Wetlands Restoration Protocol

Revised Technical Seed Document

For

Ducks Unlimited Canada

Presented to

Climate Change Central and Alberta Environment

October 15, 2010

BUSINESS CONFIDENTIAL

Head Office: 325 Dalhousie Street, Suite 204 Ottawa Canada K1N 7G2
Phone: 613 241 8000 Toll Free: 1 888 241 8003 Facsimile: 613 241 8008
Email: info@climate-check.com

Contents

1 Introduction and Summary of Project/Activity Type

Ducks Unlimited Canada has engaged ClimateCHECK, in collaboration with a Technical Working Group, to develop the proposed Wetlands Restoration Protocol. The group wishes to bring forward a protocol, based on the best available science on GHG emission reductions from management of mineral-soil wetlands in the Prairie Pothole Regions to the Alberta Protocol Development Process. Part of this protocol development process involves developing this Technical Seed Document. The protocol development follows the established process for coordinating scientific information and consensus-building according to the ISO 14064-2 GHG Project-Based Standard. As the Alberta Protocol Development Process was enhanced during the development of the Wetlands Restoration Protocol, a section (Section 7) has been added to this revised version of the Technical Seed Document to chronicle revisions made to the Wetlands Restoration Protocol following the submission of the original Technical Seed Document.

The proposed Wetlands Protocol, because of the GHG dynamics of wetlands restoration, will comprise both reduction credits and removal (or biological sequestration) credits. The reduction credits will be generated using a net removal (or sequestration) coefficient, which quantifies the rate of organic carbon storage in soils of restored wetlands in excess of the estimated increase in CH_4 or N_2O emissions. The net carbon removal is subject to potential impermanence, or reversals. The Technical Seed Document will address the issues associated with the reduction/removal character of the proposed Protocol.

A Consultation Workshop was initiated to engage key scientific researchers, technical experts and project developers, to provide advice and agreement on the best available quantification methodologies to assess GHG emissions. The decisions of the Consultation Workshop were guided by two Science Discussion Documents.

This Consultation Workshop resulted in consensus decisions concerning the development of the Wetlands Protocol, and concerning science gaps remaining to be addressed. The main decisions were:

1. Scientific evidence exists to develop a protocol to quantify net GHG emissions reductions and removals associated with functional prairie wetlands to create real and verifiable offsets;
2. Existing practice concerning wetlands restoration in the Prairie Pothole Region allows the development of a GHG quantification protocol to create real and verifiable offsets;
3. A large proportion of wetlands and associated uplands in the Prairie Pothole Region of Canada have been degraded as a result of landscape alteration and therefore it is reasonable to assume the vast majority wetlands in this region have been subjected to or are vulnerable to wetland loss;

4. The **wetland basin** will be defined as the area extending from the centre of the wetland to the outer edge of the wet meadow zone. It is understood that the size and location of the wetland basin fluctuates within and among years depending on hydrologic condition (wet/dry periods), up to and including the overflow/spill elevation;
5. The wetland margin will be defined as the area extending from the outer edge of the wetland basin to the outer edge of the toe slope;
6. The **wetland** will be defined to include the area of the wetland basin and wetland margin;
7. The **upland** will be defined as the area contributing surface runoff to the wetland zone and is composed of the landscape that is up gradient of the toe slope, but does include the foot slope;
8. The proposed Wetland Protocol will define wetland loss as including infilling, altering, or physically draining the wetland, any transitory or permanent degradation of the wetland basin and/or margin, and any type of interference with the hydrology to and from the wetland;
9. The proposed Wetlands Protocol will be designed to allow project proponents to use complementary protocols to generate GHG reductions and removals in the wetland margin and associated upland.

The Consultation Workshop Report provided the foundation of further protocol development effort by summarizing decisions to date, and by describing the gaps to be addressed in the preparation of the original Technical Seed Document.

Two types of gaps raised at the Consultation Workshop needed to be addressed in the preparation of the original Technical Seed Document. First, some polling points received agreement as the total of the two categories ‘Accept’ and ‘Accept with more work’, but outcomes with a high proportion of the ‘Accept with more work’ category must be addressed before the original Technical Seed Document was completed. Second, some gaps to be filled before completion of the original Technical Seed Document were identified during discussion between polling points throughout the Consultation Workshop.

With respect to the definitions of wetlands and the means to identify and to delineate wetlands for restoration, Ducks Unlimited Canada prepared a Procedures Document (see attachment) to address gaps identified at the Consultation Workshop and to provide full details to be used in implementing the Wetlands Restoration Protocol.

Also, Pascal Badiou has prepared a manuscript to synthesize the results of recent research to address the science gaps identified at the Consultation Workshop. This manuscript (see attachment) is ready for submission to a scientific journal.

In the later stages of development of the Wetlands Restoration, significant changes were made which were not captured or justified in the original Technical Seed Document. These changes primarily reflected requests from Alberta Environment for more prescriptive requirements concerning project documentation. The comments and concerns expressed by Alberta Environment were taken into consideration and addressed in the quantification protocol submitted for the First Round of Technical Review. The Alberta Environment's comments, the resultant changes to the Wetlands Restoration Protocol, and the rationale for these revisions are detailed in this revised Technical Seed Document (Section 7).

1.1 Background

1.1.1 Canada's National Inventory Report

Canada's National Inventory Report relies on International Panel for Climate Change (IPCC) guidance, and in some cases refines IPCC coefficients and factors using country-specific data and expert judgment. To date, IPCC has not published guidance concerning GHG emissions from conserved and restored wetlands and Canada's National Inventory Report does not address this kind of land use change.

Wetlands are addressed under the Land Use, Land Use Change and Forestry (LULUCF) section in Canada's National Inventory Report. The LULUCF Sector addresses GHG fluxes between the atmosphere and Canada's managed lands, as well as those associated with land-use changes. A LULUCF assessment includes emissions and removals of CO_2, and additional emissions of CH_4 and N2O following land conversion to cropland.

In this regard, wetlands are addressed within the LULUCF framework in terms of emissions changes when wetlands remain wetlands and when land is converted to wetlands. Within the LULUCF framework, wetlands are described as "areas where permanent or recurrent saturated conditions allow the establishment of vegetation and soil development typical of these conditions and that are not already in forest land, cropland, or agricultural grasslands". Due to this exact classification of wetlands, wetlands currently situated within agricultural land in the Prairie Pothole Region cannot be addressed simply as wetlands, but must fall under the additional category of "managed wetlands". Managed wetlands are defined as areas where human interventions have altered the water table (e.g. draining of wetlands in the Prairie Pothole Region for cropland).

Additionally, within the LULUCF framework wetlands are further categorized as either managed peatlands or flooded lands (reservoirs). Given that wetlands within the Prairie Pothole Region of Canada are either drained for cropland use, or exist in their natural state (not considered a peatland, and only flooded for parts of the year), a quantification approach is needed to address the unique physiological characteristics of these mineral wetlands.

