Missouri	8	88	154	219	negative
corn-silage	corn-silage	-North Carolina	7	48	106	135	n.s.
corn-silage	corn-silage	-North Dakota	3	80	103	123	n.s.
corn-silage	corn-silage	-Nebraska	8	144	156	177	n.s.
corn-silage	corn-silage	-New York	4	51	65	75	n.s.
corn-silage	corn-silage	-Ohio	7	130	148	177	n.s.
corn-silage	corn-silage	-Pennsylvania	6	70	89	117	n.s.
corn-silage	corn-silage	-South Carolina	4	107	107	107	*
corn-silage	corn-silage	-South Dakota	6	78	105	131	n.s.
corn-silage	corn-silage	-Texas	7	132	141	154	n.s.
corn-silage	corn-silage	-Wisconsin	8	70	84	105	positive
corn-silage	soybean	-Georgia	4	115	115	115	*
corn-silage	soybean	-Iowa	8	120	129	140	positive
corn-silage	soybean	-Illinois	8	146	156	167	n.s.
corn-silage	soybean	-Indiana	8	140	149	164	n.s.
corn-silage	soybean	-Kansas	7	116	135	154	n.s.
corn-silage	soybean	-Kentucky	7	159	172	188	n.s.
corn-silage	soybean	-Michigan	8	87	128	143	n.s.
corn-silage	soybean	-Minnesota	8	114	123	134	n.s.
corn-silage	soybean	-Missouri	8	129	150	173	n.s.
corn-silage	soybean	-North Carolina	7	98	133	153	n.s.
corn-silage	soybean	-North Dakota	4	113	129	142	n.s.
corn-silage	soybean	-Nebraska	8	109	123	140	positive
corn-silage	soybean	-New York	4	69	69	69	*
corn-silage	soybean	-Ohio	8	150	160	174	n.s.
corn-silage	soybean	-Pennsylvania	5	68	94	122	n.s.
corn-silage	soybean	-South Carolina	4	122	122	122	*

corn-silage	soybean	-South-Dakota	8	89	105	133	positive
corn-silage	soybean	-Texas	1	103	103	103	*
corn-silage	soybean	-Wisconsin	8	89	111	146	n.s.
spring-wheat	NA	national	4	72	75	78	n.s.
spring-wheat	NA	Colorado	1	80	80	80	*
spring-wheat	NA	Idaho	3	106	111	117	n.s.
spring-wheat	NA	Minnesota	4	86	93	99	positive
spring-wheat	NA	Montana	4	49	55	58	n.s.
spring-wheat	NA	North-Dakota	4	72	76	80	n.s.
spring-wheat	NA	Oregon	3	59	71	82	n.s.
spring-wheat	NA	South-Dakota	4	56	71	87	positive
spring-wheat	NA	Washington	3	75	87	105	n.s.
winter-wheat	NA	national	4	62	66	68	n.s.
winter-wheat	NA	Arkansas	1	101	101	101	*
winter-wheat	NA	California	1	93	93	93	*
winter-wheat	NA	Colorado	4	36	41	50	n.s.
winter-wheat	NA	Georgia	1	97	97	97	*
winter-wheat	NA	Idaho	4	108	113	118	n.s.
winter-wheat	NA	Illinois	4	86	97	103	n.s.
winter-wheat	NA	Kansas	4	54	58	62	n.s.
winter-wheat	NA	Kentucky	1	97	97	97	*
winter-wheat	NA	Louisiana	1	101	101	101	*
winter-wheat	NA	Michigan	2	88	95	102	*
winter-wheat	NA	Minnesota	1	67	67	67	*
winter-wheat	NA	Mississippi	1	139	139	139	*
winter-wheat	NA	Missouri	4	86	99	109	n.s.
winter-wheat	NA	Montana	4	46	54	60	n.s.
winter-wheat	NA	Nebraska	4	44	49	59	n.s.
winter-wheat	NA	North Carolina	2	96	110	124	*
winter-wheat	NA	North-Dakota	1	94	94	94	*
winter-wheat	NA	Ohio	4	89	95	102	n.s.
winter-wheat	NA	Oklahoma	4	57	64	73	n.s.
winter-wheat	NA	Oregon	4	54	65	72	n.s.
winter-wheat	NA	South-Dakota	4	50	62	72	n.s.
winter-wheat	NA	Texas	4	47	68	84	n.s.
winter-wheat	NA	Washington	4	60	70	77	n.s.
durum-wheat	NA	National	4	60	63	69	n.s.
durum-wheat	NA	California	1	226	226	226	*
durum-wheat	NA	Idaho	1	164	164	164	*
durum-wheat	NA	Montana	2	53	55	56	*
durum-wheat	NA	North-Dakota	4	60	62	63	n.s.

Appendix B Science Advisory Committee Process and Recommendations for Nitrogen Management Practices

~~This section is adapted from the Final Report the Reserve published on the SAC meeting. Draft Appendix B is included for your reference, but it is not final and subject to further edits.~~

B.1 Committee Background

The Reserve together with the Nicholas Institute of Duke University assembled a group of leading scientific experts on agricultural N₂O emissions to form a Science Advisory Committee (SAC). The purpose of the SAC was to help the Reserve interpret and apply the best available science into the Nitrogen Management Project Protocol.

Committee membership was by invitation from the Reserve and the Nicholas Institute.

~~Involvement~~SAC members were invited based on their involvement in the Technical Working Group on Agricultural Greenhouse Gases (T-AGG), ~~led by the Nicholas Institute, was a priority qualification as this is an a~~ respected and well-established bodyworking group of agricultural scientists led by the Nicholas Institute, with relevant scientific expertise, knowledge of GHG offset protocol development issues, and an explicit interest in translating research into GHG mitigation policy applications for agriculture. In addition, scientists must have met the following criteria to be eligible to participate in the committee: ~~(1)~~ a PhD in soil science or related field, ~~(2)~~ 10+ years of experience in research, with a research emphasis directly relevant to agricultural nitrogen management and N₂O emissions, and ~~(3)~~ multiple publications in soil science, ecosystem science, agronomy or related fields. A list of SAC members is available in the Acknowledgements section of this protocol.

The SAC, ~~alongside the protocol workgroup~~, has provided invaluable guidance on interpreting the most up-to-date science and has provided input ~~during~~throughout the protocol development process ~~in determining appropriate performance standards for~~. Most importantly, the SAC provided recommendations on which nitrogen management practices ~~were well studied with consistent results that should be prioritized for development, informed on~~ boundaries for accurate and conservative ~~greenhouse gas project assessment~~GHG accounting, and weighed considerations of scientifically valid and ~~economical~~economically practical quantification methods. ~~A list of SAC members is available in the Acknowledgements section of this protocol and a (e.g. comparing Tier 1, 2, and 3 methods). A~~ summary of the SAC effort is presented ~~below~~in this appendix.

B.2 Potential Nitrogen Management Practices

The SAC evaluated a list of nitrogen management practices identified by T-AGG ~~to that~~ result in N₂O emissions reductions, using significant N₂O emission reduction potential. The SAC assessed the practices based on criteria such as the available number of field studies (particularly side-by-side comparison studies comparisons) showing measured N₂O emission reductions in the field, whether these studies consistently showed consistent results, emission reductions across a range of variables (including precipitation, temperature, soil texture, SOC), and whether N₂O emission reductions were direct or indirect. SAC members rated the practices

and made a recommendation on which practices should be prioritized for development, i.e. which had the highest potential of being incorporated into a project protocol based on best available science. Summaries of the priority list of practices recommended by the SAC are provided below ~~in Table 2.1.~~

B.2.1 Reducing the Amount of Nitrogen Applied

This practice involves reducing the total amount of nitrogen applied to a field (i.e. reducing the “N application rate”). The SAC recommended this practice for inclusion in an offset protocol on the condition that N rate reductions are not implemented at the expense of crop yield. Consequently, the Reserve has defined the project activity so that N rate reductions must occur without going below the nitrogen uptake demand of crops. This practice is the most well-studied of the practices considered, with the most consistent N₂O effects in terms of reductions (e.g. most directional certainty). The SAC ~~determined~~ recommended that there should be a focus on improved nitrogen-use efficiency rather than nitrogen application ~~rates~~ rate reductions because site variably and different management systems have different agronomic optimum nitrogen application rates, which ~~affects~~ affect how much nitrogen can be reduced on a given field before exhibiting yield effects.

