TECHNICAL SEED DOCUMENT

FOR

SUMMERFALLOW REDUCTION PROTOCOL

TO

ALBERTA AGRICULTURE AND RURAL DEVELOPMENT

&

CLIMATE CHANGE CENTRAL

12 MARCH 2009

CONTENT

1 Summary

1.1 Content & Purpose of Technical Seed Document for Summerfallow Reduction Protocol

This Technical Seed Document records the development to date of the proposed Summerfallow Reduction Protocol. This Protocol is under development for approval in the Alberta Offsets System, and is therefore designed according to the ISO 14064-2 (International Standards Organization, 2006) and prepared according to a process adapted for the Alberta Offset System (Alberta Environment 2008a). This Technical Seed Document incorporates the design options based on scientific knowledge and policy framework developed through discussion and decision concerning the proposed Protocol at a Consultation Workshop. The consensus reached at the Workshop was guided and informed by considerations and recommendations provided in a Science Discussion Document.

1.2 Framework of the Summerfallow Reduction Protocol

The quantification of greenhouse gas (GHG) removals (i.e. carbon sequestration) associated with the land management change to continuous cropping (project condition) from summerfallow (baseline condition) is described in Canada's National Inventory Report (NIR, Environment Canada 2007). The NIR quantification calculations are accumulated to an eco-area scale, and calculations of carbon sequestration are based on variables associated with soil type. The quantification of GHG reductions (i.e. methane and nitrous oxide emission reductions) resulting from management changes in the proposed Summerfallow Reduction Protocol is based on published decisions of Canadian scientists involved in the NIR process, as well as on agricultural GHG emission estimation tools; GHGFarm (Helgason 2005) and the more recently developed Holos[1] (Little *et al.* 2008) calculators.

The main elements of the framework of the Summerfallow Reduction Protocol include requirements for:

- Co-implementation with the Alberta Tillage System Protocol; and
- Baseline calculated from farm-specific data of summerfallow activity for three years prior to the project for the participating farm.

1.3 Gaps for the Development and Adaptation of the Summerfallow Reduction Protocol

Using the compiled knowledge and consultation results compiled in this Technical Seed Document, the Summerfallow Reduction Protocol will be adapted into the standardized Alberta Protocol Format in preparation for the Expert Technical, Stakeholder and Public Reviews required for approval in the Alberta Offset System (Alberta Environment 2008a). Development requirements for completion during the protocol standardization process include:

- Details of the co-implementation requirements and market-based assurance approach;
- Functional equivalence of baseline and project (emissions per hectare, per farm, etc.)

[1] The HOLOS tool is available at http://www.agr.gc.ca/nlwis/index_e.cfm?s1=tools_outils&page=intro.

- Data requirements for calculations of assurance (Alberta Financial Services Corporation (AFSC) crop insurance database, etc.); and
- Quantification plan.

2 Introduction

A strategy to optimize the quality and quantity of greenhouse gas (GHG) emission reductions achieved at minimum transaction cost involves the development of an approved quantification protocol. In Canada, quantification protocols are commonly developed in a four-step process that is consistent with the requirements of ISO 14064-2 (International Standards Organization, 2006) and led by, or at least involving, a governmental or not-for-profit non-governmental organization (NGO). First, the scientific knowledge is compiled relevant to the quantification of the emissions associated with a baseline scenario that represents "business-as-usual" practices, and of the emission reductions or removals associated with a specified scope of project condition practices. Second, scientific and technical experts evaluate the soundness of the scientific knowledge base. Third, a reduction quantification plan is developed (including deriving emission coefficients, if needed) using the understanding approved in the consultation. The quantification plan is then made available to stakeholders and the public for review. Finally, the quantification plan is justified and implemented by the government or NGO (or by their designates) according to the requirements of ISO 14064-2 to create an emission reduction protocol. The credibility of the final protocol thus depends upon the authority of the compiled science, the expertise of the engaged experts and the transparency of the government- or NGO-led process, all directed within the discipline imposed by the ISO 14064-2 standard.

ClimateCHECK was engaged by Alberta Agriculture and Rural Development in collaboration with Climate Change Central to provide a Technical Seed Document to compile and coordinate scientific information concerning greenhouse gas ("GHG") emission reductions associated with changes in agricultural management practices that result in reduced areas of summerfallow in the Canadian Prairies. The science regarding the sequestration of CO_2 and changes in emissions of CH_4 and N_2O associated with decreased use of summerfallow is reasonably well developed. Indeed, Canada's National Inventory Report accounts for changing GHG emissions with changing patterns of summerfallow use. This Technical Seed Document, as guided in the requirements of the ISO 14064-2 standard, integrates the knowledge compiled and decisions made during the protocol development process, to provide the basis for a proposed Summerfallow Reduction Protocol.

The development of this Technical Seed Document is guided and reviewed by a Technical Working Group, comprised of the following individuals:

- Sheilah Nolan — Research Agrologist, Alberta Agriculture and Rural Development (ARD), Coordinator;
- Karen Haugen-Kozyra — Director Policy Development and Offset Solutions, Climate Change Central, Protocol Standardization/Coordination Workshop;
- Rob Dunn — Land Management Specialist, ARD, Technical Advisor;
- Peter Gamache — Lead Agronomist, Reduced Tillage Linkages, Technical Advisor
- Alan Efetha — Irrigation Specialist, ARD, Technical Advisor;

- Rob Janzen – VP Western Canadian Operations, ClimateCHECK Corporation

This Technical Seed Document proceeds on the premise that the proposed Summerfallow Reduction Protocol will be used in conjunction with other quantification protocols of the Alberta Offsets System. Where the proposed Protocol shares components with Alberta-approved protocols, such as the Quantification Protocol for Tillage System Management (Tillage System Protocol), it is expected that the existing components will be incorporated in the proposed Protocol.

3 Development of the Technical Seed Document

The development of this Technical Seed Document involved a process of compilation and consultation. First, a draft technical document was compiled to provide a context within which to develop the Summerfallow Reduction Protocol. Based on the compiled knowledge and policy, the Technical Working Group proposed a framework for the Summerfallow Reduction Protocol. Second, the proposed framework was fully developed in a Science Discussion Document (Janzen *et al.* 2008) containing options for consideration and points of recommendation regarding the development of the Summerfallow Reduction Protocol. The Science Discussion Document was sent to all technical experts and market stakeholders invited to the Consultation Workshop. Third, invited experts and stakeholders gathered at the Consultation Workshop to discover consensus concerning the design and implementation of the Summerfallow Reduction Protocol. The decisions of the Consultation Workshop are integrated in this final Technical Seed Document.

3.1 Draft Technical Document

Timeline — July to September 2008

Based on the knowledge compiled in the draft technical document, the Technical Working Group proposed a framework for the Summerfallow Reduction Protocol according to the following principles:

- The quantification of GHG reductions could be accomplished using the method described in Canada's National Inventory Report;
- The co-implementation with the Tillage System Protocol would enhance the feasibility of the proposed Protocol; and
- A project-specific approach to baseline determination would enhance the credibility of the proposed Protocol.

The content draft technical document was expanded to create the Science Discussion Document (Janzen 2008) to provide the rationale and justification for consultation concerning the design of the Summerfallow Reduction Protocol.

3.2 Science Discussion Document

Timeline — October to November 2008

3.2.1 *Content & Purpose of Science Discussion Document for Summerfallow Reduction Protocol*

The Science Discussion Document (Janzen *et al.* 2008) proposed that the Summerfallow Reduction Protocol should be developed according to the ISO 14064-2 (International Standards Organization 2006) standard as adapted in the Alberta Offset System (Alberta Environment 2008a). It also provided the scientific knowledge and policy framework to guide discussion and decision concerning the proposed Protocol at the Consultation Workshop.

3.2.2 *Foundation of the Summerfallow Reduction Protocol*

The Science Discussion Document demonstrated that the method described in Canada's National Inventory Report (NIR, Environment Canada 2008a) could be used for the quantification of greenhouse gas (GHG) removals (i.e. carbon sequestration) associated with the land management change from reduced summerfallow (baseline condition) as compared with continuous cropping (project condition). The NIR quantification calculations are accumulated to an eco-area scale, and calculations of carbon sequestration are based on variables associated with soil type. The Science Discussion Document showed that the quantification of GHG reductions (i.e. methane and nitrous oxide emission reductions) resulting from management changes in the proposed Summerfallow Reduction Protocol could be based on research results and decisions of Canadian scientists involved in the NIR, as well as research results used to build GHGFarm (Helgason 2005) and the more recently developed Holos (Little *et al.* 2008) agricultural GHG emission estimation tools.

The Science Discussion Document (Janzen *et al.* 2008) provided points of consideration and also some recommendations to facilitate consensus among participants of the Consultation Workshop concerning the technical and operational foundation of the Summerfallow Reduction Protocol.

3.2.3 *Protocol Operational Framework*

The Science Discussion Document pointed out that the proposed Summerfallow Reduction Protocol has many common features with the Alberta-approved Tillage System Protocol (Alberta Environment 2007). To design the operations of the proposed Summerfallow Reduction Protocol, three types of questions related to the application of scientific knowledge were addressed in the Science Discussion Document (Janzen *et al.* 2008):

- Will the proposed Protocol be independent, or will participation in the Tillage System Protocol be required to participate in the Summerfallow Reduction Protocol?
- Will the 'default/discount' approach used in the Tillage System Protocol be applied in the Summerfallow Reduction Protocol, or will an alternative approach be used?
- Is the assurance factor approach used in the Tillage System Protocol valid for use in the Summerfallow Reduction Protocol, or will an alternative approach be used?