The Canadian National Inventory Report addresses GHG emissions from wetlands as follows;

- In accordance with IPCC guidance (IPCC 2006), two types of managed wetlands are considered;

- Where human intervention has directly altered the water table level and thereby the dynamics of GHG emissions/removals.
- Peat lands that are drained for peat harvesting; and flooded land (namely, the creation of reservoirs).
- GHG emissions from cropland and grassland converted to wetlands are not estimated in the national inventory.

The IPCC, which guides the development of Canada's National Inventory Report, notes that restoration of wetlands is becoming a more prevalent land management change. But, in the most recent IPCC guidelines, this activity is set aside for 'future methodological development'. The following excerpt summarizes the status of conserved and restored wetlands in IPCC (IPCC 2006, p. 7.22):

> "At the time of preparation of these *Guidelines*, published studies based on observational data are too recent and limited to develop default emission factors for any of the major greenhouse gases — CO_2, CH_4 or N_2O. Better understanding of the biogeochemical fluxes within drainage basins will be needed to prevent double-counting emissions due to fertilizer application and waste treatment. Hence, the estimation of greenhouse gas emissions and removals from restored or constructed wetlands remains an area for further development."

Although Canada's National Inventory report should be consulted and considered when developing GHG quantification guidelines and programs in Canada, it relies on IPCC guidance, and therefore does not appear to address wetland restoration activities in the specialized manner needed for development of a Wetlands Protocol. It is important to note current land-based quantification protocols approved for the Alberta Offset System, and those submitted for initial consideration to Canada's Offset System, use factors and equations derived by scientists responsible to populate Canada's National Inventory Report.

1.1.2 Agriculture and Wetlands Greenhouse Gas Initiative (AWGI)

A significant and ongoing research program pertinent to the quantification of GHG emissions and potential GHG reductions in wetlands of Canada is the Agriculture and Wetlands Greenhouse Gas Initiative (AWGI). Major funding for this initiative is provided by Agriculture and Agri-Food Canada, Environment Canada, Natural Resources Canada, Ducks Unlimited Canada, and Natural Resources Engineering Research Council of Canada/BIOCAP Strategic Grant. This project uses a landscape approach to examine the functional linkages between prairie wetlands, riparian areas and their adjacent agricultural fields in terms of carbon sequestration and greenhouse gas (GHG) flux. The major objectives of this project include:

- A quantitative assessment of the role of prairie wetlands and riparian areas as net carbon sinks, including carbon storage and GHG emissions.

- Recommendations for beneficial management practices for agricultural land adjacent to wetlands that will enhance the carbon sink potential of uplands, riparian areas, and wetlands.
- Development of support systems based on partnerships to assist landowners with GHG management of their wetlands.

As the AWGI project was completed in 2009, few of the research results have been published as yet in the peer-reviewed literature. A synthesis of this research was provided by Pascal Badiou at the Consultation Workshop. Graduate theses, conference presentations, progress reports have been completed, and some final results have been compiled and shared among collaborators.

Some of the preliminary AWGI research concludes that restored wetlands are net sinks of GHGs and sequester 9.6 Mg CO_{2eq} ha^{-1} $year^{-1}$ (range 7.3 – 11.8). Additionally, results on other aspects of GHG flux from PPR wetlands support the conclusion that:

- CH_4 flux decreases with increasing SO_4 concentration in wetland water — negligible CH_4 was measured in water with SO_4 concentration ≥ 200 mg L^{-1}
- C sequestration rate based on SOC difference between short-term and long-term restored wetlands: 11.8 Mg CO_{2eq} ha^{-1}
- GHG (CH_4 + N_2O) flux rate from Prairie wetlands: Mean = 2.2 Mg CO_{2eq} ha^{-1}, Range (0.1 – 4.5 Mg CO_{2eq} ha^{-1})

1.1.3 ISO 14064-2 Standard and the Alberta Offset System

Since the ISO 14064-2 standard continues to emerge as a premier standard for quantifying GHG reduction credits in both compliance and voluntary markets, this TECHNICAL SEED DOCUMENT will be equally applicable to compliance and voluntary carbon markets in North America. As such, the ISO 14064-2 standard (2006, Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements) is the framework for protocols in the Alberta Offsets System and in the proposed Canada's Offset System, as well as in a number of US programs (Voluntary Carbon Standard, CAR, RGGI, etc.).

1.1.4 Technical Background Document (TBD)

A Technical Background Document was compiled by ClimateCHECK in collaboration with the Technical Working Group. The Technical Background Document (1) provided information from which an expert panel could assess emission reduction coefficients, and (2) identified gaps in knowledge and proposed conservative coefficients with which to conduct an expert assessment and opinion in accordance with ISO-14064:2 quantification principles. The primary GHGs considered in the report were carbon dioxide, nitrous oxide, and methane. Furthermore, the various issues addressed in the Technical Background Document were developed more comprehensively in the two Science Discussion Documents.

The Technical Background Document concluded that "the existing data and discussions within the scientific community appear to support the consensus of opinion that conserved or restored wetlands of the Prairie Pothole Region represent net GHG sinks. However, this consensus also supports an emphasis that site-specific factors must be controlled to limit positive GHG flux from conserved and restored wetlands."

An important outcome of the Technical Background Document was the understanding that Canada's National GHG Inventory Report does not provide a method to quantify net reductions from conservation and restoration of wetlands in the Prairie Pothole Region. This outcome created a challenge for the development of the proposed Wetlands Protocol; namely, to develop a quantification and implementation approach at a high level of credibility, but sensitive to the site-specific factors governing net GHG dynamics in the wetlands of the Prairie Pothole Region.

1.1.5 Science Discussion Document 1 - Implementation

In protocol development efforts under the defunct National Offsets Quantification Team process and within the required process for protocol approval of the Alberta Offsets System, the policy or implementation requirements as well as the science or quantification requirements of a protocol are discussed in a single Science Discussion Document. However, the Phase 1 efforts for the development of the proposed Wetlands Protocol determined the need for separate Discussion Documents for the implementation and quantification components. The main reason for the separation is the unusually complex nature of the development effort required for the quantification component for the proposed Wetlands Protocol. That is, since no quantification approach for wetlands restoration is included in Canada's National Inventory Report, the Wetlands Protocol quantification approach must be developed on the basis of research data and expert judgment.

The policy pertinent to GHG reductions associated with land use change and avoided land use change is evolving. Therefore, the Implementation Discussion Document focused on supporting consensus among policy decision-makers and technical experts concerning issues of additionality or incrementality, permanence, and leakage. These issues were addressed in the context of global GHG programs, and were ultimately structured according to principles in compliance with the emission reductions criteria of ISO 14064-based North American GHG programs.