The relationship between N₂O emissions and nitrogen application rate can be linear or non-linear depending on characteristics of specific crops and regions. However, these relationships can be described with the development of system-specific (as opposed to generic) emission factors. This practice was ~~determined to be eligible~~ recommended for consideration in all ~~U.S.~~ regions of the U.S.

B.2.2 Using Nitrification Inhibitors and/or ~~Using Nitrification Inhibitors Combined with Urease Inhibitors~~

~~A~~ The SAC recommended applying nitrification inhibitors, as well as applying nitrification inhibitors with urease inhibitors, as practices that demonstrated promise for inclusion in the NMPP because they have been well studied and showed consistent emission reductions in certain U.S. regions; however, more research is needed to quantify emission reduction potential.

An extensive and recent literature review by Akiyama et al. (2010)¹³⁹ showed emission reduction potential for the use of nitrification inhibitors ~~in certain regions and the SAC was also confident about the combination of and~~ nitrification ~~and inhibitors combined with~~ urease inhibitors.

in certain regions. However, ~~Akiyama~~ Akiyama et al. (2010) include relatively few North American sites, and other studies on U.S. sites show no effects or inconsistent effects. ~~On the other hand; therefore, more studies are needed to develop a quantification methodology for this practice. Nevertheless,~~ the practice could ~~be an enabler for enable~~ lower N ~~rate. In rates, which would be eligible under the current NMPP but, in some cases studies, and particularly if not used properly by growers,~~ nitrification inhibitors ~~may~~ could have the adverse effect of decreasing yield potential and increasing residual soil nitrogen by maintaining immobile ammonia (NH₃) in the soil during the critical crop development stage.

¹³⁹ Akiyama, H., X.Y. Yan, and K. Yagi. 2010. Evaluation of effectiveness of enhanced-efficiency fertilizers as mitigation options for N₂O and NO emissions from agricultural soils: Meta-analysis. *Global Change Biology* 16(6):1837–46.

~~There is likely to be~~The SAC was also concerned about regional variability in the effect of this practice on N₂O emissions, particularly due to the lack of U.S. studies in the Akiyama meta-analysis. The practice consistently reduces emissions in ~~western~~drier climates ~~and~~, where water is intensively managed, such as the western U.S. Results in rain fed regions are inconsistent, however, particularly for nitrification inhibitors by themselves. In the mid-southern U.S., due to the types of soils, the activity could potentially increase nitrogen losses, including N₂O emissions. As well, the SAC did not recommend the use of urease inhibitors on their own, due to inconsistent results and emission increases in some studies.

B.2.3 Using Slow-Release Fertilizer

The SAC believed that using slow-release fertilizer was a practice with promise for inclusion in the NMPP, but noted that more research is needed.

High N₂O emissions may occur when slow-release fertilizer application is followed by significant precipitation events. However, GHG reductions are assessed relative to a project's "business as usual" baseline in which the precipitation event also would have happened. Therefore, if the precipitation effect is can be factored into the baseline and project emission estimates, resulting in a net N₂O reduction is possible when slow-release fertilizer is applied.

It should be noted that the use of slow-release fertilizer could have an adverse effect of decreasing yield potential and increasing residual soil nitrogen, if the activity limits available nitrogen in the soil during the critical crop development stage.

This practice results in less consistent emission reductions in wetter regions due to greater volatilization. Slow-release fertilizers are more consistent at reducing emissions in a no till system compared to a conventional till system.

B.2.4 Changing Fertilizer Composition

This practice shows potential for certain fertilizer sources, particularly switching from anhydrous ammonia to urea. The effects are mostly consistent, but depend on the application rate (before and after switch). The practice change will have less N₂O emission reduction effect at lower nitrogen rates than at higher nitrogen rates.

Production of urea fertilizer results in significantly more emissions than production of anhydrous ammonia, so the difference in production emissions may need to be considered for conservativeness. Switching to urea from anhydrous ammonia may also increase nitric oxide emissions, an issue that would need to be addressed from an environmental impact perspective.

There was consistent directional certainty (e.g. that a switch in fertilizer would consistently reduce N₂O emissions) regardless of region. However, results from Canada showed no difference in N₂O emissions between Aqua Ammonia and urea, demonstrating potential regional differences.

Other fertilizer source switching may have potential, but were not directly addressed by the SAC.

B.2.5 Synchronizing Plant Nitrogen Uptake with Nitrogen Application

B.2.5.1 Increasing the Number of Applications

This practice showed possible potential for fertigation only. There are not enough studies that show consistent direct N₂O emission reductions; some studies have yielded conflicting results and may have simultaneously tested other management changes. The results of this practice are highly dependent on water management, placement of the increased number of applications, and how the applications are delivered. In some cases, the practice could increase emissions as a result of a pulsing response (i.e. bursts of N₂O emissions associated with the application). However, more applications over a season with fertigation (i.e. applying nitrogen through sprinkler and drip irrigation systems) generally would be expected to reduce nitrogen losses and N₂O emissions; though, it is not entirely known whether fertigation alone or the change in irrigation cause the effects.

Also, by providing nitrogen to crops in a manner more synchronous to crop nitrogen uptake, it helps to limit the pool of nitrogen available at any given time. Generally, this will reduce nitrate runoff and leaching, leading to indirect emission reductions. In regions with a deep water table, the amount of nitrogen leached is generally less.

There may be potential for N₂O emission reductions from increasing the number of nitrogen applications delivered via fertigation in irrigated western regions. However, rain fed systems would require further study, as results are unpredictable.

B.2.5.2 Switching from Fall to Spring Application

This practice could have significant potential, particularly in regions with winter freeze or spring thaw but the number of studies is limited, with some conflicting results. Additional research is needed for spring-planted crops before strong conclusions can be drawn.

This practice generally results in reduced nitrate leaching, leading to indirect emission reductions. In regions with a deep water table, there is usually less leached nitrogen. There is likely to be regional variability in potential for this practice with the largest consistent reductions in northern and Corn Belt regions of the U.S. where there is typically a spring thaw.

B.2.6 Applying Nitrogen Closer to the Root System

This practice showed possible potential when changing the placement of fertilizer. There are conflicting results from studies in different regions, but there may be limited potential in dry regions with irrigated systems, where reductions have been observed. The potential of this practice in rain fed systems in humid climates (i.e. defined as greater than 500 mm growing season precipitation) is less predictable. However, some studies have also shown that banding applications will increase N₂O emissions.

B.2.7 Adding Nitrogen Scavenging Cover Crops

Emission reduction potential of this practice is highly dependent on cover crop mixture and fertilizer management. However, if managed properly, there is potential to reduce N₂O emissions and increase yield, although studies show no or small reductions in indirect N₂O emissions. The practice may enable a nitrogen rate reduction and reduce nitrate leaching.

B.3 Practices Not Currently Eligible for Nitrogen Management

The following table outlines nitrogen management practices that were considered by the SAC but deemed not eligible for inclusion in the protocol due to lack of scientific data and/or consistent and reliable reductions in N₂O. See the table below for assessments of the specific practices.

<u>Practice</u>	<u>Assessment</u>
<u>Variable Rate (VR) technologies and precision farming</u>	<u>VR technology may result in N rate reductions. However, no studies in North America quantify specifically how implementation of VR affects N₂O. May consider this as a technology that enables N rate reductions, but not necessarily an N₂O-reduction practice in and of itself.</u>
<u>Use of urease inhibitors (stand alone)</u>	<u>Akiyama et al. (2010) showed no significant effect of urease inhibitors, except for one (hydroquinone) that reduced N₂O emissions. The article did not show a significant increase in N₂O emissions with other urease inhibitors, but a high degree of variability in data used.</u>
<u>Supplying N in organic form through manure application</u>	<p><u>Most studies show an increase or no change in N₂O emissions with manure application. However, direct N₂O emissions are highly dependent on manure type and application method. If soil carbon storage were the primary intended GHG effect, then manure application could lead to a net GHG benefit.</u></p> <p><u>The net or landscape scale GHG effects should be considered, to ensure that emissions and sequestration are not simply being moved from one part of the landscape to another. Net reductions from soil carbon stock changes would occur when readily oxidized organic matter under “business as usual” is converted to or replaced by resistant organic matter through the project activity.</u></p> <p><u>By providing N in the form of organic material (manure) instead of fertilizer, residual mineral N in the soil can be reduced, thus having potential to reduce indirect N₂O emissions. However, available N during critical crop development stage may also be lowered (and insufficient), reducing yield and making such systems less desirable.</u></p>
<u>Supplying N in organic form through legume incorporation</u>	<p><u>Leguminous cover crops may reduce N₂O, but only if properly managed with cover crop varieties and changes in irrigation. Over time, these practices can increase soil fertility, which may enable an N rate reduction.</u></p> <p><u>However, leguminous cover crops can also potentially result in no change or an increase in emissions. Emissions also depend on how far cover crops are allowed to mature. Not enough research or consistent results are available to include the practice at this time.</u></p>
<u>Supplying N in organic form through composting</u>	<u>Not enough studies are available at this time to indicate that consistent N₂O reductions occur. According to available studies, the practice could potentially reduce or increase emissions, depending on soil type, management methods, and the composition of composted materials. However, even in cases where N₂O may increase, if soil carbon sequestration is the intended primary GHG effect, there could be net GHG reductions due to increased soil carbon sequestration. As with manure, a life cycle or landscape-scale analysis of the net GHG emissions from the compost may be necessary. Studies are underway for this practice and should be reexamined once more research results are published.</u>
<u>Adding deep rooting plants to the rotation</u>	<u>Effects of this practice are currently unknown and there is not enough data available. Indirect N₂O emissions are likely to be consistently reduced, but baseline management is hard to establish as well as the potential leakage implications.</u>