The Science Discussion Document (Janzen *et al.* 2008) was sent with the invitation to participate in the Consultation Workshop. The invited participants were asked to contribute to the protocol development process in keeping with the following principle excerpted from the Science Discussion Document:

> **PRINCIPLE**: At the Consultation Workshop, consensus will be sought for each Decision Point, along with an opinion concerning the degree of uncertainty associated with the information upon which the decision is based. Decision Points receiving a consensus opinion, defined as at least 80% agreement among designated scientific participants, will be the foundation for further NERP development. Thus, the Workshop is designed to serve as 'in-person peer review', where the collective experience and expertise of the designated scientific participants is the authority for decisions. Usually, this will mean the scientific participants will be asked to interpret and apply evidence presented in the peer-reviewed literature. In some instances the designated scientific participants will be asked to use their judgement to fill gaps in the published scientific literature.

3.3 Consultation Workshop

The Consultation Workshop for the Summerfallow Reduction Protocol was held at the J.G. O'Donoghue Building in Edmonton on 18 November 2008.

3.3.1 *Names, Affiliations, and Roles of Participants in the Consultation Workshop*

The participants of the Consultation Workshop comprised representatives of government and university research organizations, industry associations, fertilizer manufacturers and retailers, and government agencies. Excluding the Technical Working Group, about 30 individuals received invitations to the Workshop and received the Science Discussion Document (Janzen *et al.* 2008) for review and comments, and 18 of these individuals attended the Consultation Workshop.

Table 1. Names and Affiliations of Participants in the Consultation Workshop.

Name	Affiliation	Attend[1]
Technical Working Group		
Rob Dunn	Alberta Agriculture and Rural Development	Yes
Alan Efetha	Alberta Agriculture and Rural Development	No
Peter Gamache	Reduced Tillage Linkages	No
Karen Haugen-Kozyra	Climate Change Central	Yes
Sheilah Nolan (Coordinator)	Alberta Agriculture and Rural Development	Yes
Contractors and Workshop Facilitators		
Faye Banham (Minutes)	Climate Change Central	Yes
Keith Driver	Blue Source Canada	Yes
Jessica Goforth	Blue Source Canada	Yes
Rob Janzen	ClimateCHECK	Yes
Fiona Law	CompuTouch	Yes
Amanda Stuparyk	Climate Change Central	Yes

Canadian Researchers		
Brian McConkey	Agriculture and Agri-Food Canada	Yes
Eric Bremer	Symbio Ag Consulting	Yes
Tony Brierly	Agriculture and Agri-Food Canada	Yes
Ben Ellert	Agriculture and Agri-Food Canada	Yes
Yongsheng Feng	University of Alberta	No
Robert Grant	University of Alberta	Yes
Henry Janzen	Agriculture and Agri-Food Canada	No
Gary Kachinowski	University of Alberta	Yes
Regis Karamanos		Yes
Len Kryzanowski	Alberta Agriculture and Rural Development	No
Guy Lafond	Agriculture and Agri-Food Canada	No
Frank Larney	Agriculture and Agri-Food Canada	No
Xiaomei Li	Alberta Research Council	No
Reynald Lemke	Agriculture and Agri-Food Canada	Yes
Ross McKenzie	Alberta Agriculture and Rural Development	No
Jim Robertson	University of Alberta (Emeritus)	No
Industry Representatives		
Keith Anderson	Carbon Offset Trade Association	Yes
Robert Coulter	Emission Credits Corporation	Yes
Len Leskiw	Paragon Soil and Environmental Consulting Ltd.	Yes
Emmanuel Mapfumo	EBA Engineering Consultants Ltd.	Yes
Blair McClinton	Saskatchewan Soil Conservation Association	No
Wayne Pettapiece	Pettapiece Pedology	Yes
Milton Sanders	Emission Credits Corporation	Yes
Rheanna Sand	Emission Credits Corporation	Yes
Government		
Dennis Haak	Agriculture and Agri-Food Canada	No
Tom Goddard	Alberta Agriculture and Rural Development	Yes
Rod Bennett	Alberta Agriculture and Rural Development	No
Susan Crump	Agricultural Financial Services Corporation	Yes
Jim Jones	Alberta Agriculture and Rural Development	Yes
Kerrianne Koehler-Munro	Alberta Agriculture and Rural Development	Yes
Bob Riewe	Alberta Agriculture and Rural Development	No
Don Wentz	Alberta Agriculture and Rural Development	No

[1] All invited participants received a copy of the Science Discussion Document, and were given the opportunity to provide written comments.

3.3.2 *Agenda*

The PowerPoint presentations from the key resource persons at the Consultation Workshop are available at the Carbon Offset Solutions website (Carbon Offset Solutions 2008).

9:00 **Welcome and Introductions** – Review and Confirm agenda, *Karen Haugen-Kozyra, Climate Change Central*

9:15 **Setting the Scene** – Carbon Offsets and Policy Approaches in Alberta, *Karen Haugen-Kozyra*

10:15 **Overview of the NCGAVS National Emissions Inventory Work – How the Summerfalllow Coefficients were Derived: Canada's Quantification Approach,** *Brian McConkey, Agriculture and Agri-Food Canada*

10:45 **$N_2$0 Changes with Summerfallow Reduction – Comparison with Cropped Conditions**, *Reynald Lemke, Agriculture and Agri-Food Canada*

11:00 **Refreshment Break**

11:15 **Building on Existing Knowledge – The Summerfallow Science Discussion Document,** *Rob Janzen, ClimateCHECK*

12:00 **LUNCH**

1:00 **Dealing with Baseline Conditions, Additionality, and Permanence – Proposed Approach,** *Karen Haugen-Kozyra and Rob Janzen*

2:00 **Refreshment Break**

2:15 **Discussion and Ratification of Options**

4:15 **Summary and Workshop Close,** *Karen Haugen-Kozyra, Climate Change Central*

3.3.3 *Decisions by Polling*

For the Consultation Workshop of the Summerfallow Reduction Protocol, all participants were given the opportunity to vote on Decision Points. Some of participants did not hold advanced degrees in a pertinent subject matter, but they were included in the voting because they were experienced with a privately developed draft summerfallow reduction protocol. These non-typical voters represented only about 15% of the voters, and including or excluding these votes did not change the decisions and did not substantively alter the degree of acceptance. The results are reported without including results from the non-typical votes. Climate Change Central recorded the complete minutes of the Consultation Workshop (Banham 2008).

The decisions from polling are incorporated in the version of the Summerfallow Reduction Protocol submitted to the next phase of development: namely, adaptation into the format required for the technical review process of the Alberta Offset System (Alberta Environment 2008a). That is, the decisions from polling regarding the Decision Points in the Science Discussion Document (Janzen *et al.* 2008) form the foundation of the technical and operational framework of the Summerfallow Reduction Protocol as presented in Sections 5 of this Technical Seed Document. The actual voting results from the Consultation Workshop are inserted in the relevant sub-sections of Section 5.

Note that in some instances the participants of the Consultation Workshop provided consensus concerning the type of further work required under Option 2 - Accept with more work, of the decision point polling. Where this consensus guidance was given, it is recorded in red bolded text after the statement of acceptance below the decision point boxes in the sub-sections of Section 5. This further work will be accomplished in the subsequent work to standardize the Summerfallow Reduction Protocol for the Expert Technical, Stakeholder and Public Review process.

3.3.4 *Record of Decisions*

The minutes of the Consultation Workshop were recorded by Climate Change Central (Banham 2008).

4 Protocol Technical Foundation

The quantification methodology for estimating the summerfallow-related GHG emissions and reductions in the proposed Summerfallow Reduction Protocol is based on the best and most recently available science, as described in Canada's National Inventory Report (Environment Canada 2008a). The factors used in the National Inventory Report are derived in the Canadian Agricultural Greenhouse Gas Monitoring and Reporting System (CanAG-MARS, McConkey et al. 2007). The proposed Summerfallow Reduction Protocol thus builds on existing technical and scientific knowledge for the specialized purpose of quantifying GHG reduction credits within the requirements of ISO14064-based GHG offset programs. The scientists involved in CanAG-MARS have also contributed to the development of GHGFarm version 1.0 (Helgason 2005), which has been further developed into Holos version 1.1.x (Little *et al.* 2008), by Agriculture and Agri-Food Canada as "a tool to estimate and reduce GHGs from farms". This GHG estimation tool describes changes in the farm energy use associated with changes in management such as decreased summerfallow. The coefficients and factors for decreased energy use in GHGFarm were used within the approved Tillage System Protocol, and so these factors and coefficients represent a standard for use in the proposed Summerfallow Reduction Protocol.

4.1 Quantification of Removals (Sequestration)

The CanAg-MARS process derived the factors to estimate GHG dynamics associated with decreased use of summerfallow in Canada according to empirical data and predictions by the Century model. The details of this process were presented to the participants of the Consultation Workshop by Brian McConkey, a research scientist from Agriculture and Agri-Food Canada who is leading the quantification of soil carbon dynamics associated with land use and land use change for the Canadian National Inventory Report (Carbon Offset Solutions 2008).

Table 2. Sequestration coefficients for soil zones of the Prairies as derived by CanAG-MARS, based on empirical measurements reported in Campbell et al. (2005)

Soil Zone	Mg C ha^{-1} y^{-1}	Mg CO_2e ha^{-1} y^{-1}	Mg CO_2e ac^{-1} y^{-1}
Brown and Dark Brown	0.53	1.95	0.79
Black and Gray †	0.18	0.66	0.27

† The coefficient for the Grey and Black soil zones provided here is based on limited research (only 7 rotation comparisons as compared with 51 rotation comparisons for the Brown and Dark Brown soil zones)and as such may need to be treated separately as final protocol development is completed.

4.2 Quantification of Reductions (N_2O from Fields and CO_2 / N_2O from Energy Use)

The National Inventory Report also implements CanAG-MARS decisions concerning N_2O emissions from land in summerfallow. However, the N_2O emissions from land in summerfallow, resulting from N released from decomposing organic matter, are similar to emissions from similar cropped land receiving fertilizer (Reynald Lemke, Research Scientist, Agriculture and Agr-Food Canada, personal communication). Thus, there is justification for the Summerfallow Reduction Protocol to exclude these emissions from quantification.