The policy or implementation framework of the Wetlands Restoration Protocol ("Wetlands Protocol"), as proposed in the "Implementation Discussion Document", was based on the criteria of the ISO 14064-2 standard, and was designed according to the requirements of the Alberta Offsets System. Additionally, an important frame of reference for further development of the implementation aspects of the Wetlands Protocol is the experience gained by Ducks Unlimited Canada and other agencies through completion of restoration projects.

The Implementation Discussion Document provided decision points regarding definitions and delineation of wetlands and wetland loss. The wetland is defined to include both the wetland basin and margin. The upland is the area contributing run-off to the wetland. And, wetland loss involves degradation of the wetland and/or upland. Further, global GHG policy and national wetlands policy were also addressed in the Implementation Discussion Document to describe the context within which the implementation aspect of the Wetlands Protocol is developed. Momentum in the global compliance and voluntary GHG programs is focused on avoided deforestation and degradation and on wetlands with biological and hydrological characteristics different than those for the Prairie Pothole Region. So, although these advancements provide effective but indirect support, the design and development of the Wetlands Protocol will require extraordinary innovation and effort.

The Implementation Discussion Document provided the foundation for the implementation decisions concerning the scope of the Wetlands Protocol. As such, the Wetlands Protocol will be designed to include restoration projects on private lands in the Prairie Pothole Region of Canada. The Wetlands Protocol will apply to the restoration of seasonal (class 3), semi-permanent (class 4), and permanent (class 5) wetland. For restoration projects, the Implementation Discussion Document proposed that the Wetland Protocol should prescribe improved management of the uplands in addition to the practices prescribed for management of the wetland basin and margin.

The Implementation Discussion Document also proposed (and the subsequent discussion confirmed) that the 'business as usual' scenario in the Prairie Pothole Region involves degradation or destruction of the vast majority of wetlands. Options for approaches to determine and justify this baseline scenario are presented. As well, the Implementation Discussion Document described a number of barriers to support the conclusion that the Wetlands Protocol prescribes practices which are additional to business as usual.

Additionally, the Implementation Discussion Document proposed that criteria of ownership, permanence, and leakage are best developed for the Wetlands Protocol using the procedures, systems, and databases of Ducks Unlimited Canada and similar agencies. Future assessments of leakage and permanence will be limited to within the Prairie Pothole Region of Canada, and will be addressed using databases of Ducks Unlimited and other agencies as enhanced by the results from the projects completed under the Wetlands Protocol.

1.1.6 Science Discussion Document 2 - Quantification

The Quantification Discussion Document was prepared as a companion piece to the Implementation Discussion Document, focusing on the details of quantifying GHG reductions and removals associated with the restoration of class 3-5 wetlands in the Prairie Pothole Region of Canada.

The science is emerging regarding quantification of emissions of GHG from conserved and restored wetlands, and from the pristine and agricultural lands surrounding these wetlands. Therefore, the Quantification Discussion Document focused on discovering and supporting consensus among scientific researchers and technical practitioners concerning quantifiable and verifiable restoration practices and GHG quantification methodologies to meet the emission reductions criteria of ISO 14064-based North American GHG programs. The researchers and practitioners then gathered at a Consultation Workshop where consensus was sought based on questions posed in this Quantification Discussion Document.

The science or quantification framework of the Wetlands Restoration Protocol ("Wetlands Protocol"), as proposed in the "Quantification Discussion Document", is based on the criteria of the ISO 14064-2 standard, and is designed according to the requirements of the Alberta Offsets System. An important frame of reference for further development of the quantification aspects of the Wetlands Protocol is the experience gained by Ducks Unlimited Canada and other agencies through completion of restoration projects.

The Quantification Discussion Document provided discussion points pertaining to quantification of net GHG removals in restored wetlands. Canada's National Inventory Report does not provide a method to complete this quantification, so the emphasis of the Quantification Science Discussion Document was on compilation and interpretation of scientific evidence relevant to the seasonal or semi-permanent wetlands on mineral soil of the Prairie Pothole Region.

The Quantification Discussion Document identified, described, and assessed for relevance the GHG sources, sinks, and reservoirs within the scope of the proposed Wetlands Protocol.
The Quantification Discussion Document also compiled the comprehensive research results reported by credible research organizations are available to assess the net GHG reductions and removals associated with restoration of wetlands of the Prairie Pothole Region. Previously published research provided evidence that conserved or restored wetlands sequester more soil organic carbon than do drained and cultivated wetlands. Further, recent research by the Agriculture and Wetlands Greenhouse Gas Initiative (AWGI) provides evidence that the flux of methane and nitrous oxide associated with restored wetlands is small relative to the sequestered carbon (standardized in terms of CO_2e).

In addition to the aspects covered above, the Quantification Discussion Document addressed the difficulty of developing detailed documentation for the procedures and controls needed to delineate, restore, and monitor the activities to be prescribed under the proposed Wetlands Protocol.

1.1.7 General Scientific Literature

Most scientific literature addresses carbon dynamics and GHG flux for permanent wetlands with organic soils (including peatlands), while the wetlands in the Prairie Pothole Region tend to be seasonal or semi-permanent on mineral soil. Mitsch and Gosselink (2007) conclude, using average global carbon sequestration and methane emission estimates, “the overall impact of wetlands on climate change in the carbon cycle is minimal”.

Thus, an important consideration in reviewing current scientific literature concerning wetlands is to distinguish between wetlands on organic and mineral soils. The existing peer-reviewed literature, with a focus on the wetlands in temperate climates and on mineral soils, appears to support the conclusion that there would be a net decrease in GHG emissions and net increase in carbon sequestration associated with wetland restoration projects in the Prairie Pothole Region. The introductory report by the Prairie CO_2 Reduction (PCOR) Partnership (Gleason *et al.* 2005) emphasizes the evaluation of net GHG emissions associated with restoration activities in the Prairie Pothole Region needs to use data and knowledge specific to this region. The following excerpt highlights this distinctive character, and therefore the limited knowledge base, concerning wetlands in the Prairie Pothole Region (Gleason *et al.* 2005, page 14):

"Studies suggest that wetlands contribute 20% to 40% of the annual global atmospheric CH_4 flux; however, the lowest emissions come from temperate regions (10% of total wetland flux; Bartlett and Harriss, 1993) such as the PPR. Most studies demonstrating high emission of CH_4 are from permanently inundated marshes and peatlands (Updegraff et al., 2001; Whiting and Chanton, 2001) where the combination of organic soils and lengthy periods of soil reduction maximize CH_4 production. In contrast, most restored prairie wetlands are only seasonally inundated and have mineral soils (Order Mollisols) that in combination are less conducive for CH_4 production. Consequently, the notion that high CH_4 emissions may come from prairie wetlands has been influenced by studies conducted outside the PPR."