B.4 GHG Assessment Boundary for Nitrogen Management

The SAC briefly discussed which GHG sources, sinks, and reservoirs (SSRs) must be quantified to accurately and conservatively assess the net effect of a change in nitrogen management.

Direct N₂O emissions from soil are the primary GHG source intended for quantifying GHG reductions. Some practices may also incidentally reduce indirect N₂O emissions from leaching, run-off, and volatilization (LVRO), which the SAC recommended for consideration as a primary GHG source, although more uncertainty is associated with its quantification (see below). While there may be soil carbon benefit from some practices, all of the practices recommended for inclusion in the protocol should primarily have the potential to reduce direct N₂O emissions. Some practices may also incidentally reduce indirect N₂O emissions from leaching, runoff, and volatilization. Soil carbon impacts would need to be included in the GHG accounting boundary, but only for practices that decrease soil carbon stocks and generate higher CO₂ emissions.¹⁴⁰

Notwithstanding the potential of some practices to increase soil carbon sequestration, it is conservative to exclude the soil carbon pool from the quantification methodology. While some practices (e.g. cover crops) have the potential to both decrease N₂O emissions and increase soil carbon sequestration, none of the practices are likely to substantially decrease soil carbon stocks or sequestration rates as a result of project activities.¹⁴¹

The majority of SAC members agreed that it is important to include indirect N₂O emissions from volatilization, leaching, and runoff in the GHG accounting boundary for completeness. Further, SAC members recommended it should be a source directly targeted by the project activity (e.g. primary source). Indirect N₂O emissions result from the transport of nitrogen away from the project site via air or water (surface and groundwater) and eventual conversion to N₂O elsewhere. The ability to directly monitor the movement of nitrogen and the eventual indirect N₂O emissions is fairly limited. Therefore, the SAC felt the IPCC methodology for estimating indirect N₂O emissions for national GHG inventory reporting purposes was sufficient and is the best available option for capturing these effects.

B.5 Quantification Approach by Tier

Nitrogen management quantification approaches considered for this protocol were divided into tiers based on the IPCC Tier 1, Tier 2, and Tier 3 method definitions. The table below provides a brief summary of the tiered approach referenced in this protocol.

	Definition and Examples
Tier 1	A general emission factor developed for broad scales. For example, an emission factor recommended on a national scale for GHG inventories, such the IPCC emission factors.

¹⁴⁰ The effect on soil carbon stocks and CO₂ emissions was a concern when assessing the application of manure in reducing N₂O emissions (see Section B.3) and contributed to the decision to exclude the practice at this time.

¹⁴¹ Studies show inconsistent results for N₂O impacts of cover crops and leguminous cover crops may actually increase N₂O emissions.

Tier 2	<u>A regionally specific emission factor or simplified multivariate statistical model, derived from field data or biogeochemical process model runs based on changes in project activities. For example, a model to quantify N₂O emissions from N rate reduction derived from field studies in one state and potentially applicable to crop rotations throughout an entire region of the U.S.</u>
Tier 3	<u>A biogeochemical process model with site-specific inputs or site-specific measurement of emissions. For example, the use of the DNDC model with field-level quantification of N₂O emission reductions.</u>
Combination of Tiers	<u>The MSU-EPRI protocol, referenced throughout the NMPP, uses a Tier 2 methodology for corn systems in the North Central Region, derived from empirical field measurements in Michigan, and a Tier 1 (IPCC emission factor) methodology for all other crops and regions in the US.</u>

B.6 Quantifying GHG Reductions from Nitrogen Management Practices

The SAC discussed scientifically valid, economically practical, and verifiable approaches to quantifying GHG reductions from nitrogen management projects. The following points summarizeThis section summarizes their conclusions about prioritizing quantification approaches.

- 1. It is advisable to use the most accurate quantification methods possible that meet a minimum data standard. Ideally, additional costs of using more accurate methodologies are balanced by the value of being able to more accurately estimate reductions.
- 2. It is believed that not enough practice-based trials have been conducted to develop biogeochemical process models, (Tier 3), such as DNDC, with site-specific inputs or site-specific measurement of N₂O emissions (the latter of which is too costly given current technology and too time consuming, and therefore impractical for offset projects) into a comprehensive protocol methodology at this point in protocol development. However, there may be potential for using DNDC to develop regionally-specific emission factors (Tier 2) based on biogeochemical process model results, in circumstances where the model is known to perform well.
- 3. Regionally-specific emission factors (Tier 2) or simplified multivariate statistical models, (Tier 2), derived from field data or biogeochemical process model runs, are ideal as a quantification method at this point in time. Data are available to develop models for nitrogen-rate reduction accounting for soils and climate as well as other practices like inhibitors, fall to spring, and formulation.
- 4. General emission factors (Tier 1) may be appropriate, especially at regional and national scales and when regionally-specific emission factors (Tier 2) are not available (e.g. for indirect emission quantification). However, they should be used with care and it is preferable to work towards developing regionally-specific approaches.

B.6.1 Quantifying Aggregated Projects

The SAC established that allowing for unlimited numbers of fields to join together in an aggregate and act as a single project would generate improved accuracy of GHG reduction estimates at the aggregate scale. They noted that a key consideration is making sure the fields within the aggregate represent a diversity of situations so as to avoid propagating systematic biases in estimation methods, which would skew the aggregate total. It was suggested that if aggregates were made up of a variety of climates and practices, this particular risk could be addressed. The SAC discussed how a minimum aggregate size could be constructed from rough estimates of what is an economically viable quantity of GHG emission reduction credits for a project.

Appendix C Overview of Water Quality Regulations: Impacts on Legal Requirements and Regulatory Compliance

~~This draft version of Appendix C is included for your reference, as it is helpful to the reader's general understanding of the legal requirements that may affect project eligibility. However, the Reserve is still working to complete Appendix C, and as such, please be aware it is subject to further edits and additions.~~

No federal laws exist that regulate the composition or efficacy of fertilizers. State-level laws addressing composition and/or efficacy ~~will be~~^{are} discussed further below. Numerous regulations exist, including at the federal level, concerning the production of fertilizer. However, as fertilizer production is outside the GHG project boundary ~~under~~^{of} this protocol, regulations on fertilizer production ~~will be~~^{are} not ~~be~~ addressed here. Regulations concerning the use and disposal of hazardous materials, such as fertilizer, and regulations protecting against the contamination of drinking and surface water and ~~even against~~ air pollution, ~~(related indirectly to the land application of fertilizers will be)~~ ^{are} addressed further, ~~discussed~~^{discussed} below.¹⁴²

C.1 Clean Water Act

Though the Reserve could identify no existing federal ~~regulations~~^{regulation} that explicitly ~~and consistently require~~^{requires} implementation of the approved project ~~activities~~^{activity}, state or local implementation of the federal Clean Water Act may result in direct and indirect requirements for nutrient management.

The Clean Water Act (CWA) is the federal law regulating water quality for surface waters in the United States. It establishes a comprehensive federal system for regulating the discharge of pollutants into navigable ~~water bodies~~^{water bodies}, while restoring and maintaining the health of the nation's surface waters.¹⁴³ The CWA meets these objectives by authorizing water quality standards, requiring and issuing permits for point source discharges (the National Pollution Discharge Elimination System, NPDES),¹⁴⁴ ~~assists~~^{assisting} with the funding of municipal sewage treatment plant construction, and ~~helps~~^{helping} with planning to manage nonpoint source pollution. The CWA authorizes EPA as the primary agency tasked with implementation and enforcement, but in practice, most implementation is through state environmental agencies and state-level regulations, and as such state-level implementation can be highly variable. States have the authority to set their own water quality standards, so long as they meet or exceed EPA's minimum requirements.