Implementing the project activity of continuous cropping involves the use of equipment and inputs to plant the crop, apply fertilizer and herbicides and harvest the crop, and as such, the use of energy in the project condition is increased relative to the baseline scenario of summerfallow. The energy coefficients used in the Tillage system Protocol were evaluated and found to be appropriate for the proposed Summerfallow Reduction Protocol (Table 3). These coefficients do not include the energy used to manufacture fertilizer since this is beyond on-farm project boundaries, as described further in Section 5.1.1. To calculate the net emissions reduction, the increased energy use associated with the farm-specific change of practice (i.e. change from no till or reduced till summerfallow to no till or reduced till cropping) must be deducted from the carbon sequestered as a result of the practice change.

Table 3. Energy consumption for tillage systems adapted from Little *et al.* 2008.

	Tillage system	Crop Rotation	Fuel	Herbicide	Total
			GJ ha^{-1} yr^{-1}	GJ ha^{-1} yr^{-1}	Mg CO_{2e} ha^{-1} yr^{-1}
Black	Reduced Till	Crop	2.39	0.23	0.20
		Fallow	1.71	0.11	0.14
	No Till	Crop	1.43	0.46	0.14
		Fallow	0.93	0.60	0.10
Brown	Reduced Till	Crop	1.78	0.23	0.15
and Dark		Fallow	1.16	0.07	0.10
Brown	No Till	Crop	1.42	0.46	0.14
		Fallow	0.34	0.78	0.06

Note: Conversion factors are: fuel – 0.081, herbicide – 0.043 Mg $CO_{2\ equivalent}$ GJ^{-1} (Helgason 2005).

5 Protocol Operational Framework

The criteria for participation in the proposed Summerfallow Reduction Protocol will be designed to meet the general requirements of the Alberta Offset System (Alberta Environment 2008a), and to provide a practical approach to implement the quantification of the GHG benefits of reduced use of summerfallow.

The Alberta Specified Gas Emitters Regulation (SGER 2007) specifies criteria applicable to the proposed Summerfallow Reduction Protocol. And, the Alberta Quantification Protocol for Tillage System Management (Tillage System Protocol) is a source of good practice guidance for applying the SGER requirements in an agricultural protocol.

Since the science of quantifying GHG reductions associated with a land management change to discontinue summerfallow is well understood, the essential issue in the development of the proposed Summerfallow Reduction Protocol is to determine the best approach to implementing the established knowledge. The general operational framework of the proposed Summerfallow Reduction Protocol is similar to the Tillage System Protocol that has been approved in the Alberta Offset System. However, an important task in the development of the proposed Protocol is to determine whether lessons learned from the implementation for the Tillage System Protocol support retention or replacement of principles.

In some instances text from the Tillage System Protocol may be directly transferrable to the 'protocol applicability' section of the proposed Protocol, for example, see the following excerpt for the Tillage System Protocol:

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

1. Farms must be producing annual crops on the applicable land as confirmed by an affirmation from the project developer and farm records;
2. Farms in the project must operate on the applicable land in a no-till or reduced till system as defined in this protocol as confirmed by an affirmation from the project developer and farm records;
3. The quantification of reductions achieved by the project is based on actual measurement and monitoring (except where indicated in this protocol) as indicated by the proper application of this protocol; and,
4. The project must meet the requirements for offset eligibility as specified in the applicable regulation and guidance documents for the Alberta Offset System (Alberta Environment, 2008). [Of particular note:
    a. [The project may generate emission reduction offsets for a period of 20 years as indicated by farm and offset system records. Additional credit duration periods require a reassessment of the baseline condition; and,]
    b. [Ownership of the emission reduction offsets must be established as indicated by facility records.]

However, in other instances specific decisions concerning the framework of the proposed Summerfallow Reduction Protocol were required by the Technical Working Group and the consulted Technical and Scientific Advisors. These decisions are summarized as follows:

- The proposed Summerfallow Reduction Protocol will require co-implementation of the proposed Protocol with the Tillage System Protocol as addressed in this Technical Seed Document.
- The proposed Summerfallow Reduction Protocol will not use the 'default/discount' approach used in the Tillage System Protocol. Rather, the project condition will be initiated by a practice change (from summerfallow to continuous cropping), and the project emission reductions will be assessed relative to the baseline scenario of a three-year average of summerfallow area relative to the total land base of the operator. Functional equivalence to compare the baseline and project conditions may then be calculated on a Mg CO_2e per farm basis.
- The proposed Summerfallow Reduction Protocol will not use the assurance factor approach used in the Tillage System Protocol. Rather, project proponents will be required to use a market-based approach to address permanence that will be developed further during the next standardization phase, using input regarding market influences on rates of summerfallow adoption based on data collected by the Alberta Financial Services Corporation (AFSC).

5.1 Project

This Technical Seed Document is developed from the perspective that the proposed Protocol will require co-implementation with the Tillage System Protocol. Thus, the main thrust of this Technical Seed Document is to describe the development of the proposed Protocol for co-implementation with the Tillage System Protocol. However, some alternative options are also presented to provide the rationale or justification for this approach.

The decisions of the participants of the Consultation Workshop are inserted in the relevant sections below.

5.1.1 *Project Sources and Sinks (SSs)*

The SSs for the project condition for the proposed Summerfallow Reduction Protocol are the same as the SSs for the Tillage System Protocol (Figure 1). This means that the assessment of controlled, related, or affected status of the SSs, and the selection of relevant SSs, will also be the same as for the Tillage System Protocol.

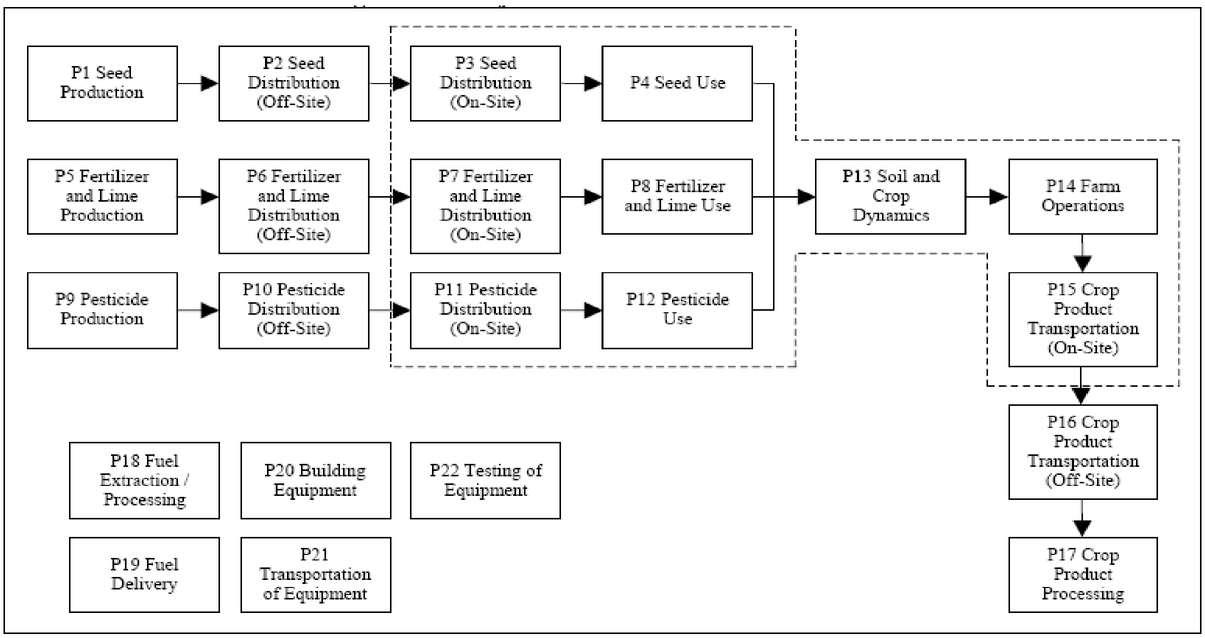

Figure 1. Diagram of project SSs for the proposed Summerfallow Reduction Protocol (from the Quantification Protocol for Tillage System Management, Alberta Environment 2007).

5.1.2 *Scope*

This Technical Seed Document addresses the emissions of CO_2, CH_4, and N_2O associated with transition of land management from summerfallow to continuous cropping.

5.1.2.1 Sequestration of Carbon in Fields Converted from Summerfallow to Crop

The factors for total increases in soil organic carbon (C) associated with land management change (LMC) from summerfallow to continuous cropping over a 20 year period are developed primarily from empirical data published in refereed scientific publications. The Century model was also used to identify rate of C increase, as described in the following excerpt from the CANAG-MARS report.

> The same Century-based method was used to predict C change for reduction of fallow. The Century model predicted rate of C storage for converting from a crop-fallow rotation to a continuous cropping rotation, for the Prairies (0.33 Mg ha^{-1} yr^{-1}) was more than double the average rate derived from two independent assessments (0.15 ± 0.06 Mg ha^{-1} yr^{-1}) (VandenBygaart et al., 2003; Campbell et al., 2005). One important reason for the higher predicted change in C for reducing fallow from the Century model simulations was the large simulated change in C by eliminating fallow in cropping systems that were assumed to contain hay and pasture crops in rotation. None of the empirical studies involved fallow changes within cropping systems with perennial crops. There is a large amount of empirical data available on the change of soil C by reducing fallow (ΔC_{LMCmax}), therefore the decision was made to use a total C change after 20 years equal to 6 Mg ha^{-1} (equivalent to average change of 0.15 Mg ha^{-1} yr^{-1} for 20 years after conversion from crop-fallow to continuous cropping). Although the empirical data was rich regarding total C change after several decades, there was insufficient time series of measured C to reliably derive the k value. Therefore, the latter parameter was that from the fit of Century-derived C change for fallow change. Campbell et al. (2005) concluded that fallow change was similar for subhumid and semiarid prairies; a mean k was derived across these two Reporting Zones. Section 2.1.3.2 (McConkey *et al.* 2007).