Further, Gleason *et al.* (2005) point out the breadth of knowledge required to understand GHG dynamics in degraded and functioning wetlands, pointing out the inter-relatedness of upland management and wetland GHG emissions. An effective summary of the GHG-related opportunity and challenge concerning restoration of wetlands in the Prairie Pothole Region, despite current gaps in knowledge, is provided in the following excerpt for the PCOR report (Gleason *et al.* 2005, page 14-15):

"Although there are valid concerns over the release of CH_4 and N_2O emissions from restored wetlands, limited data suggest that restoration of previously farmed wetlands may actually reduce emission of these GHGs. Data from a glaciated region in north-eastern Germany similar to the PPR suggests that enrichment of wetlands by nitrogen fertilizers and accelerated mineralization of soil organic matter elevates the emission of CH_4 and N_2O (Merbach et al., 2002). The emission of CH_4 and N_2O from German wetlands has been shown to increase up to 35-fold because of eutrophication of wetland basins by agricultural fertilizers. These findings from Germany are consistent with conceptual models and findings from field studies saying that nitrogen fertilization overloads the assimilative capacity of plants and microorganisms, resulting in enhanced emission of N_2O (Davidson et al., 2000). Most wetlands in the PPR are embedded in an agricultural landscape where they receive agricultural runoff-laden sediment and agricultural fertilizers (Gleason and Euliss, 1998). Consequently, converting cultivated cropland to permanent grass within restored wetland catchments should reduce nutrient enrichment in restored wetlands and lower emissions of N_2O and, possibly, CH_4 from wetland basins. Any reduction in emissions of CH_4 and N_2O that results from restorations would represent an additional GHG reduction benefit. Currently, there is no published literature on emission of CH_4 and N_2O from PPR wetlands. However, studies have been initiated in the United States and Canada by PCOR Partnership partners to evaluate the potential of restored wetlands to reduce emissions of CH_4 and N_2O."

The PCOR Partnership project, and the research ongoing and completed by members of PCOR, is a significant resource used to develop the proposed protocol.

Bedard-Haughn *et al.* (2006) used extensive contour-directed sampling to compare SOC of uncultivated, cultivated, and native wetlands in a site in Saskatchewan as follows:

SOC density to 45 cm was assessed at seven uncultivated wetlands, seven cultivated wetlands, and twelve native wetlands. Mean SOC density decreased from 175.1 mg ha^{-1} to 30 cm (equivalent mass depth) for the native wetlands to 168.6 mg ha^{-1} for the uncultivated wetlands and 87.2 mg ha^{-1} for the cultivated wetlands in the agricultural field.

This detailed approach enhanced understanding of the increasing density of SOC towards the centre of the wetland basins (Figure 3), and also provided an estimate of the rate and variability of SOC density increase associated with wetland restoration (Table 5). However, in this study restoration involved cessation of cultivation and establishment of grassland, and did not result in creation of prolonged anaerobic conditions. In this study, gross estimated gain of SOC density was 3.8 Mg CO_2e ha^{-1} $year^{-1}$.

Table 1: Mean density of soil organic matter (SOC) in basins at the St. Denis National Wildlife Area (SDNWA) and nearby native sites. From Bedard-Haughn et al. 2006.

Row	Wetland class	Wetland	*N* [a]	Soil organic carbon	
				SOC_{eqm} to 30 cm (Mg ha^{-1})	
				Mean	S.D.
1	Cultivated	102	9	86.1	21.7
2		104	11	131.2	46.5
3		108	4	78.8	35.8
4		118	9	82.7	29.2
5		102a	16	91.0	28.8
6		104a	8	80.7	21.8
7		105a	8	59.8	22.6
8	Uncultivated	99	6	242.9	69.6
9		100	6	204.3	16.9
10		117	24	100.9	36.1
11		120	62	219.3	91.0

12		103	4	136.7	36.0
13		105	6	150.2	32.0
14		119	4	125.7	21.1
15	Native	N1	5	169.4	17.9
16		N2	6	159.9	22.9
17		N3	6	219.9	48.4
18		N4	5	224.1	50.6
19		N5	5	156.0	20.1
20		N6	5	133.8	28.7
21		N7	5	203.8	29.9
22		N8	6	301.5	68.8
23		N9	4	129.6	16.2
24		N10	4	138.3	30.5
25		N11	5	137.1	41.3
26		N12	4	127.4	10.0
27	Cultivated		7	87.2	21.7
28	Uncultivated		7	168.6	21.5
29	Native		12	175.1	52.8

[a] *N*: number of samples within a given wetland for rows 1-26

1.2 Glossary of New Terms

Qualified Wetland Aquatic Environment Specialist (QWAES): an expert with detailed knowledge of the aquatic environment, wetland soils, wetland species, hydrology and wetland margin habitat and their management or assessment. Credentials of the QWAES are described in the Guide to the Code of Practice for Pipelines and Telecommunication Lines Crossing a Body of Water (Alberta Environment 2007a).

Stewart and Kantrud (1971) wetland classification system:

- **Class I - Ephemeral Wetlands** typically have free surface water for only a short period of time after snowmelt or storm events in early spring. Because of the porous condition of the soils, the rate of water seepage from ephemeral wetlands is very rapid after thawing of the underlying frost seal. They may be periodically covered by standing or slow moving water. Water is retained long enough to establish some wetland or aquatic processes. They are typically dominated by Kentucky bluegrass, goldenrod and other wetland or low prairie species.
- **Class II - Temporary Wetlands** are periodically covered by standing or slow moving water. They typically have open water for only a few weeks after snowmelt or several days after heavy storm events. Water seepage is fairly rapid, but surface water usually lingers for a few weeks after spring snowmelt and for several days after heavy rainstorms at other times of the year. Water is retained long enough to establish wetland or aquatic

processes. They are dominated by wet meadow vegetation such as fine-stemmed grasses, sedges and associated forbs.

- **Class III - Seasonal Ponds and Lakes** are characterized by shallow marsh vegetation, which generally occurs in the deepest zone (usually dry by midsummer). These wetlands are typically dominated by emergent wetland grasses, sedges and rushes.
- **Class IV - Semi-permanent Ponds and Lakes** are characterized by marsh vegetation, which dominates the central zone of the wetland, as well as coarse emergent plants or submerged aquatics, including cattails, bulrushes and pondweeds. These wetlands frequently maintain surface water throughout the growing season, i.e., from May to September.
- **Class V - Permanent Ponds and Lakes** have permanent open water in central zone that is generally devoid of vegetation. Submerged plants may be present in the deepest zone, while emergent plants are found along the edges. Plants commonly present in these wetlands include cattails, red swampfire and spiral ditchgrass.
- **Class VI - Fen Ponds** are wetlands in which fen vegetation dominates the deepest portion of the wetland area. This wetland type often has wet meadow and low prairie vegetation present on the periphery. The soils are normally saturated by alkaline groundwater seepage. Fen ponds often have quaking or floating mats of emergent vegetation, which includes sedges, grasses and other herbaceous plants.