¹⁴² EPA, "Background Report on Fertilizer Use, Contaminants, and Regulations," January, 1999, Office of Pollution, Prevention and Toxics, EPA 747-R-98-003. Available at: <http://www.epa.gov/oppt/pubs/fertilizer.pdf>

¹⁴³ The Clean Water Act (CWA) was formerly known as the Federal Water Pollution Control Act (FWPCA), which was first enacted in 1948. Following its significant reorganization and amendments in 1972 and 1977, the FWPCA came to be known by its current name, the CWA. The FWPCA / CWA can be found in 33 U.S.C. §§ 1251-1387.

¹⁴⁴ Legal requirements of NPDES permits, as they pertain to CAFOs, will be addressed in Section C.6 of this Appendix.

Though the CWA explicitly defines “point sources” (e.g. industrial or sewage treatment plants, CAFOs), ~~and it does not definedefines~~ nonpoint sources (e.g. agricultural runoff, urban runoff), ~~instead defining nonpoint sources~~ as anything not considered a point source by the CWA or EPA regulation. The CWA makes it unlawful for point sources to discharge any pollutant into navigable waters without a permit (specifically an NPDES permit). Nonpoint source (NPS) pollution, however, comes from many ~~defuseddiffuse~~ sources and is caused by runoff from rainfall or snowmelt moving over and through the ground, picking up pollutants and eventually depositing them in ~~waterbodieswater bodies~~. When watersheds are successfully meeting the CWA’s water quality standards, nonpoint sources are generally unregulated, and in fact agricultural stormwater discharges and return flows from irrigated agriculture are specifically exempt under the CWA.¹⁴⁵ However, in polluted watersheds that are not attaining the proper water quality standards (i.e. “impaired” waters), nonpoint sources may come under regulation as part of efforts to restore water quality.

~~However, in polluted watersheds that are not attaining the proper water quality standards (e.g. “impaired” waters), nonpoint sources may come under regulation as part of the efforts to restore water quality,~~

States are responsible for monitoring water quality of surface waters within their jurisdiction, and biennially, states are required to provide an inventory of the condition of state ~~waterbodieswater bodies~~ and progress toward CWA goals (305(b) ~~for~~) as well as to identify which waters are “impaired” (~~i.e.g.~~ not currently meeting water quality standards) or “threatened” (~~i.e.g.~~ believed likely to become “impaired” by the time the next “303(d) List” is due).¹⁴⁶ Subsequent to listing waters on the 303(d) List, states are required to prioritize restoration of these waters based on the severity of pollution and begin developing Total Maximum Daily Loads (TMDLs)¹⁴⁷ for these waters. In practice, once a TMDL is established, the state implements a concrete plan to reach this limit through a combination of regulations and voluntary incentives that reduce NPS pollution. EPA funding is typically available to help states implement their ~~nonpointnon-point~~ source management programs.¹⁴⁸ If runoff from agricultural sources is determined to be contributing to the impairment, the TMDL implementation plan typically will include some degree of agricultural ~~Best Management Practicesbest management practices~~ (BMPs). Typically, voluntary incentive payments are the preferred policy mechanism for agricultural sources, as has been the strategy for Maryland, where the state is working towards its Chesapeake Bay TMDL goals through incentive payments which have significantly increased the acres of farmland voluntarily planting cover crops. However, states may also chose to legally require conservation or nutrient management plans, as has recently become the case in California,

¹⁴⁵ King, Ephraim, “Nutrients: A National Overview Need for Strong Partnerships & Joint Accountability,” U.S. EPA, Office of Science and Technology, Presented at “Nutrient Summit” Springfield, Illinois, 13 September 2010. Available at: http://www.epa.state.il.us/water/nutrient/presentations/ephraim_king.pdf

¹⁴⁶ These reports contribute to the “National Water Quality Inventory” (Part 305(b) of CWA) and the “Impaired or Threatened Waters List” or the “303(d) List” (Part 303(d) of the CWA), respectively. Once identified as impaired or threatened, these waters will appear on the “303(d) List.” As this list is updated frequently, project developers and verifiers should refer to the U.S. EPA website for the most up-to-date list of impaired watersheds:

http://iaspub.epa.gov/waters10/attains_nation_cy.control?p_report_type=T

¹⁴⁷ Total Maximum Daily Load (TMDL) is a calculation of the maximum amount of a pollutant, such as nitrate, that a given waterbody can receive without violating water quality standards. The term TMDL, however, is often used to refer to the whole process of establishing a TMDL, including all aspects of TMDL implementation and monitoring.

¹⁴⁸ Specifically, EPA funding is available through CWA Section 319(h) grants specifically for nonpoint source management, while states can also participate in the Clean Water State Revolving Fund (CWSRF) program, in which EPA to provide grants to states to establish loan funds which then provides low-cost financing to third parties (municipalities, non-profits, businesses) to implement water quality infrastructure projects.

where the Central Coast Water Board adopted new stringent regulations on March 15, 2012.¹⁴⁹ Particularly relevant to the NMPP, if agriculture is determined to be the source of impairment, and the ~~waterbody~~water body is impaired by high levels of ~~Nitrogen~~nitrogen (in any of its forms, e.g. nitrate, nitrite, etc.), agricultural BMPs related to nitrogen management are likely to become part of the TMDL.

Circumstances exist where the agricultural producer has significant flexibility for meeting ~~their~~its TMDL obligations, ~~where producers~~. Producers often self-select ~~which~~what best management practices will become part of their legally required pollution reduction strategy, typically in the form of Conservation Management Plans (CMPs), which address a variety of conservation management practices, or in the form of Nutrient Management Plans (NMPs), which focus more on nutrient management practices, ~~particularly those related to nitrogen management~~. As noted in Section 3.5.2, once a practice is self-selected as part of an NPS pollution obligation, the Reserve considers that practice non-voluntary, as continued implementation of that practice is required by law, and that practice ~~will not be~~is no longer considered an eligible project activity for that farm.

~~C.2 NCR Circumstances (placeholder)~~

~~C.3 California Circumstances (placeholder)~~

In California, ~~water quality is governed by a State Water Resources Control Board (SWRCB) and nine Regional Water Quality Control Boards (RWQCB). The State Water Board sets overall state policy, such as the comprehensive statewide Nonpoint Source Pollution Control Program (NPS Implementation Program, which ensures that the Regional Water Boards have the same administrative tools available to each to implement their respective Basin Plans. However, the Regional Boards then develop and implement regional water quality control plans (Basin Plans) for each of the state's nine hydrologic regions, which are reviewed and updated triennially and serve as the implementation instruments for state and federal water policy. Notably, the Regional Water Boards have a significant degree of autonomy and flexibility with regards to the implementation of Basin Plans, as long as the Region's water quality objectives are met. This autonomy is particular notable in a comparison of the irrigated lands programs across Regions, which vary significantly.~~

~~California's regulation of nonpoint source pollution is considered progressive compared to other states and has continued to evolve since the state's first nonpoint source control plan in 1987.¹⁴⁹ Until 1999, California agriculture historically avoided direct regulations by securing conditional waivers (frequently referred to as "Ag Waivers" or "Ag Orders") from the Regional Water Boards, which temporarily allow individuals to discharge agricultural waste water from fields without securing individual permits. Though meant to be conditional, in reality, these waivers have historically been granted with relatively few conditions or monitoring requirements, were typically were not subject to much oversight, and were not reviewed periodically.~~

~~Though agricultural nonpoint discharges are still not "directly regulated," nonpoint source pollution regulations in California has continued to move in that direction. Since 1999, all Regional Water Boards were required to begin reviewing all conditional waivers and either renew the waivers or replace them with a more appropriate permit (specifically a Waste~~

¹⁴⁹ Add reference to CA circumstances below.

¹⁵⁰ ~~Smith, Lee N. and Loren J. Harlow. "Regulation of Nonpoint Source Agricultural Discharge in California."~~

Discharge Requirements permit (WDR), which is functionally similar to an NPDES permit). Today, all conditional waivers must be renewed at minimum every five years. Conditional waivers today also require more extensive monitoring and reporting, require education of the discharger on best management practices and typically require some level of implementation of best management practices (referred to as “management measures” in California law), notably including management measures for both nutrient management and irrigation water management. However, even where agricultural producers are required to implement these management measures, compliance is not measured in terms of whether or not the management measures are implemented, but rather whether water quality objectives are being met. As such, regulatory compliance is assessed at the watershed scale.