Based on these CanAG-MARS decisions, the average factor for rate of increased C storage with decreased summerfallow in the National Inventory Report is 0.30 Mg C $ha^{-1}y^{-1}$ for all soils of the Canadian Prairies. This average factor corresponds to 1.101 Mg CO_2 $ha^{-1}y^{-1}$, or 0.446 Mg CO_2 $ac^{-1}y^{-1}$, for all soils of Alberta.

For the development of the proposed Summerfallow Reduction Protocol, Dr. McConkey reassessed the empirical data underlying the coefficients used for the National Inventory Report. He concluded sufficient data existed to derive separate coefficients for the Brown and Dark Browns soils is 0.79 Mg CO_2 $ac^{-1}y^{-1}$ (Table 2). The factor of 0.27 Mg CO_2 $ac^{-1}y^{-1}$ for the Gray and Black soils (Table 2) is based on more limited data and as such, may not be supported in a Protocol, particularly since the proportion of summerfallow in the Gray and Black soil zones is less than 10% (see Appendix 1).

The CanAg-MARS Methodology also concludes there is no interaction between tillage and rotation, so the C sequestration achieved by the land management change (LMC) of reducing summerfallow is additive to any sequestration achieved by decreasing intensity of tillage. The rationale for this decision is described in the following excerpt.

> This assumption of additivity assumes there is no interaction between LMC. The assumption of additivity can not be rejected as there is no conclusive evidence that there are important interactions. There are many studies that involve tillage and crop rotation in factorial experiments. McConkey et al. (2003) report on five experiments in Western Canada and found no interaction between tillage and rotation. Peterson et al. (1998) summarized results from many experiments in the Great Plains of the United States and concluded that reducing tillage increased soil C across rotations and reducing fallow increased soil C across tillage treatments without clear interactions. West and Post (2002) did an analysis of world-wide literature and did not find an interaction between rotation and tillage excepting that reduction in tillage in wheat-fallow systems had less impact on soil C than in other rotations. The results from single experiments are inconclusive as some have showed interactions between tillage and rotation (Halvorson et al., 2002a; Huggins et al., 2007) whereas other studies have not shown significant

> interactions (Halvorson et al., 2002b; Yang and Kay, 2001). (Annex G, McConkey *et al.* 2007, pp 102-104).

These sequestration coefficients from the CanAG-MARS report will be used to quantify GHG emission removals in the Summerfallow Reduction Protocol.

5.1.2.2 Energy Use in Fields Converted from Summerfallow to Crop

The participants in the proposed Summerfallow Reduction Protocol will be increasing energy consumption as they change from summerfallow to No Till cropping. The emissions associated with a change in the energy use of cropping practices are addressed in the Technical Seed Document for the Tillage System Protocol that was based on Canada's Offset System for Greenhouse Gases Technical Background Document (Haak *et al.* 2006). The energy use coefficients developed for the GHGFarm calculator (Helgason 2005) were based on estimates of requirements for fuel, herbicide and machinery. The GHGFarm calculator has been developed further to create Holos (Little *et al.* 2008) as described below.

> Holos is a whole-farm modelling software program that estimates greenhouse gas (GHG) emissions based on information entered for individual farms. Holos estimates carbon dioxide, nitrous oxide and methane emissions from enteric fermentation and manure management, cropping systems and energy use. Carbon storage and loss from lineal tree plantings and changes in land use and management are also estimated resulting in a whole-farm GHG estimate. The main purpose of Holos is to envision and test possible ways of reducing GHG emissions from farms.

Many of the scientists of Agriculture and Agri-Food Canada involved in the development of the Tillage System Protocol and in the proposed Summerfallow Reduction Protocol are also contributors to the development of the Holos calculator, so some values are similar between calculators. However, in the case of the energy calculation, there were changes to the energy use values reported in the GHGFarm documentation (Helgason 2005). The Holos calculator did not include energy requirement estimates for machinery, although the coefficients for fuel and herbicide used in GHGFarm were still represented. Exclusion of the machinery estimate decreased the total energy use requirements reported in GHGFarm by about 20% for both the fallow and the cropped systems. This Summerfallow Reduction Technical Seed Document uses the most recent values from Holos (Little *et al.* 2008) for the energy calculation.

Because the regional discount/default approach was used in the Tillage System Protocol, the energy factors were adjusted by weight to account for the proportion of summerfallow and cropped land in each region. These adjusted regional coefficients were then used to calculate the energy savings that would result from the transition from conventional tillage to conservation tillage. For the proposed Summerfallow Reduction Protocol, a farm-specific baseline level of summerfallow practice will be determined and so no adjustment of the energy coefficients is needed for the baseline condition.

For the project condition, the increased consumption of energy associated with the transition from summerfallow to cropping can be significant on the Canadian Prairies (Table 3). The change from No Till summerfallow to No Till cropping results in an estimated increased emissions of about 0.04 Mg CO_2e ha^{-1} yr^{-1} (0.01 Mg CO_2e ac^{-1} yr^{-1}) in the Black soil zone and

0.07 Mg CO_2e ha^{-1} yr^{-1} (0.03 Mg CO_2e ac^{-1} yr^{-1}) in the Brown and Dark Brown soil zones. Similarly, the change from Reduced Till summerfallow to Reduced Till cropping results in an estimated increase in emissions of 0.06 Mg CO_2e ha^{-1} yr^{-1} (0.02 Mg CO_2e ac^{-1} yr^{-1}) in the Black soil zone and also 0.06 Mg CO_2e ha^{-1} yr^{-1} (0.02 Mg CO_2e ac^{-1} yr^{-1}) in the Brown and Dark Brown soil zones.

Thus, each farm participating in the Summerfallow Reduction Protocol would use the energy emission appropriate for their transition in practice. For example, a farm converting from No Tillage summerfallow to No Tillage cropping would use a different coefficient from Table 3 than would a farm converting from Reduced Tillage summerfallow to Reduced Tillage cropping.

5.1.2.3 N_2O Emissions from Fields Converted from Summerfallow to Crop

Based on discussions with Reynald Lemke, one of the scientists responsible to address the emissions of N_2O from agricultural soils of the Canadian Prairies, it was determined that substantive changes in N_2O emissions from soil will not be associated with implementation of the proposed Protocol. This decision is based on the knowledge that emissions of N_2O from fertilized fields are similar to those from summerfallow fields. The data to support this decision was presented by Dr. Lemke at the Consultation Workshop (Carbon Offset Solutions 2008).

DECISION POINT — Emissions of N_2O from fertilized fields are similar to those from summerfallow fields. (restriction for the Canadian Prairies):

1. Accept = 67%
2. Accept with more work = 19%
3. Hold for now = 14%

86% CONSENSUS — Accepted: Exclude N_2O emissions from fertilizer applied to cropped fields from the calculation of emissions reduction by the Summerfallow Reduction Protocol.

5.1.2.4 Tillage System Protocol Co-Implementation Approach

This decision requires farms to enrol in a project under the Tillage System Protocol to be eligible to participate in a project under the proposed Reduced Summerfallow Protocol. Since the data requirements for monitoring the two types of projects are expected to be similar, efficiency of effort could be achieved.

This approach recognizes the relationship between adoption of No Till or Reduced Till, and the reduction of summerfallow. In the judgment of the Technical Working Group, supported by the results of peer-reviewed scientific literature (Lafond *et al.* 1994), adoption of conservation tillage techniques such as No Till has facilitated reduction of summerfallow in the Canadian Prairies. Lafond *et al.* (1994) conclude that conservation tillage can increase spring soil moisture, thereby substituting for a benefit of summerfallow. This means projects such as those involving the change from No Till summerfallow to No Till cropping are less likely to be reversed for reason of low soil moisture. Thus, requiring the Tillage System Protocol as a prerequisite for the proposed Summerfallow Reduction Protocol would decrease the discount associated with an assurance factor, or would decrease the magnitude of the required buffer pool of credits.

As part of the larger land use strategy, conservation tillage land management is more credible as a non-business-as-usual practice if it is used to manage the risk associated with reduction of summerfallow. Even when conservation tillage is implemented, however, the risk of crop failure increases with elimination of summerfallow from the rotation in the Canadian Prairies (Zentner *et al.* 2002). Thus, the incentive provided by income from GHG reduction credits associated with conservation tillage and reduced summerfallow could be important to increasing the transition from summerfallow to cropping.

Some advantages of co-implementing the two protocols are:

- Data monitoring and data management capability exist for aggregation and verification;
- Enhances credibility of GHG reduction credit, both for those quantified using the proposed Protocol as well as or those from the Tillage System Protocol;
- Allows reduction-type GHG reductions in cases where summerfallow involved energy use for intensive tillage; and
- Facilitates eligibility of a broad range of farms.

Some disadvantages of co-implementing the two protocols are:

- Will limit the number of farms eligible for participation in the proposed Protocol, but the environmental integrity requirements of the Alberta Offsets System demand such eligibility constraints; and
- May increase complexity of projects by increasing the data needed by aggregators.

DECISION POINT — The Summerfallow Reduction Protocol should require co-implementation of the Tillage System Protocol.

1. Accept = 78%
2. Accept with more work = 17%
3. Hold for now = 4%

95% CONSENSUS — Accepted: Require co-implementation of the Tillage System Protocol with the Summerfallow Reduction Protocol. **More work is required to refine the details of the co-implementation.**

5.1.3 *Definitions of Practices*

The CanAG-MARS methodology to provide data for Canada's National Inventory Report defines summerfallow practice, and the land management change (LMC) and carbon (C) levels associated with it, as follows:

> ***Summerfallow Practices***
> Fallow cropland is land that is intentionally left idle or unseeded during a growing season with all plant growth periodically terminated with tillage or herbicides. Two types of LMC can affect C levels: a change in fallow area or a change in fallow tillage practices. The net change in fallow area is inferred directly from the Census of Agriculture by comparing the areas of fallow land reported in two successive periods. The change in tillage intensity on fallow is defined by the Census of Agriculture question described under Tillage Practices and is included as a change in tillage practice. (Section 2.1.2.1 in McConkey *et al.* 2007)

This Technical Seed Document addresses the two types of land management change categories, summerfallow area and tillage intensity, accounted in the National Inventory Report. However, the experience gained by farmers and aggregators in implementing the Tillage System Protocol should provide good practice guidance concerning the definition and monitoring of practices.