Upland — will be defined as the area contributing surface runoff to the wetland zone and is composed of the landscape that is upgradient of the toe slope, but does include the foot slope.

Wetland — includes the area of the wetland basin and wetland margin.

Wetland Basin — is the area extending from the centre of the wetland to the outer edge of the wet meadow zone. It is understood that the size and location of the wetland basin fluctuates within and among years depending on hydrologic condition (wet/dry periods) [.. up to and including the overflow/spill elevation].

Wetland Loss — includes infilling, altering, or physically draining the wetland, any impact to the riparian area and buffers strips, and any type of interference with the hydrology to and from the wetland.

Wetland Margin — is the area extending from the outer edge of the wetland basin to the outer edge of the toe slope. [floodplain]

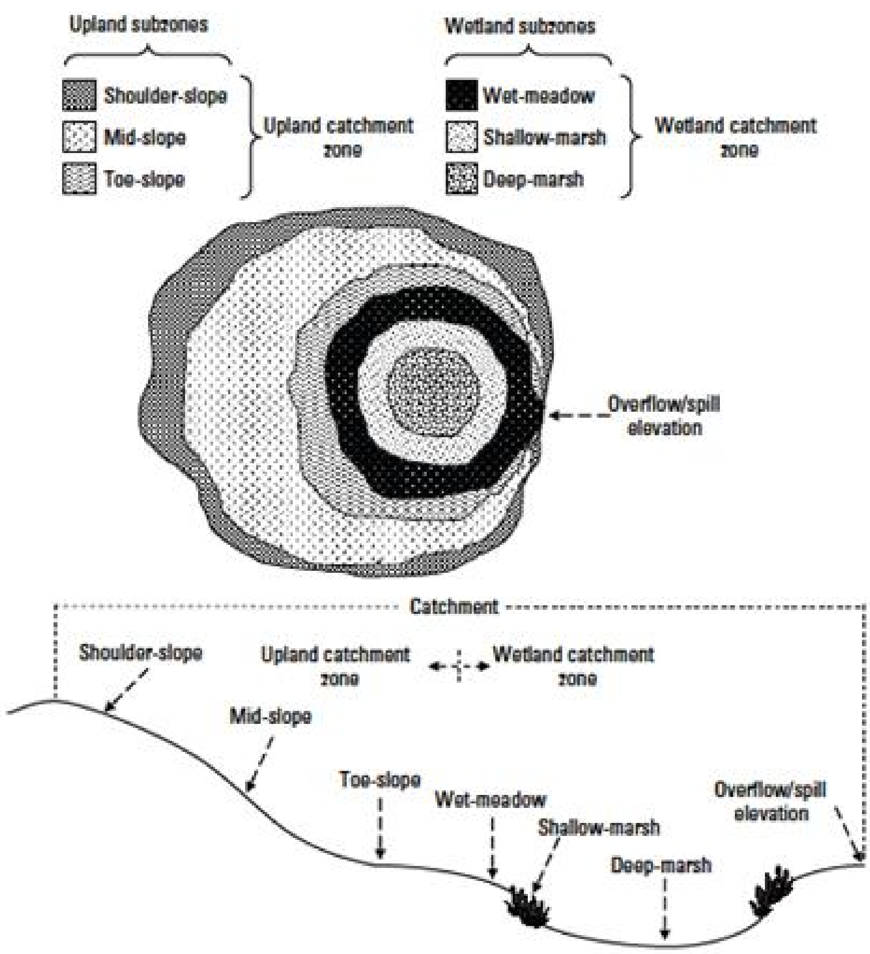
Wetland Restoration — re-establishment of a naturally occurring wetland with a functioning natural ecosystem whose characteristics are as close as possible to conditions prior to drainage or other alteration. Restoration activity thus includes:

- Termination of burning, clearing, and cultivating of the wetland margin;
- Improvement of management of the wetland margin;
- Improvement of management of the upland; and
- Reversal of drainage and filling.

1.2.1 Wetlands Definition

The functional definition of wetland basin within the scope of this manual is based on a geomorphic description that incorporates both topographic and vegetative indicators. Gleason et al. 2008 characterizes the entire wetland catchment or contributing area by distinguishing between upland and wetland zones. The **wetland basin** is defined as the entirety of the wetland zone extending outward from the deepest portion of the wetland to the outer perimeter of the wet meadow zone. The wetland basin is comprised of the Deep Marsh, Shallow Marsh, and Wet-meadow wetland subzones and is subject to change in extent and composition in response to variable hydrologic conditions. As a functional definition within this manual the term **wetland** includes the wetland basin as well as the wetland margin that corresponds with outflow/spill elevation. (Figure 1) This topographic definition of **wetland** includes the wetland basin which is frequently inundated or saturated extending outward to the surrounding flood plain which is infrequently flooded or saturated in response to large meteorological events.

Figure 1: Wetland Definition



Adapted from Gleason *et al*. 2008.

The wetland water balance is controlled by redistribution of snow from adjacent uplands, incident precipitation, local runoff, evapotranspiration, groundwater exchange, and antecedent status of soil and depressional storage (Fang and Pomeroy 2008; van der Kamp and Hayashi 2009). Dependant on water balance, wetlands will vary from shallow and seasonal to deeper and relatively permanent (Pomeroy *et al.* 2009).

1.2.2 Ducks Unlimited Procedures Document

Ducks Unlimited Canada personnel involved in operation of wetlands restoration projects have compiled a Manual to guide implementation of the procedures needed for participation in the wetlands Protocol.

The purpose of this manual is to provide practical and repeatable technical guidelines necessary to define the extent of restored wetlands within the Alberta Offset System. Restored wetland area delineated using this methodology will serve as the basis to apply coefficients necessary to quantify GHG emission reductions associated with restoration of wetlands in the PPR in Alberta. The application of the method will generate appropriate data to verify the location and extent of restored wetlands while establishing a baseline for compliance monitoring throughout the lifespan of the agreement with the landowner.

It is the objective of the manual to:

1. Present heuristic guidelines for establishing a historical benchmark and determining physical wetland restoration opportunities.
2. Present appropriate survey methods and specifications to accurately delineate restored wetlands for incorporation into the wetland protocol.
3. Establish a framework for capturing the 'Asbuilt' condition of restored wetlands appropriate to determine the carbon sequestration value of restored wetland within the protocol.
4. Provide monitoring guidelines for insuring compliance on the restoration projects under the protocol

The full text of this Procedures Document is included as an attachment to this Technical Seed Document. And, the details provided in the Procedures Document are inserted as appropriate throughout the Technical Seed Document. The guidance of the Procedure Document will be incorporated into the Wetlands Protocol as formatted for submission to the review process of the Alberta Offset System.