Further, the individual agricultural producer that is required to implement management measures is given significant flexibility to implement management measures, which will help them achieve their water quality objectives without yield impacts. The State’s management measure for nutrient management instructs growers to “develop, implement, and periodically update a nutrient management plan to (1) apply nutrients at rates necessary to achieve realistic crop yields, (2) improve the timing of nutrient application, and (3) use agronomic crop production technology to increase nutrient use efficiency,” and the State Water Board encourages development of a nutrient management plan (NMP) in accordance with the USDA NRCS Standard 590.¹⁵¹ However, the producer may choose from a long list of management practices known to reduce nutrient loss to include in their NMP, meaning that management plans for individual farms will vary greatly.

Though conditional waivers may theoretically be issued to individual dischargers, they are typically issued to “coalition groups,” which are essentially third-party groups representing a certain type of discharger (e.g. agricultural). Dischargers must file a “Notice of Intent” to join a coalition group and be covered by the waiver, and coalition groups in turn help perform much of the monitoring and reporting required by the conditional waiver on behalf of their members, to demonstrate that the coalition group is helping implement the Region’s water quality objectives.

The specific conditions and requirements of a conditional waiver, the makeup of coalition groups, and which sectors or coalition groups are granted waivers vary across Regional Water Board jurisdiction, making a standardized assessment of the legal requirements for agricultural discharges in California somewhat challenging. The Regional Water Boards of the Los Angeles, Central Coast, Central Valley, and San Diego Regions, for example, have all adopted comprehensive conditional waivers that vary somewhat. A standardized assessment of legal requirements is further complicated by the fact that not all Regional Boards have decided to use conditional waivers. The Colorado River Basin and North Coast RWQCBs have adopted Conditional Prohibitions as part of their respective Basin Plans, and the Santa Ana RWQCB is in the initial phases of developing an irrigated lands regulatory program. San Francisco Bay and Lahontan RWQCBs have no immediate plans to adopt comprehensive waivers for agricultural discharges,¹⁵² though San Francisco is in the early stages of developing a waiver for vineyards. More detail on each Region can be found in the table below. Ultimately, however, it seems that legal requirements for irrigated lands in California may need to be assessed at the Basin level.

¹⁵¹ “4C Nutrient Management,” *NPS Encyclopedia*, 2009, California State Water Resources Control Board. http://www.waterboards.ca.gov/water_issues/programs/nps/encyclopedia/4c_nutrient.shtml

¹⁵² “Irrigated Lands Regulatory Program Fact Sheet” http://www.swrcb.ca.gov/water_issues/programs/agriculture/docs/about_agwaivers.pdf

Region	Status of Irrigated Lands Program
3—Central Coast	Have adopted and renewed multiple conditional waivers for agriculture. The 2004 Agricultural Order first expired in 2009 and has been temporarily renewed (by both the Board and Executive Officer) numerous times. Most recently expired September 30, 2011, due to lack of quorum needed to vote on the new regulation, and was extended one year by the Executive, as well as amended to include additional monitoring and reporting. ¹⁵³ Growers must enroll in waiver by submitting Notice of Intent, and must then develop a Farm Water Quality Management Plan and implement water quality management practices. ¹⁵⁴ [NOTE: this section will be updated to reflect March 15, 2012 decision]
4—Los Angeles	Conditional Waiver was renewed on October 7, 2010. There are two discharger groups (LA and Ventura counties). Dischargers must submit notice of intent to join waiver and are required to implement Best Management Practices (BMPs) to attain water quality benchmarks, which they must then monitor and report on to comply
5—Central Valley	Adopted comprehensive conditional waivers for agriculture in 2003, renewed in 2006. Currently 25,000 growers (out of 35,000 in CV) with 5 million acres of land are regulated and part of coalition groups. The Board is exploring issuing up to 7 or 8 geographic or commodity-specific Orders with waste discharge requirements (WDRs) tailored to each geography or commodity. ¹⁵⁵

C.4 Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) encourages states/tribes to preserve, protect, restore or enhance natural coastal areas, including wetlands, floodplains, estuaries, beaches, and dunes. Eligible areas border the Atlantic, Pacific, and Arctic Oceans, Gulf of Mexico, Long Island Sound, and Great Lakes. Participation is completely voluntary. To encourage states/tribes to participate, the act makes federal financial assistance available to develop and implement a comprehensive coastal management program. Most eligible states/tribes participate in the program. Section 6217 of the CZMA, administered jointly by EPA and the National Oceanic and Atmospheric Agency (NOAA), specifically supports states to develop and implement nonpoint pollution control programs for coastal areas.¹⁵⁶ Within a guiding document specifying typical measures to control nonpoint source pollution published by the EPA¹⁵⁷ in 1993, commercial N fertilizer is identified as a pollutant to coastal areas. Management measures to reduce pollution include development and implementation of a nutrient management plan focusing on (1) applying nutrients at rates necessary to achieve realistic crop yields, (2) improving the timing of nutrient application, and (3) using agronomic crop production technology to increase nutrient use efficiency. In 2003, EPA updated and expanded the 1993 coastal nonpoint source manual to address the control of agricultural nonpoint source pollution for the entire United States.¹⁵⁸ *National Management Measures to Control Nonpoint Source Pollution from Agriculture* highlights best available, economically achievable means of combating nonpoint source pollution, and discusses monitoring techniques, load estimation techniques, and watershed approaches.

¹⁵³ Oct 2011 Irrigated Lands report

¹⁵⁴ http://www.waterboards.ca.gov/centralcoast/water_issues/programs/ag_waivers/index.shtml

¹⁵⁵ http://www.swrcb.ca.gov/centralvalley/water_issues/irrigated_land/long_term_program_development/long_term_program_q&a.pdf

¹⁵⁶ See <http://coastalmanagement.noaa.gov/nonpoint/welcome.html>

¹⁵⁷ Available at http://water.epa.gov/polwaste/nps/czara/MMGI_index.cfm

¹⁵⁸ Available at http://water.epa.gov/polwaste/nps/agriculture/agmm_index.cfm

As participation is voluntary, assistance received through CZMA does not affect field eligibility. Any financial assistance received by project participants shall be disclosed to the project verifier and Reserve per Section 3.5.3.

C.5 Safe Water Drinking Act

The Safe Drinking Water Act (SDWA), the main federal law to ensure drinking water quality, requires actions to prevent the contamination of surface and ground sources of drinking water (e.g. rivers, lakes, reservoirs, springs, ground water wells, but not private wells, serving less than 25 people). Although EPA is primarily responsible for enforcement of the federal SDWA, states may apply to EPA for the authority to implement the SDWA and its enforcement within their jurisdictions (e.g. “primacy”), so long as they can demonstrate that state standards will be at least as stringent as the national standards and that state water systems meet these standards.

The SDWA authorizes EPA to set national health-based standards limiting the amount of contaminants, such as nitrates and nitrites, in drinking water. In practice, these health-based standards are legally enforceable limits, called maximum contaminant levels (MCLs). The SDWA includes MCLs for both nitrates and nitrites, for which fertilizer runoff and leaching from agriculture is the major source in drinking water. The MCL for nitrate is set at 10 mg/L or 10 ppm, while the MCL for nitrite is set at 1 mg/L or 1 ppm, both of which are measured in nitrogen.

The SDWA requires states and water suppliers to conduct assessments of potential contamination of water sources, and states are required to implement measures to protect water sources through voluntary incentive programs (to encourage agricultural BMPs) or legal enforcement actions, such as notices of violation (NOVs). Any individual discharger could, in theory, be found to be causing levels of nitrate or nitrite to exceed the MCL and receive a notice of violation. However, due to the nonpoint source nature of agricultural discharges, it is relatively difficult to identify one agricultural discharger as the source of an impairment and, as such, NOVs are typically only issued against agricultural discharges when the discharge is particularly egregious.

Though one of the main tools to limit agriculture’s effect on drinking water quality are agricultural BMPs, to our knowledge, there is no legal requirement within the context of the SDWA to require best nitrogen management practices. However, any case of regulatory non-compliance, such as a NOV due to a violation of the SDWA, must be reported to the verifier, who will determine if the violation is material to the project.