5.1.3.1 Summerfallow Area

The definition of summerfallow is straightforward, but participants in the proposed Summerfallow Reduction Protocol will need to provide data to document the area of the farm that is in summerfallow. Various types of data could be submitted. For example, according to personal communication with Dr. Susan Crump, Agricultural Financial Services Corporation (AFSC), AFSC has records of annual acreage of summerfallow for many farms in Alberta, so farmers could in many instances use crop insurance data. Also, to meet the requirements of the Tillage System Protocol, farmers and aggregators have collected data with respect to area of summerfallow fields. These data have included farmer field records, aerial photography, and crop advisor records.

5.1.3.2 Tillage Intensity

This Technical Seed Document describes the decision to require co-implementation of the Summerfallow Reduction Protocol with the Tillage System Protocol. Therefore, definitions of tillage intensity used in the Tillage System Protocol (Table 4) apply. Thus, two or less cultivations per year on summerfallow will represent tillage practice in the baseline scenario for participants in the proposed Summerfallow Reduction Protocol.

Also, to meet the requirements of the Tillage System Protocol, farmers and aggregators have collected data with respect to intensity of tillage on all fields. These data have included equipment purchase records and crop advisor records.

Table 4. Tillage definitions in the Parkland (Black and Grey) and Dry Prairie (Brown and Dark Brown) areas (from Tillage System Protocol, Alberta Environment 2007).

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

Notes:

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

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

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

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

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

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

5.1.4 *Permanence and Reversibility*

5.1.4.1 Assessing Risks of Reversal

Removal-type credits achieved by sequestration of soil organic matter associated with elimination of summerfallow, are subject to reversal if summerfallow is reinstituted on a field. A number of factors increase the likelihood of reversal of a land use change to decreased summerfallow. First, since reducing summerfallow does not necessarily require a change in equipment (whereas as the change to reduced tillage does), the decision whether or not to summerfallow can be made each spring. So, in drier areas or in periods of drought, farmers tend to increase use of summerfallow when soil moisture is low before seeding. And, the same reversal occurs when crop prices decline relative to cropping input costs. In the judgement of the Technical Working Group, reversals of 10 to 20% are possible, due to drought cycles and low grain prices relative to input costs, which are expected every 2 to 4 years during a 20 year period. However, the Technical Working Group also agrees that some developments in the sector mitigate against these weather- and price-driven reversals. For example, innovative crop rotations and tillage practices improve the potential for continuous cropping (see Lafond *et al.* 1994). Zentner *et al.* (2002) support this judgment, concluding that "including oilseed and pulse crops in the rotation with cereal grains contributes to higher and more stable net farm income in most soil–climatic regions, despite a requirement for increased expenditures on purchased inputs." The net result is that the reversal of land use change to reduce summerfallow is likely higher than that associated with land use change to No Till.

The magnitude of the losses of soil organic carbon with reinstatement of summerfallow is estimated by the CanAg-ARS Methodology to be the reverse of the gain in soil organic matter associated with elimination of summerfallow. Thus, in the Canadian Prairies the average C loss upon reinstatement of summerfallow is 0.79 Mg CO_2e $ac^{-1}y^{-1}$ for the Brown and Dark Brown soils zones, and 0.27 Mg CO_2e $ac^{-1}y^{-1}$ for the Gray and Black zones.

5.1.4.2 Addressing Risks of Reversal

For the Tillage System Protocol, the Government of Alberta underwrites an assurance factor, calculated to address the likelihood of reversal of land use change to No Till. In this approach, the calculated increase in C sequestration (or the increase in CO_2e removal) for a project participating in the Tillage System Protocol is multiplied by the soil zone-specific assurance factors to discount the total GHG reductions asserted. The No Till assurance factor for the Parkland (Black and Grey soil zones) region is 0.925, and 0.875 for the Dry Prairie (Brown and Dark Brown soil zones) region. The development of these assurance factors, as well as factors for Reduced Till, is described in Appendix B of the Tillage System Protocol. Such an approach was possible for the Tillage System Protocol, because of the relative stability of reduced tillage practice — once farmers purchase the equipment and implement reduced tillage, they rarely reverse. Reduced summerfallow practice, however, is not similarly stable — farmers are continually modifying summerfallow area as a result of weather factors and market forces. Thus, this Technical Seed Document reports the decision to use a strategy to address permanence which differs from the approach used in the Tillage System Protocol.

The approach used in the Summerfallow Reduction Protocol to address potential for reversal has two components.

First, the proposed Protocol will require the baseline scenario to be determined for each project farm as the average of three years of summerfallow area. This means much of the normal variation in level of summerfallow activity arising from short-term weather factors and market forces will be captured in the baseline, thereby increasing the likelihood of quantifying permanent reductions.

Second, the Technical Working Group, the science experts, and the market stakeholders involved in the development of the Summerfallow Reduction Protocol agree the proposed Protocol should use a market-based approach to address potential reversals of summerfallow reduction practice. A helpful description of such a market-based approach is proposed by the Voluntary Carbon Standard (VCS) for assurance of permanence of Agriculture, Forestry and Other Land Uses (AFOLU) projects (Voluntary Carbon Standard 2008). The excerpt below introduces this approach.

> The VCS approach for addressing non-permanence is to require that projects maintain adequate buffer reserves of non-tradable carbon credits to cover unforeseen losses in carbon stocks. The buffer credits from all projects are held in a single pooled VCS buffer account.
>
> The number of buffer credits that a given project must deposit into the pooled VCS buffer account is based on an assessment of the project's potential for future carbon loss. Project proponents are charged with: (1) undertaking the initial risk assessment, which must consider both transient and permanent potential losses in carbon stocks; and (2) determining the appropriate buffer reserve based on guidance provided in this document. This self risk assessment must be clearly documented and substantiated where possible. During verification, the VCS verifier will evaluate the project's risk assessment and adjust it as appropriate before determining the project's required buffer reserve.

Also, the White Paper published by the Offset Quality Initiative provides an assessment of the risks of reversibility associated with 'biological sink' projects, and lists some of the emerging market-based approaches available to address this risk (Offset Quality Initiative 2008). This White Paper represents the thinking of a number of the foremost not-for-profit organizations in North America involved in the development of standards for carbon market.

Finally, temporary credits have been suggested as a potential market-based solution to the problem of reversibility. For example, Canada's Offset System proposes this type of credit, generated by storing carbon for one year, which is not fully interchangeable with other credits. However, as the White Paper from the Offset Quality Initiative points out, this 'other' category of credits is not feasible "due to its barriers to inter-market fungibility, additional administrative requirements, and movement towards a globally tradable and credible commodity".

DECISION POINT — A 'market' approach, such as a pooled buffer or reserve hold-back, should be used to address permanence in the Summerfallow Reduction Protocol.

1. Accept = 61%
2. Accept with more work = 30%
3. Hold for now = 9%

91% CONSENSUS — Accepted: Require a market-based approach to address permanence. **Additional work is required to prescribe the requirement of such a market-based approach to address permanence of removals from the Summerfallow Reduction Protocol.**

5.1.5 *Ownership*

Since a significant portion of agricultural land in Alberta is managed by non-owners, the proposed Summerfallow Reduction Protocol will require the proof to establish the participant in the Protocol has rights to the GHG reductions generated. Substantive experience has been gained in documenting this evidence in the implementation of the Tillage System Protocol. Thus, both aggregators and verifiers in Alberta are familiar with addressing the requirement for proof of ownership for projects similar to those expected under the proposed Protocol.

5.1.6 *Verification*

Substantive experience has also been gained in monitoring, documenting, and verifying the implementation of the Tillage System Protocol. Thus, both aggregators and verifiers in Alberta are familiar with addressing the requirements of verification for projects similar to those expected under the proposed Protocol.

A distinction between the Tillage System Protocol and the proposed Protocol, however, is the requirement for farm-specific baseline with evidence of practice change to initiate the project condition. It is expected that these data requirements are compatible with existing databases used to monitor and administer projects under the Tillage System Protocol, such as crop insurance records, air photo interpretation and proof of ownership.

5.2 Baseline

The identification of a baseline, or 'business-as-usual', scenario for the proposed Summerfallow Reduction Protocol represents a balancing of two aspects of the evolving land use and land management practices on Prairie farms. On the one hand, Canada Census data confirms a trend for declining areas of summerfallow in the Brown and Dark Brown soil zones (Table 5) of the Canadian Prairies. This trend is closely correlated with increasing implementation of No Till, which increases the water use efficiency of agriculture in the Prairies, and with the enhanced effectiveness of chemical herbicides, which minimizes the need for mechanical weed control. On the other hand, continuous cropping supported by No Till remains a somewhat risky enterprise in the drier regions of the Prairies. In the judgment of the Technical Working Group, science experts, and market stakeholders involved in developing the proposed Protocol, summerfallow remains an attractive option for modern farmers by increasing stability of annual crop yield, and by minimizing cash costs for fertilizer and pest control. In support of this judgment, Zentner *et al.* (2002) conclude, "in the Brown soil zone and parts of the Dark Brown soil zone, the short-term economic benefits of using conservation tillage practices are more marginal and often less profitable than comparable conventional tillage practices". This circumstance of available technology and continuing financial risk provides the context for determining the baseline scenario for the Summerfallow Reduction Protocol.

Table 5. Estimation of fallow frequency for Alberta's Brown (BSZ), and Dark Brown (DBSZ), Black (BlSZ), and Gray (GSZ) soil zones.