2 Scope and Applicability of Protocol

Determining the appropriate scope of the proposed Wetlands Protocol involves discussion of policy or implementation components as well and discussion of science or quantification components. In terms of quantification of GHG emissions associated with restored wetlands, numerous studies support the conclusion that upland land use influences wetland GHG dynamics. For example, unless the upland is managed to prevent excess accumulation of soluble nitrogen in the soil, the potential exists for emissions of N_2O from the wetland in sufficient magnitude to make the restored wetland a net source of emission reductions (Merbach *et al.* 2002, Gleason *et al.* 2005).

In terms of the implementation component, determining the scope of the Wetlands Protocol involves consideration of three issues. First, the issue of whether to include both conserved and restored wetlands within the Protocol must be considered. Second, the types of wetlands to be included needed to be determined. Third, the boundary of the Protocol needs to be addressed. It was decided, via voting at the Consultation Workshop, that both the conservation and the restoration of wetlands would be included in the scope of the protocol. However, based on guidance received from Alberta Environment, only wetland restoration is addressed in this Technical Seed Document. At the Consultation Workshop, participants agreed only Classes III through V, as classified in the Stewart and Kantrud scheme, should be included in the scope of the Wetlands Protocol. With respect to protocol boundary, the Implementation Science Discussion Document noted that the proposed protocol needs to address management of soil, plants, and nutrients on land surrounding the wetlands. Consistent with the definition of wetlands, the scope of the proposed Wetlands Protocol will be designed to accommodate the inter-relatedness of upland management and wetland GHG emissions and reductions.

Additionally, the scope of the "procedures document" was stated to apply to drained freshwater mineral wetlands (Lentic) in the Prairie and Parkland Ecoregions of Alberta. Prior to the construction of agricultural drainage infrastructure these Seasonal to Permanent wetlands were closed basins forming internally drained areas that under normal conditions were isolated from natural external drainage systems.

In conclusion, the proposed Wetlands Protocol would encompass the restoration of drained wetlands and potentially the conservation of existing wetlands in the near future. In both instances, the baseline scenario (that is, the activities and emissions occurring in the absence of the project) involves SSRs associated with a drained wetland. And, in both instances, the project involves SSRs associated with a functional wetland. GHGs included within the scope of the proposed protocol include emissions of N_2O and CH_4, as well as SSRs where carbon is sequestered. But, only the SSRs for restored wetlands are addressed in this Technical Seed Document.

Details concerning specific aspects of the scope of the proposed protocol are provided in the following subsections.

2.1 Determination of Appropriate Scope

In order for the restoration of wetlands to be an eligible category (and thus included within the scope of the proposed protocol) that accrues additional or incremental reductions and removals of GHGs, it is necessary to demonstrate that drained wetlands are remaining under alternative land use. The following decision point for the Workshop regarding eligible categories was therefore proposed and agreed upon:

> "Such a large proportion of wetlands and associated uplands in the Prairie Pothole Region of Canada have been degraded as a result of landscape alteration that it is reasonable to assert the vast majority wetlands in this region are subject to wetland loss."

With respect to boundaries, the Implementation Discussion Document noted that the proposed protocol may need to address management of soil, plants, and nutrients on land surrounding the wetlands. Consistent with the definition of a wetland, the scope of the proposed Wetlands Protocol could be designed to accommodate the inter-relatedness of upland management and wetland GHG emissions and reductions. Based on this, the following decision points for the workshop regarding boundaries were proposed and agreed upon (although only considered "acceptable with more work"). The implementation Science Discussion Document included a decision point for deciding eligible restoration activities. As such "In the proposed Wetlands Protocol, restoration will include activity to reverse wetland loss as a result of permanent impacts (Turner et al. 1987). Thus, restoration activity involves:

1. Termination of burning, clearing, and cultivating of the wetland margin; and
2. Managed grazing and haying in the wetland margin,
3. Improvement of management of the associated upland, and
4. Reversal of drainage and filling."

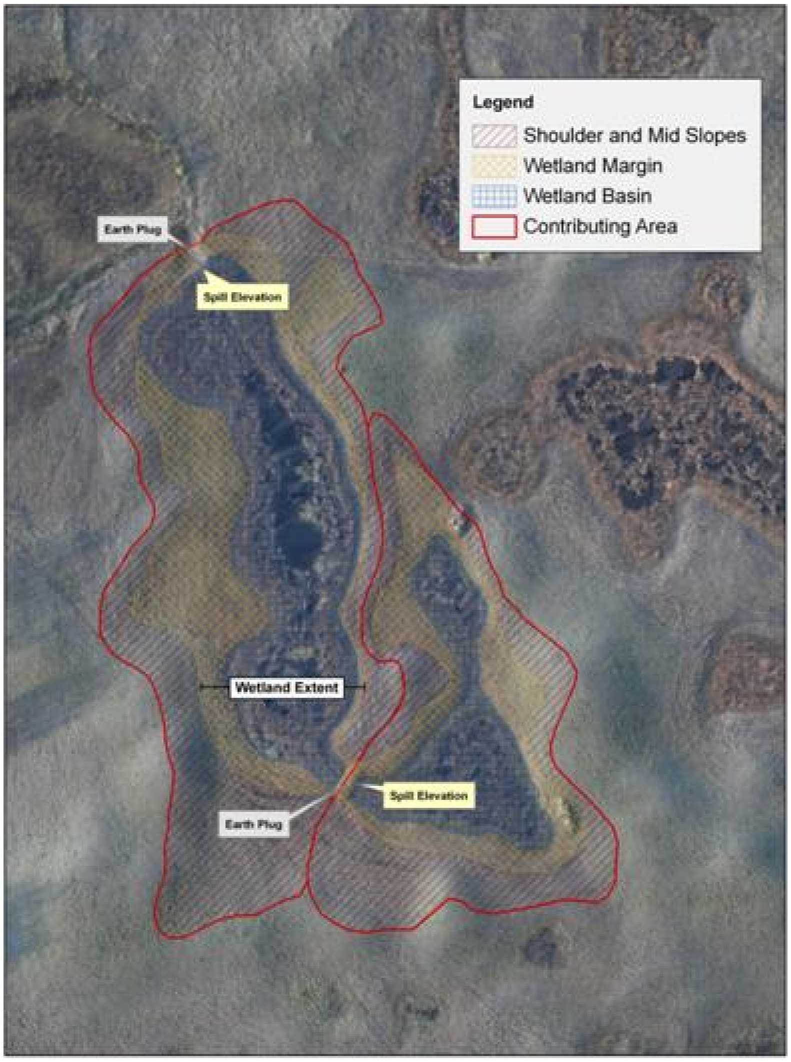
Improved management of associated uplands should require these uplands to be managed according to approved GHG reduction protocols appropriate for the upland land use. For example, associated cropland could be managed according to the practices prescribed by the Tillage System Management Protocol and the forthcoming Nitrous Oxide Emission Reduction Protocol. Or, associated grassland should be managed according to a specified grassland management protocol.