C.6 Water Quality Regulations for CAFOs

~~Confined Animal Feeding Operations (CAFOs) are required to seek NPDES permit coverage (National Pollutant Discharge Elimination System) if they will discharge or if they propose to discharge pollutants into waters of the United States.¹⁵⁹ This requirement applies to all owners and operators of CAFOs regardless of the volume or duration of the discharge.¹⁶⁰ For the Nitrogen Management Project Protocol, the extent to which legal requirements for CAFOs and NPDES permits apply to land application of manure is of primary concern. All other onsite~~

¹⁵⁹ ~~On March 15, 2011, the U.S. 5th Circuit Court of Appeals vacated the requirement that CAFOs “proposing” to discharge apply for NPDES permits, as required by the 2008 Rule. EPA is revising the NPDES CAFO regulations to be consistent with that ruling. However, regardless of the time frame for finalizing this rule, conclusions made by this review are not expected to be impacted.~~

¹⁶⁰ ~~Regulations include the Clean Water Act, as well as 40 CFR 122.23, 123.~~

~~manure management practices (whether legally required or not) are outside the scope of this protocol.~~

~~According to 40 CFR 122.23(e), “Land application discharges” from a CAFO are exempt from NPDES permit requirements if the discharge qualifies as an “agricultural storm water discharge.” Agricultural storm water discharge is defined as discharge “where the manure, litter or process wastewater has been applied in accordance with site specific nutrient management practices that ensure appropriate agricultural utilization of the nutrients in the manure, litter or process wastewater” and is specifically “a precipitation related discharge of manure, litter or process wastewater from land areas under the control of a CAFO.” Notably, any discharges from land application when the weather is dry, and therefore not due to precipitation, are not exempt from NPDES regulations.¹⁶¹~~

~~NPDES permits for CAFOs require implementation of a nutrient management plan (NMP), which must (among other things), identify site specific conservation practices to be implemented, such as buffers, establish protocols for testing of manure and land application of manure that ensures appropriate agricultural utilization of the nutrient in the manure, and identify recordkeeping procedures. In short, once a CAFO is regulated by a NPDES permit, they will be required to implement a NMP that prevents over application of manure.~~

~~However, not all CAFOs are required to secure NPDES permits; CAFOs only discharging “agricultural stormwater” are not required to secure NPDES permits, and in some states and regions, where EPA is the permitting authority, non-discharging CAFOs may actually seek certification demonstrating that status. Because any discharge from an unpermitted CAFO is illegal, including agricultural stormwater discharges which may later be determined to *not* be exempt due to over-application of manure, the unpermitted CAFO must continually reexamine its compliance with the CWA. In fact, EPA guidance strongly encourages unpermitted CAFOs to implement the best management practices for land applying manure, which are outlined in land application protocols and standards and site specific Nutrient Management Plans, as well as to keep detailed operations and maintenance records, so as to demonstrate that the CAFO’s agricultural stormwater discharges continue to be exempt from regulation.¹⁶²~~

~~In practice, the combination of NPDES permits and EPA guidance impose a *de facto* regulation on land application of manure, in that land application must ensure the “appropriate utilization of manure,” as outlined in “technical standards” for land application by the state permitting authority level.~~

C.6.1 Inclusion of CAFO’s Croplands in the NMPP

~~Though a certain level of nutrient management best practices are legally required on the croplands of CAFOs used to produce feed crops, the Reserve believes there may be additional potential to reduce nitrous oxide emissions from these croplands, since these BMPs and NMPs have been implemented so as to limit water quality impacts, not air quality ones. For both CAFOs that are required to hold NPDES permits and for those that are not, historic practices and rates for land application of manure are likely to be a good representation of the baseline, as well as a good approximation of the site-specific legally required N rate, as long as no notices of violation have been issued. In the case of CAFOs that have held NPDES permits for~~

¹⁶¹ EPA, Office of Water, “Implementation Guidance on CAFO Regulations—CAFOs that Discharge or Are Proposing to Discharge,” EPA-833-R-10-006

¹⁶² Ibid.

~~less than five years, the baseline shall be based on the historical land application practices from the time period since the NPDES permit was issued.~~

C.7 Fertilizer Content Labeling Laws

There are no federal laws ~~in the U.S.~~ regulating the composition or efficacy of fertilizer in the U.S., but most states have developed their own fertilizer regulatory programs, which are generally administered by their respective departments of agriculture. These regulatory programs typically address efficacy claims and composition statements of the active ingredients displayed on labels for commercially available fertilizer.

~~Therefore, the~~The Association of American Plant Food Control Officials (AAPFCO), tasked with making regulation among states uniform, stated that metals in N fertilizer generally do not pose harm to the environment as long as the metal concentration in fertilizer is below a specific threshold.¹⁶³ In addition to trace metal composition testing, state fertilizer laws generally require product registration, licensing and efficacy testing to assure that statements made on the label are correct. Also, at the state level, fertilizer is primarily regulated for quality, as for any manufactured good. These regulations are usually administered through the state's department of agriculture.

None of these laws should impact additionality or the eligibility of particular fertilizers.

¹⁶³ See <http://www.aapfco.org/rules.html> for the specific heavy metal threshold concentrations.

Appendix D Minimum Standard for Data for Consideration in Quantification Methodology Development

D.1 Introduction

As noted throughout the NMPP, the Reserve plans to expand this protocol in future versions, as new quantification methodologies become available. The lack of field data on N₂O emissions for different regions, crops, and [nitrogen management](#) practices has been a significant limitation in the development of further quantification approaches, particularly a lack of data from “pairwise” or “side-by-side” comparisons (e.g. comparisons of baseline and project treatments on the same field in a given year). As such, this Appendix D provides general guidelines for establishing field experiments which are most useful for developing reference data sets which can be used to develop (Tier 2) and/or calibrate and validate (Tier 2, Tier 3) standardized quantification methodologies. These guidelines are referred to throughout the protocol as the “minimum data standards.”

D.1.1 Methodologies and Priorities for Future Protocol Expansion

The Reserve encourages field experiments and the development of reference data sets to support a variety of quantification approaches. Though the NMPP includes a Tier 2 quantification methodology (e.g. a quantification methodology using standardized region-specific emission factors to quantify emission reductions from the project activity¹⁶⁴), the [NMPP’s current Tier 2 approach does not necessarily set precedent for future expansions of the NMPP, as the](#) Reserve has not made a determination of preference between Tier 2 and Tier 3 methods (e.g. higher order quantification methods, such as validated biogeochemical models or comprehensive field sampling¹⁶⁴). Rather, the Reserve believes that robust yet simple regional Tier 2 emission factors may be better suited for cropping systems that cover large areas, have management practices that are fairly homogenous, and that are grown in relatively simple rotations. Examples of such cropping systems are [rainfed corn systems \(included in v 1.0 of the NMPP\)](#), irrigated corn systems, or wheat cropping systems. Tier 3 approaches, including validated biogeochemical models may be preferred for specialty crops for which the management is often varying and that are grown in more complex rotations. Examples of such cropping systems are vegetable or fruit cropping systems (e.g. [most cropping systems as grown in California](#)). Reference data sets will be reviewed by the Reserve to determine whether the data [may be used is appropriate](#) for developing a Tier 2 methodology, [further validating a previously accepted Tier 2 methodology, or for](#) calibrating and validating a Tier 3 methodology (e.g. DNDC). [Stakeholders](#), or for further validating a previously accepted NMPP methodology (both Tier 2 and Tier 3). In addition to the data sets themselves, [stakeholders](#) are encouraged to develop and submit new Tier 2 or Tier 3 quantification methodologies, developed from these reference data sets, including justification of why the selected methodology (i.e. Tier 2 or Tier 3) made most sense for that specific crop/state/practice combination.

D.1.2 Process for Future Protocol Expansion

The minimum data standards presented [herein this Appendix](#) will serve as internal guidance for the Reserve in determining whether reference data are sufficiently robust. Circumstances may exist in which reference data meet most, but not all, of the guidelines established by this data

¹⁶⁴ As defined by the Volume 4 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

standard. When such circumstances arise, the Reserve shall use its own best judgment and expert opinion in determining whether more flexibility in meeting this data standard is justified for that particular reference data set.¹⁶⁵ The Reserve will also maintain a Nitrogen Management Science Advisory Committee (SAC) into the future, and the Reserve will consult the SAC, as needed, when making determinations about the quality of proposed methodologies, their underlying reference datasets, and independent reference datasets.