Soil Zone	1996 Census			2001 Census			2006 Census		
	'000 Hectares		%	'000 Hectares		%	'000 Hectares		%
	Crop	**SF**	**SF (Adj)***	**Crop**	**SF**	**SF (Adj)***	**Crop**	**SF**	**SF (Adj)***
BSZ	1287.6	500.2	29.6	1297.1	1241.1	30.9	1396.2	967.5	24.3
DBSZ	1506.1	372.3	21.1	1539.8	697.1	16.5	1578.9	508.6	12.3
BlSZ	3809.7	293.9	7.2	3799.2	485	4.9	3768.4	319	3.3
GSZ	5870.4	260.7	8.3	2961.1	605	7.7	2756.7	419	5.8

* % fallow, adjusted for irrigated cropland within the area for Brown and Dark Brown soil zones (Census of Canada, 2006). The crop, summerfallow, and adjusted summerfallow data for each soil type in each municipality are provided in Appendix 1.

5.2.1 *Baseline SSs*

The baseline scenario for the proposed Summerfallow Reduction Protocol is land managed as summerfallow, or farmed land with no seeded crop. Thus, the SSs of the baseline scenario are those SSs from the project condition which do not pertain to crop production (Figure 2).

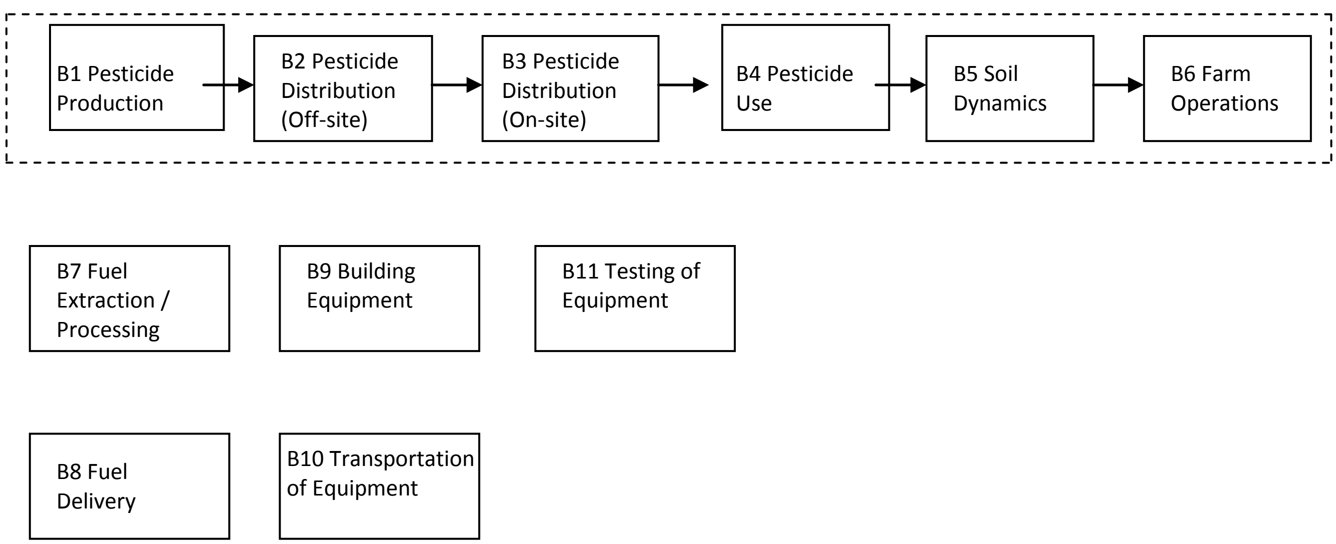

Figure 2. Diagram of Baseline SSs for the proposed Summerfallow Reduction Protocol. The SSs inside the dashed area represent the controlled SSRs relevant for quantification of project emissions.

5.2.2 *Baseline Determination*

The options for baseline determination are considered according to temporal and spatial categories. The following list is not exhaustive, but demonstrates the range of options.

5.2.2.1 Scale for Activity Baseline

For the proposed Summerfallow Reduction Protocol, baseline activity is defined as the total area or proportion of farmland managed as summerfallow. The decision pertaining to scale of baseline involves whether to use a baseline for the Brown Soil Zone and for the Dark Brown Soil Zone, or for each participating farm. The advantages and disadvantages of using baseline activity for soil zone and for single farm scale or basis are listed (Table 6).

Table 6. Advantages and disadvantages of selected sample options to determine the baseline scale.

Option	Advantage	Disadvantage
Soil Zone	• Less project development effort required; • Gives same opportunity to all eligible farms; • Relies on census data, which has standardized quality; and • Parallel to Tillage System Protocol.	• Gives same opportunity to all eligible farms; and • Increases likelihood of criticism concerning additionality.
Single Farm	• More project development effort required; • Gives opportunity according to farm practices; and • Minimizes criticism concerning additionality.	• More data required; and • Less control on data quality. • Fewer farms eligible

After considering these options, the participants of the Consultation Workshop concluded that the Summerfallow Reduction Protocol should use a farm-specific scale of baseline activity. This Technical Seed Document thus reports the decision, which represents the consensus of the Technical Working Group and the consulted science experts and market stakeholders, that the baseline level of summerfallow practice should be determined for each participating farm.

DECISION POINT — The scale to determine the activity baseline of the Summerfallow Reduction Protocol should be farm-specific.

1. Accept = 96%
2. Accept with more work = 4%
3. Hold for now = 0%

100% CONSENSUS – Accepted: Use a farm-specific baseline for the Summerfallow Reduction Protocol.

5.2.2.2 Time Period for Activity Baseline

The decision pertaining to time of baseline involves whether to use a single baseline year or the average of several years (i.e. capture a trend), and whether to use a past year or a recent year (Table 7).

Table 7. Advantages and disadvantages of selected sample options to determine the baseline time.

Option	Advantage	Disadvantage
Single Year	• Less data required; and • Can be aligned with a program eligibility date.	• Greater risk of distortion from short-term weather or economic factors; and • Can be construed as arbitrary.
Average of Several Years	• Less risk of distortion from short-term weather or economic factors; and • Captures longer term trends.	• More data required; and • Can be construed as arbitrary.
Past (single year or average to match with 2001 baseline of other Alberta protocols)	• Allows participation of more farms, more area per farm; and • Consistent with other Alberta Protocols.	• Less credibility of offset quality; and • Inconsistent with Canada's Offset System.
Recent (single year or average capture new practice change)	• Greater credibility of offset quality; and • Consistent with Canada's Offset System.	• Allows participation of fewer farms, less area per farm; and • Inconsistent with other Alberta Protocols.

After considering these options, the participants of the Consultation Workshop concluded that the Summerfallow Reduction Protocol should use the average of three years as the baseline level of summerfallow activity. This Technical Seed Document thus reports the decision, which represents the consensus of the Technical Working Group and the consulted science experts and market stakeholders, that the baseline level of summerfallow practice should be determined as the average of the three years prior to the project for each participating farm.

DECISION POINT — Best practice guidance is to set the time period to determine the baseline of the Summerfallow Reduction Protocol to the average of three years prior to the project.

1. Accept = 82%
2. Accept with more work = 18%
3. Hold for now = 0%

100% CONSENSUS - Accepted. Require three-year average to establish to baseline for the Summerfallow Reduction Protocol. **Additional work is required to prescribe the data needed to determine the baseline, and to ensure functional equivalence between the baseline scenario and the project condition.**

5.2.2.3 Default/Discount Approach

A default/discount approach was used to develop the baseline for the Tillage System Protocol for the Alberta Offset System (Alberta Environment, http://www.environment.alberta.ca/documents/ Tillage_Protocol_v1.3_Feb_08.pdf). This involved decreasing the emission reduction and removal factors from the National Inventory Report by the degree of adoption of No Till and Reduced Till practices in the Canadian Prairies. This approach was deemed appropriate because of the perceived stability of conversion to conservation tillage. That is, the demonstrated benefits of conservation tillage (lower fuel costs, higher yields, etc.) and the cost of specialized equipment motivate farmers to continue conservation tillage after adoption.

A similar approach could be used for the proposed Summerfallow Reduction Protocol to design a default/discount approach based on trends of decreased use of summerfallow in the Canadian Prairies (see Table 5). This approach could use Canada Census data to assess level of summerfallow use in the project eligibility year (e.g. 2001), compare it to summerfallow use in some reference year (e.g. pre-1980), and discount the reduction by multiplying by the ratio of reference level to project level. In addition, this approach could derive discounted factors for each type of land use change — from Tilled summerfallow to Tilled cropping, from Tilled summerfallow to No Till cropping, from No Till summerfallow to No Till cropping, etc. However, it may be difficult to assure regulatory agencies that appropriate discount factors could be developed for summerfallow reduction. The significance of short-term weather and market factors as influences on decisions by farmers to use more or less summerfallow complicate the prediction of trends of summerfallow activity may be difficult to determine, although further investigation of this question is needed. This difficulty is exacerbated if conversions from Full Till summerfallow to Full Till cropping are included in the calculation of activity trends.

Some advantages of the discount/default approach are:

- Rewards early adoption of reduced summerfallow practice, but discount ensures only 'new carbon' is quantified as a GHG reduction credit;
- Allows reduction-type GHG reductions in cases where summerfallow involved energy use for intensive tillage; and
- Facilitates eligibility of a broad range of farms.

Some disadvantages of this approach are:

- Difficulty in identifying establishing appropriate discount factors, because farmers may frequently increase and decrease level of summerfallow activity on the farm;
- May require larger assurance factor or buffer reserve, because farmers changing from Full Till summerfallow to Full Till cropping may be more likely to revert back to summerfallow, and
- Opens the proposed Protocol to the criticisms levelled against the Tillage System Protocol (i.e. rewarding farmers for business-as-usual practice, no proof of practice change, etc.).

After considering these advantages and disadvantages, the participants of the Consultation Workshop concluded that the Summerfallow Reduction Protocol should use a farm data of practice change. This Technical Seed Document reports the decision, which represents the consensus of the Technical Working Group and the consulted science experts and market stakeholders, that the baseline level of summerfallow practice should not be determined by a discount/default approach.