The proposed Wetlands Protocol will also be designed to allow project proponents to use complementary protocols to generate GHG reductions and removals in the wetland margin and associated upland.

2.1.1 Intent of Wetland Restoration and Site Suitability

The intent of wetland restoration is to re-establish as close to possible the natural flood regime of the wetland. Construction of appropriately sized earth plugs at specific locations, graded to historical basin elevation will re-establish the flood regime of the wetland. The re-establishment of the flood regime over a period of years will recreate anaerobic soil conditions and consequently re-establish the hydrophytic communities adapted to thrive in these environments. Figure 2 graphically illustrates the intent of restoration in conjunction with the wetland definition previously discussed.

Figure 2: Restored Wetlands



The viability of physical restoration must consider:

1. The location of the historical basin edge estimated through analysis of historical aerial photography, confirmed in the field using expert judgment by a qualified wetland restoration technician.
2. The depth of the drained wetland, expert judgment is required to determine if the restored wetland depth has the potential to be restored to Seasonal, Semi-permanent or Permanent wetland class as defined by (Stewart and Kandrund 1971).

3. The dimensions of earth plug required to re-establish hydrology at the historical basin margin confirmed in the field by a qualified wetland restoration specialist. The earth plug must be appropriately sized to manage the volume stored at full supply level at the historical basin margin.
4. The morphology of the wetland's contributing area and the potential for large meteorological events for washing out the structure. The earth plug must be appropriately sized to manage the volume stored anticipated to accumulate in large events. Furthermore, the earth plug must be appropriately shaped to allow outflow around the plug when stored water levels exceed full supply.
5. The size of the backflood area behind the earth dam and the potential to flood adjacent properties upstream and the potential to cause downstream damages in the event of earth plug failure.
6. The size of the wetland margin and the willingness of the landowner to change land use in conjunction with restoration of the basin area.

Further information is provided Appendix B (the Technical Seed Document Procedures document). The "Procedures Document" provides information on the practical and repeatable technical guidelines necessary to define the extent of restored wetlands within the Alberta Offset System. A restored wetland area delineated using the Procedures Document will serve as the basis to apply coefficients necessary to quantify GHG emission reductions associated with the restoration of wetlands in the Prairie Pothole Region.

2.1.2 Drained Wetland Targets

A drained wetland occurs when surface or ground water has been removed by artificial means such that the area will no longer support hydrophytic vegetation (CE, 1987). The construction of drainage infrastructure into the wetland basin in effect lowers the spill elevation, altering the depressional storage capacity of the wetland, disrupting the natural flood regime of the wetland basin. This hydrologic disturbance alters the extent and duration of flooding and consequently removes the anaerobic soil conditions which support the hydrophytic communities within the wetland basin (CE, 1987).

From a wetland definition perspective the identification of drained wetlands remotely or in the field is difficult given that two primary indicators of wetland have been removed from the depression. Hydrologic indicators are only present for brief periods during large meterologic events and vegetation indicators can no longer persist in the altered hydrologic condition or have been directly removed by annual cultivation. Often, the only remaining indicator available to confirm the historical presence or to define historical wetland extent would be the presence and extent of hydric soils (CE, 1987). Comprehensive soil sampling as a means to locate drained wetlands is viewed as impractical for operational restoration. The practical alternative is to rely on historical aerial photography and field observations to determine the historical presence of a wetland basin and to estimate historical wetland extent (restoration potential).

The removal of key wetland indicators from the basin poses similar challenges for determining the permanence class achievable through restoration. Traditional field classification or typing of the wetland is not possible due to disruption of the hydrologic regime and consequently the removal of vegetation indicators. Thus, maximum depth of the wetland measured at the deepest portion of the basin represents a proxy for estimating the permanence class of restored wetlands. Table 1 presents the depth/permanence class relationship for establishing permanence of restored wetlands within the GHG Offset Protocol. However, the relationship between depth and permanence class is an operational assumption that has not been rigorously tested or authenticated.

Table 2: Restored Wetland Maximum Depth and Permanence Classification[1]

Depth (m)	Steward and Kantrund Class
0-0.10	Class I Ephemeral Pond
0.10-0.30	Class II Temporary Pond
0.30-0.60	Class III Seasonal Pond
>0.60	Class IV & Class V Semi-Permanent/Permanent Pond

2.1.3 Wetland Restoration Workflow

The following sections build on existing operational procedures from a qualified Wetland Restoration Agent. The intent of following sections is to provide general workflow guidelines for:

- Identifying potential sites for physical restoration (historical to current conditions)
- Assembling the initial project plan and negotiating with the landowner.
- Conducting the field survey and documenting the construction of the restoration project.
- Compiling appropriate data for submission to the verifier for future compliance monitoring.

The most cost effective means of locating drained wetlands is through comparative analysis of historic and recent aerial photography. Visual comparison of a historical baseline captured prior to hydrologic impact is required to determine the historic location and extend of drained wetland basins.

The Ducks Unlimited Procedures Document provides details to implement the procedures to locate drained wetlands.

[1] Note: Only Classes III through V are eligible for restoration under the proposed Wetlands Protocol.

2.2 Protocol Development Context

Due to the absence of protocols pertaining to wetlands restoration in other GHG programs, a review of general GHG policy and specific practices concerning wetland restoration has been conducted for adaptation as guidance in the development of the proposed Wetlands Protocol. The GHG policy context includes post-Bali UNFCCC, Compliance Markets in Canada and the United States, the Voluntary Carbon Standard (VCS), the Offset Quality Initiative, and the Ducks Unlimited Inc. Avoided Grassland Conversion Project. Practices reviewed included Alberta and Canadian wetlands management policies, as well as other current wetland restoration activities and initiatives.

Based on the review, the Implementation Discussion Document proposed the following decision points for the workshop regarding the protocol development context (which were agreed upon by the technical working group):

- The premise of the Wetlands Restoration Protocol is consistent in logic with recent policy developments in compliance and voluntary GHG programs across the world
- The existing policy and practice concerning wetland mitigation in the Prairie Pothole Region allows the development of a GHG quantification protocol to create real and verifiable offsets
- Regardless of the emerging context to support development of a Wetlands Protocol, it is clear the proposed Wetlands Protocol is innovative. This means development of this protocol will require extraordinary commitment of time, talent, and resources

2.3 Scope and Identification of SS`s

Based on the knowledge compiled and considered in Phase 1 of development of the Wetlands Protocol, the proposed Protocol will address the emissions of CO_2, CH_4, and N_2O from with the wetland, as well as from the riparian and upland zones associated with wetlands. The Quantification Discussion Document describes the importance of ensuring that the scope (boundaries) of the Wetlands Protocol consider the inter-relatedness of upland management and wetland GHG emissions; prescribe eligible sequestration mechanisms; the potential is introduced for a wider range of project conditions, and therefore a greater number of possible SSs, should establishing permanent cover be associated with the restoration of wetlands; and defining the physical activities required to restore wetlands need to be defined as well as determining the energy requirements of these.