Stakeholders are encouraged to submit new reference datasets and quantification methodologies to the Reserve at any time (e.g. as soon as they become available). Information on this submittal process is available on the Nitrogen Management Project Protocol webpage. Stakeholders will be asked to fill out an NMPP New Data Submittal Form, which will be used to assess whether the dataset meets the minimum data standards included in this appendix, and if not, whether additional justification has been provided. The stakeholder submitting data will also be asked to provide recommendations for data on adoption rates of a given practice to be used for performance standard development. The Reserve will review new data submittals on an ongoing basis, to determine (1) whether submittals are complete and (2) whether preliminary performance standard assessments show promise for protocol inclusion (e.g. sufficient penetration data exists for a given crop/region/practice; adoption is low and the practice looks to be additional). Once both criteria have been met, the Reserve will periodically consult the SAC to determine whether a given data set or proposed quantification methodology should be prioritized for further development and inclusion in the protocol. Criteria that will be considered, as the Reserve weighs the different options for protocol expansion, include: (a) the existence of baseline N₂O emission measurements for the practice, region, and/or cropping system considered; (b) the total acreage and intensity of use of nitrogen fertilizer for the cropping system in question; (c) whether sufficient data exists to develop a performance standard and preliminary assessments show a project activity is likely to be additional; and (d) the economic and technical feasibility, as well as the mitigation potential, of the management practice that reduces N₂O emission under consideration.

Once the Reserve identifies specific protocol expansions, the Reserve may decide to contract out for additional expertise and/or reconvene the stakeholder workgroup. As with any new project type, once the new project type has been fully developed and included in the protocol, the protocol will go out for another 30-day public comment period, before that protocol is considered for adoption by the Reserve Board.

D.2 Minimum Data Standards for Field Experiments

The minimum data standards apply to the reference data collected in field experiments and used for developing and/or validating new N₂O quantification approaches, and/or validating existing N₂O quantification approaches using independent data.¹⁶⁶ Reference data can be new source data generated during new measuring campaigns or existing data from, *inter alia*, the following sources:¹⁶⁷ so long as minimal data requirements included in this Appendix are met: scientific and technical articles in books, journals and reports; National Statistics Agencies; Universities and extension services; United States Department of Agriculture Agricultural

¹⁶⁵ It should be noted, however, that circumstances in which the data standard is interpreted with more flexibility shall not be precedent setting. That is, each data set which deviates from this data standard shall be evaluated on its own merits.

¹⁶⁶ The minimum data standard applies for reference data used for the development of statistical models as well as for the calibration and validation of process-based biogeochemical models proposed for the quantification of N₂O emission reductions.

¹⁶⁷ ~~So long as minimal data requirements included in this Appendix are met.~~

~~Research Service~~ (USDA ~~ARS~~); sectoral experts, commodity and stakeholder organizations, and industry groups. A reference to the source of the data must be provided for existing data. For the Reserve to approve reference data for use in a new quantification method, they should comply with the minimum data standards described below.

D.2.1 Method of Data Collection

Reference data should be collected using either chamber-based or tower-based (micrometeorological) methods¹⁶⁸. ~~Currently, chamber,~~¹⁶⁹ Chamber-based methods are currently the least expensive option for measuring N₂O emissions from agricultural fields. ~~The,~~ as the materials required for building the chambers are very affordable, and analytical tools used for N₂O concentration measurements such as gas chromatography have become increasingly available. ~~omnipresent in analytical laboratories.~~

Since methodologies to measure N₂O emissions are continuously improved, specific guidelines for sampling methods are not listed in this protocol. The Reserve will only review datasets for which sample collection methods comply with the most recent peer-reviewed guidelines available for the adopted method at the start of the experiments that yielded the reference data. A brief description of the chamber design, sample collection and handling, gas analysis and data analysis should be provided. ~~The~~ For chamber-based measurements, the Reserve recommends following guidelines from the USDA ARS GRACEnet Chamber-based Trace Gas Flux Measurement Protocol.¹⁷⁰ Measurements taken through tower-based methods should be consistent with methodologies currently in use in the peer-reviewed scientific literature

D.2.2 Intensity of Data Collection

Due to the high spatial and temporal variability of N₂O emissions, accurate N₂O quantification necessitates a minimum temporal and spatial intensity of data collection.

D.2.2.1 Temporal Frequency and Scale of Data Collection

Flux measurements should take place at least once per week (every 7 days) ~~over a complete growing season.~~¹⁷¹ However, it is strongly advised to increase the measurement frequency following agronomic or environmental events known to be associated with major N₂O fluxes (i.e. tillage, fertilization, irrigation, rain, harvest). Daily flux measurements after such events should continue until N₂O emissions return to pre-event levels. Note that N₂O responses to such events may not appear until several weeks after the event. This lag effect should be incorporated in the sampling design. It is recognized that due to unforeseeable weather conditions, issues with measurement devices, and other challenges, some gaps in the data set are unavoidable. Guidelines on how to handle outlying values are included in Section D.2.3.

Measurements must also should embody the daily variations in N₂O fluxes. Multiple flux measurements could be made during one day. ~~If only~~ However, one flux measurement ~~is~~ taken

¹⁶⁸ ~~Tower-based methods (micrometeorological techniques) to measure N₂O emissions have been developed and have the advantage of being non-intrusive while providing continuous time series. Nevertheless, high investment costs make their use in replicated experiments currently prohibitive.~~

¹⁶⁹ Tower-based methods (micrometeorological techniques) to measure N₂O emissions have been developed and have the advantage of being non-intrusive while providing continuous time series. Nevertheless, high investment costs make their use in replicated experiments currently less attractive.

¹⁷⁰ Parkin, T.B. and Venterea, R.T. 2010. Sampling Protocols. Chapter 3. Chamber-Based Trace Gas Flux Measurements. IN Sampling Protocols. R.F. Follett, editor. p. 3-1 to 3-39. Available at: www.ars.usda.gov/research/GRACEnet

¹⁷¹ ~~However, year round flux data, where possible, is ideal.~~

per day, is acceptable, so long it ~~should be~~ taken at a time that corresponds to the daily average temperature, i.e. (e.g. mid-morning, or early evening).

Flux measurements should be taken over the complete growing season, at minimum, but year round flux data is preferable, whenever possible. Reference data should extend over at least two consecutive growing seasons. Flux measurements over additional growing seasons may be necessary if the two consecutive growing seasons for which measurements were taken exhibited anomalous weather conditions, with respect to that region.

D.2.2.2 Spatial Frequency and Scale of Data Collection

N₂O emissions are not only variable over time, but are also subject to high spatial variability. This spatial variability reveals itself at multiple geographic scales, including variability within a field, variability across fields within the same landscape, and across landscapes (e.g. a LRR, Land Resource Region, or a MLRA, a Major Land Resource Area). In this section, guidelines are provided to ensure that the reference data accounts for spatial variability at those different scales. Note that the terminology for “field” in the NMPP, as defined in Section 2.2.1, is different from the terminology used in design of agricultural experiments, in which a field represents a random variable and may encompass multiple plots with different treatments. In these guidelines, we will use the same terminology as is used as in design of agricultural experiments and use “replicate plot” to refer to the smallest experimental unit and “field” to designate a greater unit with multiple replicate plots. In other words, a replicate plot corresponds to a field as defined in the NMPP.

It must be demonstrated that the spatial frequency and scale of data collection adheres to the following guidelines:

1. **The dimensions of the flux chambers:** The surface area covered by the flux chamber must be large enough to capture small-scale variability in N₂O fluxes (e.g. due to the number of fertilizer granules present in the chamber, the presence of decomposing crop residues, etc.). Chamber surface areas typically cover between ~300 and ~3000 cm².
2. **The number of flux chambers per functional locations within a replicate plot:** In many cropland systems, multiple functional locations with different soil moisture conditions, soil temperature and N ~~content~~concentration can be identified within a replicate plot (For example: middle of the berm, side of the berm, the furrow in annual row crops, tree row versus tractor row in orchards, etc.). It is recommended that flux chambers be strategically placed in multiple functional locations- so as to represent the variety within the field appropriately. A minimum of 2 flux chambers per functional location within a replicate plot is recommended.
3. **The number of replicate plots per field:** The reference data should cover a minimum of 3 replicate plots per treatment (i.e. management practice) and per field. Usually, for a side-by-side (“pairwise”) comparison, there will be at least 2 treatments, with one treatment representing the baseline scenario and one treatment representing the project scenario. However, implementing and monitoring more than one potential project treatment is encouraged, so as to collect data on a wider variety of project activities. Any number of potential project activities could be implemented together as the “project treatment” on a given field (e.g. add nitrogen inhibitors, add a cover crop, trial of different N rates, N rate reduction with the addition of cover crops).