DECISION POINT — The scale to determine the activity baseline of the Summerfallow Reduction Protocol should be farm-specific.

1. Accept = 96%
2. Accept with more work = 4%
3. Hold for now = 0%

100% CONSENSUS – Accepted: Use a farm-specific baseline for the Summerfallow Reduction Protocol.

5.2.2.4 Farm-specific Approach

Although the proposed Summerfallow Reduction Protocol will require co-implementation with the Tillage System Protocol, the option remains to develop an approach that avoids the disadvantages of the discount/default approach. One option for a non-discount/default approach is to require a farm-specific approach. This approach would require individual project farms to provide proof of reduced use summerfallow, by comparing project levels of summerfallow to a farm-specific activity baseline of summerfallow. The baseline levels of summerfallow activity could be assessed for one year, as the average of several years, or for a period of time specified by the developers of the proposed Protocol. And, this approach could address each type of land use change — from Tilled summerfallow to Tilled cropping, from Tilled summerfallow to No Till cropping, from No Till summerfallow to No Till cropping, etc.

This farm-specific comprehensive approach would require more detailed baseline determination than is required in a discount/default approach, but would demonstrate the change of practice change which increases the credibility of the GHG credit.

Some advantages of this approach are:

- Enhances credibility of 'additional' or 'incremental' status of quantified GHG reduction credit;
- Allows reduction-type GHG reductions in cases where summerfallow involved energy use for intensive tillage; and
- Facilitates eligibility of a broad range of farms.

Some disadvantages of this approach are:

- May increase complexity of projects by increasing the data needed by aggregators; and
- May require larger assurance factor or buffer reserve, because farmers changing from Tilled summerfallow to Tilled cropping may be more likely to revert back to summerfallow.
- Difficulties with accounting for effects of extreme weather on baseline assessment, e.g. drought.

After considering these advantages and disadvantages, the participants of the Consultation Workshop concluded that the Summerfallow Reduction Protocol should use a farm-level data of baseline activity. This Technical Seed Document reports the decision, which represents the consensus of the Technical Working Group and the consulted science experts and market stakeholders, that the baseline level of summerfallow practice should be determined for each participating farm.

DECISION POINT — The scale to determine the activity baseline of the Summerfallow Reduction Protocol should be farm-specific.

1. Accept = 96%
2. Accept with more work = 4%
3. Hold for now = 0%

100% CONSENSUS – Accepted: Use a farm-specific baseline for the Summerfallow Reduction Protocol.

5.2.3 *Additionality or Incrementality*

Quantification protocols are intended to generate offset credits which reflect removals and reductions of GHGs exceeding decreases in emissions achieved by 'business-as-usual' activities. 'Business-as-usual' represents the level of GHG emissions expected in the absence of the instruction provided by the approved protocol and without the incentive of financial reward from the offset credits generated by using the approved protocol. In this Protocol, 'business-as-usual' will be represented as the 3-year average of summerfallow activity on the participating farm prior to the project (Section 5.2.2.2).

In the Alberta Offset System (Alberta Environment 2008b), the intent is "to ensure that the projects generating emission reductions are **additional** to what otherwise would have occurred in Alberta, prior to the January 2002 release Alberta's first climate change plan – *'Taking Action'* – was introduced." To meet this requirement to be additional, reductions and removals must:

- Result from actions taken on or after January 1, 2002;
- Occur on or after January 1, 2002;
- Be real, demonstrable, quantifiable according to a protocol approved for the Alberta Offsets System; and
- Not be required by law;

In Canada's Offset System, the term "incremental" is used to differentiate offset credits from removal and reductions occurring as business-as-usual (Environment Canada 2008b). To meet the requirement to be incremental:

- Projects must have started on or after January 1, 2000.
- Credits may be issued for reductions achieved after January 1, 2008.
- Reductions achieved must go beyond the baseline defined for the project type.
- Reductions are surplus to all legal requirements (federal, provincial/territorial and regional).
- Reductions are beyond what is expected from receipt of other climate change incentives (federal, provincial/territorial).

Some of the criteria for Additionality and Incrementality in existing offset systems focus on parameters such as start date which are relatively straightforward. Other criteria, however, such as 'real' or 'go beyond the baseline' require analysis. The rationale for the Additionality or Incrementality of the decreased use of summerfallow on the Canadian Prairies is justified in this Technical Seed Document for the Summerfallow Reduction Protocol according to several tests:

1. Surplus to regulation: Agriculture remains for the most part an unregulated sector in Canada. And, although reducing summerfallow is promoted as a good management practice, no regulations exist to require reduction of summerfallow.
2. Investment Barriers: Significant financial obstacles exist for the reduction of summerfallow. Summerfallow is traditionally used to control weeds, to allow plant-available nitrogen to accumulate from decomposition of soil organic matter, and to conserve water. As a result, rotations using summerfallow tend to require less herbicide and fertilizer, and tend to achieve lower but less variable yields. Thus, reducing summerfallow requires greater input

costs and creates greater income risk. The potential income from GHG offset credits may give sufficient incentive to address these increased costs and risks.

3. Technological barriers: The technology required to implement the reduction of summerfallow to continuous cropping is readily available.
4. Institutional barriers: For the most part, farmers use summerfallow as part of a traditional, and tested, farming practice. Thus, reduction of summerfallow represents a cultural shift and this may be barrier to participation of farmers in summerfallow reduction. The financial and social rewards available to farmers through the proposed Protocol will add to the likelihood for farmers to adopt rotations with reduced summerfallow.
5. Not common practice: Although the practice of summerfallow is decreasing on the Canadian Prairies (Table 5), the practice still represents significant areas of the Brown soil zone and the Dark Brown soil zone. In addition, an attractive option for the Summerfallow Reduction Protocol is to focuses on achieving reductions in farm-specific levels of summerfallow use. That is, farmers who are likely to reduce summerfallow as a 'business-as-usual' improvement have likely already done so, and therefore will not be able to demonstrate reduced summerfallow practice since the year 2002. So, the proposed Protocol may motivate remaining farmers to make the transition to reduced summerfallow practice.

Thus, the Additionality or Incrementality of the proposed Summerfallow Reduction Protocol is justified according to the barriers to implementation of the proposed Protocol; namely, of the five barriers tested, only the technological test is not met.

In addition, elements of the design of the Summerfallow Reduction Protocol enhance the justification for additionality or incrementality.

First, the requirement of a farm-specific baseline forces participants to demonstrate that the level of summerfallow activity has decreased on their farms. This clearly enhances the additionality or incrementality of the proposed Protocol, because most farmers who would reduce summerfallow activity as part of business as usual already have done so.

Second, the requirement for three years of baseline data to calculate the baseline will capture some reductions which are a result of a general trend toward decreased summerfallow activity. Again, this requirement helps to ensure that the reductions achieved though implementation of the Summerfallow Reduction Protocol are additional or incremental to what would have occurred as business as usual.

Third, the requirement for co-implementation with the Tillage System Protocol is an important factor contributing to the justification of the additionality or incrementality of the Summerfallow Reduction Protocol. The Technical Working Group and the consulted science and technical experts share the consensus based on published knowledge that decreased use summerfallow generally is associated with increased use of conservation tillage. Thus, participants in the Tillage System Protocol, who thereby can implement the Summerfallow Reduction Protocol, are expected to already have decreased levels of summerfallow activity. In other words, the farms likely able to document substantive decreases in summerfallow activity since the earliest eligible baseline period (that is, the three years prior to 2002) for participation in the Summerfallow Reduction Protocol were either not using conservation tillage, or were using conservation tillage and still using summerfallow. It is thus justifiable that farms eligible for the Summerfallow Reduction Protocol are demonstrating reductions in summerfallow activity that are additional or incremental to those achieved as a result of the general trend to increased use of conservation tillage on the Canadian Prairies.

6 Remaining Development and Adaptation

Using the compiled knowledge and consultation results compiled in this Technical Seed Document, the Summerfallow Reduction Protocol will be adapted for the process of technical review required for approval in the Alberta Offset System (Alberta Environment 2008, http://www.carbonoffsetsolutions.ca/offsetprotocols/abprotocolDevelopment.html). The following section is provided in the Technical Seed Document to capture the spirit of the discussions at the Consultation Workshop, but is not based on explicit polling at the Workshop. And, based on the consensus of the Technical Working Group, this section could be submitted with the Summerfallow Reduction Protocol for review in the technical review process leading to approval for the Alberta Offset System.

6.1 Farm-Specific Baseline Implementation

Land tenancy is fluid and temporary in the Canadian Prairies, and the magnitude and location of land area managed by a farmer could change between the baseline scenario and the project condition. So, the question arises, “how should changes in magnitude and location of land area be addressed in determining the level of summerfallow practice for the farm?”

Two options with respect to implementing a farm-specific baseline level of summerfallow practice are as follows:

a. Option 1 — Require a baseline of three continuous years of data for any parcel of land included in the project. If no change of tenancy occurred, this documentation could be provided by the project proponent, or by the previous land manager or from sources such as crop / hail insurance in the case of change in tenancy. This option is land centred, and requires a comparison between baseline and project for every participating hectare.

   GHG reduction = [No. of ha changed from summerfallow to crop] * Net Coefficient

b. Option 2 — Require a baseline based on three continuous years of data to determine the ‘proportion of summerfallow activity’ by the farmer participating in the proposed Protocol. The baseline documentation is limited to land controlled by the participating farmer. This option is farmer centred, basing reductions on the number of hectares of summerfallow the farmer would have had if the same proportion of summerfallow practice was implemented in the project condition ($Project_{SF}$) as in the baseline scenario ($Baseline_{SF}$).

$$\text{GHG reduction} = [(\text{Baseline}_{SF} * \text{Project Ha}) - (\text{Project}_{SF} * \text{Project Ha})] * \text{Net Coefficient}$$

6.2 Functional Equivalence of Baseline Scenario and Project Condition

Decisions remain concerning the approach to ensure functional equivalence of the baseline scenario and project condition. That is, once an option is chosen for baseline determination, it will be necessary to finalize whether emissions and reductions will be quantified on the basis of a hectare of crop, a field, a farm, or other possible units.

6.3 Co-Implementation Requirements

Decisions remain concerning the requirements for co-implementation of the Summerfallow Reduction Protocol with the Tillage System Protocol. A detailed analysis is required to ensure the requirements of the two protocols are compatible.

6.4 Quantification Plan

The detailed data requirements of the Summerfallow Protocol need to be tabulated in a Quantification Plan. Such a table is included in the Tillage System Protocol (Alberta Environment 2007, Table 2.4, page 32).

7 Sample Calculation

Consider a farm with cultivated area of 1000 ha in the Dark Brown soil zone. The farm had 350 ha of summerfallow under the baseline scenario, but only 100 ha in the project (For this example, it does not matter whether the difference between baseline and project level of summerfallow activity was calculated using Option 1 or Option 2). The farm used No Till summerfallow in the baseline and No Till cropping in the project. Thus, the coefficient for carbon sequestration in the Brown and Dark Brown soil zones is 1.95 Mg CO_2e ha^{-1} y^{-1} (Table 2) and the increased use of energy due to continuous cropping compared with fallow would amount to 0.04 (0.10 – 0.14) Mg CO_2e ha^{-1} y^{-1} (Table 3). The net coefficient for removals of carbon would amount to 1.91 (1.95 – 0.04) Mg CO_2e ha^{-1} y^{-1}. Thus, the credits generated by this farm would be 477 Mg CO_2e ha^{-1} y^{-1}.

- Farm — 1000 ha, Dark Brown
  - Baseline — 350 ha summerfallow
  - Project — 100 ha summerfallow
  - Reduction
    - Factor: 1.95 – 0.04 = 1.91 Mg CO_2e ha^{-1} y^{-1}
    - Credits: 250 ha * 1.84 = 477 Mg CO_2e ha^{-1} y^{-1}

8 References

The publications listed below represent the breadth and depth of scientific knowledge referenced to develop the technical foundation of the Summerfallow Reduction Protocol as described in this Technical Seed Document. These publications provide the evidence deliberated in the draft technical document and support the considerations integrated in the Science Discussion Document.

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9 Appendix 1 — Estimation for each rural municipality of fallow frequency for Alberta's Brown (BSZ), and Dark Brown (DBSZ), Black (BlSZ), and Gray (GSZ) soil zones.

	1996 Census			2001 Census			2006 Census		
	'000 Hectares		%	'000 Hectares		%	'000 Hectares		%
	Crop	SF	SF (Adj)*	Crop	SF	SF (Adj)*	Crop	SF	SF (Adj)*
Brown Soil Zone									
Cypress	158.1	64.1	31.6	163.4	66.4	31.6	180.3	55.1	25.5
40 Mile	259.1	118.6	34.2	254.5	129.1	36.6	287.8	96.0	27.2
Warner	212.8	52.1	20.8	217.6	63.2	23.7	223.9	44.7	17.6
Newell	125.0	22.9	23.0	127.1	26.3	25.1	131.5	20.6	19.9
Taber	195.3	49.7	26.5	198.3	43.7	23.7	213.8	23.1	12.8
Special Area 2	147.5	62.1	30.2	144.1	52.8	27.3	148.1	43.8	23.3
Acadia/ Special Area 3	189.8	130.8	40.8	192.1	120.9	38.6	210.9	108.3	34.3
Soil Zone	***1287.6***	***500.2***	***29.6***	***1297.1***	***502.5***	***30.9***	***1396.2***	***391.7***	***24.3***
Dark Brown Soil Zone									
Lethbridge	226.0	34.3	18.4	209.1	28.3	17.3	206.5	18.5	12.3
Willow Creek	193.6	18.2	9.1	191.5	14.5	7.5	180.1	6.6	3.8
Vulcan	263.1	114.5	31.7	282.0	100.2	27.4	330.8	75.4	19.4
Wheatland	283.6	66.0	19.3	292.5	41.6	12.8	302.7	27.8	8.6
Starland	130.1	46.6	26.4	147.5	26.0	15.0	162.7	19.6	10.7
Paintearth	144.5	22.6	13.5	150.7	14.5	8.8	137.5	15.4	10.1
Special Area 4	115.7	33.6	22.5	128.7	26.5	17.1	122.3	21.0	14.6
provost	149.4	36.5	19.6	137.8	30.7	18.2	136.3	21.7	13.7
Soil Zone	***1506.1***	***372.3***	***21.1***	***1539.8***	***282.2***	***16.5***	***1578.9***	***205.9***	***12.3***
Black Soil Zone									
Beaver	178.9	18.6	9.4	180.2	10.9	5.7	174.1	5.3	2.9
Camrose	234.0	12.6	5.1	234.8	8.5	3.5	233.2	3.6	1.5
Flagstaff	282.2	25.5	8.3	275.7	14.6	5.0	272.1	7.7	2.7
Kneehill	244.1	29.6	10.8	226.7	14.6	6.0	247.8	8.9	3.5
Lacombe	164.4	4.5	2.6	168.0	4.0	2.4	157.5	2.4	1.5
Lamont	153.0	10.5	6.4	145.7	8.9	5.8	139.3	7.3	5.0
Leduc	151.4	5.7	3.6	145.3	4.9	3.2	153.4	4.0	2.6

Minburn	180.6	17.8	9.0	187.9	11.3	5.7	187.0	7.7	4.0
Mountain View	200.4	10.9	5.2	197.6	6.1	3.0	210.1	5.3	2.4
Pincher Creek	82.6	4.5	5.1	82.6	4.0	4.7	79.4	2.4	3.0
Ponoka	122.7	3.2	2.6	131.6	3.2	2.4	119.4	2.4	2.0
Red Deer	240.1	6.5	2.6	241.3	8.5	3.4	226.7	4.9	2.1
Stettler	180.2	20.2	10.1	189.5	12.6	6.2	173.7	10.5	5.7
Strathcona	56.7	4.0	6.7	61.9	2.8	4.4	64.8	1.2	1.8
Sturgeon	145.3	6.5	4.3	146.2	5.7	3.7	149.8	3.6	2.4
Vermilion River	300.0	36.8	10.9	286.2	27.9	8.9	290.7	19.8	6.4
Wainwright	181.8	22.7	11.1	196.0	16.6	7.8	179.8	10.1	5.3
Wetaskiwin	128.7	4.9	3.6	129.1	5.7	4.2	139.3	4.0	2.8
Cardston	201.6	10.9	5.1	185.8	4.0	2.1	197.6	3.2	1.6
Foothills	165.6	22.3	11.9	152.2	10.9	6.7	155.5	5.7	3.5
Rocky View	215.4	15.8	6.8	234.8	10.5	4.3	217.4	8.9	3.9
Soil zone	***3809.7***	***293.9***	***7.2***	***3799.2***	***196.4***	***4.9***	***3768.4***	***129.1***	***3.3***
Gray Soil Zone									
Athabasca	126.3	15.4	10.9	133.2	8.5	6.0	121.1	8.5	6.6
Barrhead	106.5	3.6	3.3	111.3	4.0	3.5	109.3	1.6	1.5
Bonnyville	151.4	11.7	7.2	116.6	8.1	6.5	99.6	6.9	6.5
Lac Ste Anne	104.9	4.5	4.1	107.7	4.9	4.3	98.8	4.0	3.9
Parkland	88.7	3.2	3.5	92.3	4.9	5.0	83.4	3.6	4.2
Smoky Lake	85.0	7.7	8.3	92.3	4.9	5.0	89.9	4.9	5.1
St. Paul	123.9	10.1	7.6	134.0	8.9	6.2	123.1	6.5	5.0
Thorhild	85.0	6.1	6.7	87.4	4.5	4.8	70.0	5.3	7.0
Two Hills	137.7	14.2	9.3	140.5	10.9	7.2	132.8	5.7	4.1
Westlock	167.2	8.9	5.1	171.3	6.1	3.4	155.5	4.0	2.5
Birch Hills	117.0	12.6	9.7	116.6	8.1	6.5	125.9	3.6	2.8
Fairview	84.6	4.5	5.0	86.6	6.1	6.6	79.4	4.9	5.8
Grande Prairie	253.0	28.3	10.1	247.8	25.1	9.2	225.9	22.7	9.1
East Peace	74.9	5.7	7.0	80.6	7.3	8.3	81.4	4.5	5.2
Peace	53.8	4.5	7.6	48.6	4.5	8.4	52.2	2.4	4.4
Saddle Hills	134.4	21.1	13.5	140.5	19.0	11.9	127.1	11.3	8.2
Smoky River	176.9	10.1	5.4	209.3	11.3	5.1	201.2	4.9	2.4

Spirit River	53.0	5.3	9.0	51.4	6.9	11.8	50.6	5.7	10.1
Clear Hills	121.9	12.1	9.1	130.0	20.2	13.5	107.7	10.5	8.9
Northern Lights	147.0	23.9	14.0	148.2	22.7	13.3	127.1	15.0	10.5
Mackenzie	121.1	17.8	12.8	123.1	18.2	12.9	120.2	15.4	11.3
Big Lakes	64.8	9.7	13.0	74.1	8.1	9.9	72.9	3.2	4.3
Brazeau	39.3	2.4	5.8	39.7	1.2	3.0	37.7	1.2	3.1
Clearwater	81.4	2.4	2.9	82.2	4.5	5.1	83.4	2.8	3.3
Greenview	107.7	10.5	8.9	124.7	11.7	8.6	117.0	7.3	5.9
Yellowhead	63.2	4.5	6.6	71.3	4.5	5.9	63.6	3.2	4.8
Soil Zone	***2870.4***	***260.7***	***8.3***	***2961.1***	***244.9***	***7.7***	***2756.7***	***169.6***	***5.8***

* % fallow, adjusted for irrigated cropland within the municipality for Brown and Dark Brown soil zones (Census of Canada, 2006)