4. **The number of fields:** The field(s) must be representative for the conditions within the area in which the reference data sets will be used. Therefore, multiple fields are used that are located at different sites and geographic locations (e.g. different counties, different states). Ideally, the fields (and replicate plots within fields) are also chosen to represent some of the most commonly occurring soil types in a region. However, it is recognized that having multiple fields may be challenging.

D.2.3 Handling of Outliers

When experimental data are collected, it is very likely that some samples will have values that are considerably larger or smaller compared to replicate samples. Such samples are often referred to as outliers, and can be of spatial, temporal or analytical nature. Analytical outliers can be caused by inadequate closure of flux chambers, leaky sampling vials, errors in sample collection or analysis, etc. and labs can remove analytical outliers in a routine and standardized fashion. ~~Removal of temporal and spatial outliers, however, is strongly discouraged.~~

~~As~~However, as N₂O fluxes are known to be very variable in space and time, spatial and temporal 'outliers' are often merely a reflection of the variable nature of the process and should be handled as real data. As such, removal of temporal and spatial outliers is strongly discouraged; the Reserve prefers that submitted reference data include any observed temporal or spatial outliers, with notations as to which outliers were flagged for removal by lab analysis In some cases, there is a real reason for removing temporally or spatially anomalous data. Examples include local flooding due to a leak in a drip line, enhanced N₂O fluxes due to undesired animal excretions in the flux chamber, etc. Under such situations, temporal and spatial outliers ~~can may~~ be removed, as determined by the Reserve, prior to methodology development, given that the outliers were properly identified and a justification is provided, with the data set submittal. The extent to which inclusion/exclusion of this value affects the mean should be discussed in this justification.

D.3 Applicability of Field Experiment to a Region

Stakeholders will be asked to propose and justify a geographic applicability region over which a data set (or the subsequently developed quantification methodology) may be extrapolated. It is recommended that the justification includes a comparison of weather and climate, soil characteristics, and management practices between the study sites and the whole geographic applicability region.

Summaries of growing season and experimental conditions during the field trials should include a discussion of whether representative conditions (e.g. temperature, precipitation, etc.) were "typical" or "average" for that region. A comparison of the experimental growing season(s)'s mean annual temperature and precipitation data to data collected over the preceding ten year period indicates whether N₂O emissions measured for the period are representative of a "typical" year, or rather a cold, hot, wet or dry year, for example.

Further, "typical" soil type, soil texture, soil water holding capacity, soil organic carbon levels, etc., for a given region should be considered when selecting replicate plots and fields for inclusion in an experiment. Sites should be chosen for their widest applicability to multiple soil types, etc., within the region. Likewise, the management practices executed on the field trials should be selected so that they represent the overall management within this region.

Data on weather conditions during the field trials, as well as data on the dates and details of all management events, soil type, texture, water holding capacity, SOC levels, etc. exhibited in the

replicate plots will be used to help determine the applicability of a field experiment to a given region.

D.4 Independent Validation and Quantifying Uncertainty

Large uncertainty around field measurements leads to uncertainty around predicted emission reductions for any quantification approach. Therefore, the quantification approach must be robust in situations with high uncertainty. Even though a quantification methodology may ensure that projects meet minimal standards through eligibility and applicability conditions (e.g. conditions for which the model was calibrated), a significant amount of uncertainty may remain, which must be accounted for through an uncertainty deduction mechanism.

According to C-AGG's white paper on uncertainty,¹⁷² ~~"When models are used, analyses of both structural and input uncertainty related to their use must be completed."~~ so as to use and apply models appropriately.¹⁷³ Input uncertainty for an empirical model is subject to less uncertainty than a biogeochemical model, simply because there are significantly fewer critical inputs. Quantification approaches based on biogeochemical models, and quantification approaches for which the input variables are associated with a significant amount of uncertainty must require a Monte Carlo simulation to assess the effect of uncertainty around input variables on projects' N₂O emissions reduction estimates, as is done in the Reserve's Rice Cultivation Project Protocol (RCPP). In addition, all quantification approaches that are using a biogeochemical process model must include how to parameterize every single input parameter to the model. More specifically, for every input parameter, it must be explained if the parameter has to be set using field measurements, look-up tables, default values, or internal calibration. If internal calibration is used to set certain parameters, the procedures for calibration must be clearly explained, as is done in the Reserve's Rice Cultivation Project Protocol (RCPP).

Structural uncertainty (termed $\mu_{struct,f}$ in the RCPP and NMPP) represents how well the model performs against measured emissions, regardless of whether that model is an empirical model or a biogeochemical model. To estimate structural uncertainty in the RCPP, for example, independent emissions measurement data (e.g. data which were not used to build the model) for California rice fields were used to "validate" the DNDC model by comparing measured and modeled data.

The Reserve intends to develop an uncertainty deduction methodology for the NMPP that is similar to the RCPP's structural uncertainty deduction. Reference data should be gathered from a sufficient number of different data points so that the reference data can be divided into separate calibration and validation data sets. Note that if calibration data are taken primarily from one area within a larger region (such as a Land Resource Region, LRR), an extensive validation data set, including data points from other areas within the region collected from a number of sources, might allow validation of the model for a much larger geographic area than the model was otherwise developed and calibrated for.

In the case of the NMPP Version 1.0, in which an adaptation of the MSU-EPRI methodology is included (see Section 5), no additional field emissions measurement datasets for N rate trials, other than MSU-EPRI's robust data set, are currently available for the North Central Region. ~~With no independent field data, the Reserve cannot explicitly quantify the structural uncertainty~~

¹⁷² C-AGG, "Executive Summary: Uncertainty in Models and Agricultural Offset Protocols (discussion draft)," 2012.

¹⁷³ C-AGG, "Executive Summary: Uncertainty in Models and Agricultural Offset Protocols (discussion draft)," 2012.

~~of the quantification approach included in the NMPP at this time. As such, the Reserve has increased the uncertainty deduction used in the MSU-EPRI methodology, calculated using dependent data, by 25 percent, in an attempt to overestimate structural uncertainty. At a future date,¹⁷⁴ when independent data becomes available to validate the model and quantify the structural uncertainty explicitly, the Reserve plans to adjust the structural uncertainty deduction currently included in the NMPP, making it more challenging to validate the methodology and estimate structural uncertainty. However, the developers of the original MSU-EPRI methodology performed a “leave-one-out” cross-validation analysis¹⁷⁵, to approximate the structural uncertainty and found that the uncertainty increased about two to four percent compared to an uncertainty analysis using non-independent data. The uncertainty quantified using a leave-one-out cross-validation is certainly applicable for areas similar in characteristics to the study sites. However, the uncertainty is likely greater for areas far away from the study sites. As a consequence, the “leave-one-out” approach’s 2 to 4 percent increase in uncertainty was considered acceptable for the state of Michigan, where all of the study sites used to develop the MSU-EPRI quantification approach are located. However, an additional 15 percent uncertainty deduction is taken for other states in the NCR to avoid underestimating the structural uncertainty on sites that are far away from the field measurement locations. At a future date,¹⁷⁶ when independent data becomes available to validate the model and quantify the structural uncertainty explicitly for the various NCR states, the Reserve plans to adjust the structural uncertainty deduction currently included in the NMPP. Further, it is worth noting that while MSU-EPRI methodology was adapted and included in the NMPP before independent data was available, this decision is not precedent-setting. The Reserve prefers a full structural uncertainty assessment using validation data that is representative for the whole geographic applicability region over the leave-one-out approach. As such, in the future, the Reserve is unlikely to adopt new methodologies before independent datasets become available to validate additional methodologies. Further, it is worth noting that the larger the geographic applicability region a given dataset is proposed to be extrapolated to, the more diverse and further away independent datasets, used for validation, will need to be.~~

¹⁷⁴ ~~The Reserve anticipates that market drivers will try and reduce this uncertainty deduction as soon as possible, hopefully within the next five years.~~

¹⁷⁵ Generally, the goal of a cross-validation analysis is to evaluate the fit of a model to a data set that is independent of the data that were used to train the model. A leave-one-out cross-validation analysis estimates the structural uncertainty by comparing a single observation from the original sample to the outcome predicted by a model that was calibrated using the remaining observations.

¹⁷⁶ ~~The Reserve anticipates that market drivers will try and reduce this uncertainty deduction as soon as possible, hopefully within the next five years.~~