Based on these considerations, lists and associated figures SSs to be included in the scope of the baseline and project scenarios were proposed (included herein as Appendix A). The Quantification Discussion Document further proposed decision points for the workshop as to whether the lists and figures were complete and accurate.

Of the identified SSs, the Quantification Discussion Document developed a proposed list of relevant SSs and associated decision point for the workshop as to whether the list was complete and accurate. The list is included herein as Appendix B.

3 Applicability to all Alberta Offset System Criteria

The general Alberta Offset System criteria is based on the ISO 14064-2 standard (2006, Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements). The ISO standard is closely related to the GHG Protocol from WRI/WBCSD, and applies the following principles:

- *Completeness* -- Include all relevant GHG emissions and removals. Include all relevant information to support criteria and procedures;
- *Consistency* -- Enable meaningful comparisons in GHG-related information;
- *Accuracy* -- Reduce bias and uncertainties as far as is practical;
- *Transparency* -- Disclose sufficient and appropriate GHG-related information to allow intended users to make decisions with reasonable confidence;
- *Relevance* -- Select the GHG sources, GHG sinks, GHG reservoirs, data and methodologies appropriate to the needs of the intended user; and
- *Conservativeness* -- Use conservative assumptions, values and procedures to ensure that GHG emission reductions or removal enhancements are not over-estimated.

In terms of project eligibility and the project conditions, the TECHNICAL SEED DOCUMENT is in line with Alberta Offset System criteria as it describes the following aspects of the project:

1. The scope of the project;
2. Applicability of the project;
3. The quantification of the project;
4. Flexibility provisions (if applicable);
5. A glossary of new terms;
6. Functional equivalence explained between project and baseline conditions

Additionally, the Technical Seed Document identifies all sources and sinks (SS's) for the project by:

1. Outlining the process element diagrams (SSR process flow diagrams, based on materials and energy flows);
2. Identifying the controlled (on-site), related (upstream/downstream) and affected (market force impact) SSs for the project scenario.

In terms of the baseline condition, the Technical Seed Document meets the requirements as it:

1. Identifies the various baseline scenario approaches by selecting and justifying the proposed baseline scenario, including supporting documentation for or against each scenario
2. Identifies all sources and sink (SSs) for the baseline: outline the process element diagrams, based on materials and energy flows, between all upstream, downstream, and before/after project SSs for the project condition (process flow diagrams, based on materials and energy flows)

The Technical Seed Document also selects 'relevant SS's' and adheres to the following requirements for quantification:

1. Selects quantification methodologies for emissions and removals from 'relevant SS's' (formulae, emission factors, type of data, data collection frequencies, etc) along with contingent data approaches;
2. Lays out data management procedures and quality assurance and quality control (QA/QC) criteria;
3. Appendices that include relevant background information (i.e. look-up tables for emission factors, coefficients, adjustment factors, and other calculation inputs for included needed quantification approaches, relevant sample calculations etc...)

3.1 Additionality

Wetlands in Canada continue to be threatened by degradation and loss. Expansion and development in the areas of agriculture, urbanization, transportation networks, resource extraction, hydroelectricity generation, recreational properties, and forestry continue to result in losses to the wetland resource base in Canada. In many areas of Canada this continued loss of wetland area has resulted in significant alterations to entire ecoregions, compromising the overall ecosystem function for these landscapes. One such landscape that is the current focus of extensive wetlands status and trends monitoring is the Prairie Provinces region of Canada.

The policy or implementation premise regarding 'business as usual' for wetlands in the Prairie Pothole Region is that, in the absence of a restoration project, the vast majority wetlands would be degraded or destroyed. This premise received unanimous support from participants at the Consultation Workshop.

The GHG reductions and removals generated by the proposed Wetlands Protocol go beyond business as usual because the practices of wetland restoration are surplus to regulation, investment barriers, technological barriers, institutional barriers, and are not common practice.

The restoration of wetlands will not be double counted with wetlands that are required to be replaced through regulations or requirements for wetland mitigation. The focus will be on wetlands for which there are currently no requirements to restore. Currently there is very little commercial interest in restoring drained wetlands except for conservation organizations, like

DUC, or landowners who have an interest in restoring water for livestock or lifestyle purposes. There is a lot of potential for restoration of wetlands in Alberta.

A Wetlands Protocol will provide a market-based instrument to entice individuals to restore wetlands.

3.2 Baseline Condition

The participants of the Consultation Workshop agreed (85%) that the historic benchmark approach is the most suitable approach for the restoration aspect of the protocol.

The Procedures Document provides the guidance needed to establish the pre-existence of wetlands at a site.

3.3 Permanence

Additional development and rationale described in Section 7

An assessment of risk of reversal associated with the proposed Wetlands Protocol, using a process like the Voluntary Carbon Standard guidance, will be completed using data from the restoration projects of agencies such as Ducks Unlimited Canada.

The Wetlands Protocol will be based on the results of the assessment of risk of reversal using data from the restoration projects of agencies such as Ducks Unlimited Canada. And, based on the strategy defined, the procedures, systems, and controls used by agencies such as Ducks Unlimited Canada to monitor permanence of restoration projects will inform the criteria used in the Wetlands Protocol to monitor permanence.

The full details of the permanence approach used in the Wetlands Protocol will be provided in the protocol formatted for submission to the review process of the Alberta Offset System.

3.4 Leakage

Additional development and rationale described in Section 7

Although leakage needs to be considered, and techniques to address leakage for land use protocols are emerging, this issue may not be of critical importance for the proposed Wetlands Protocol. That is, when applied to the proposed Protocol, leakage refers to the possibility that restoring wetlands in the Prairie Pothole Region would cause wetlands in other regions to be degraded or drained. Although possible, such a circumstance is unlikely. Indeed, the database to be maintained by project developers in the course of their activity will contribute to development of an inventory of wetlands; thereby enhancing the capability to determine the net number of wetlands in the Prairie Pothole Region.

The Prairie Pothole Region will comprise the leakage belt for the Wetlands Protocol. The Wetlands Protocol will require project proponents and/or aggregators to contribute to a database for monitoring of wetlands of the Prairie Pothole Region. This database would be used to assess intra-region leakage.

3.5 Conservativeness

The research conducted to date follows the principle of conservativeness in design by using averages across regions and throughout the annual cycle, during which wetlands are frozen with little activity for up to six months of the year. Further, these research data are obtained from long-term projects which span sufficient time to integrate the influence of annual fluctuations in dry / wet cycles. In all cases, conservative assumptions, values and procedures are used to ensure that the GHG emission reductions and removals associated with wetlands are not over-estimated. Further, the estimation of CH4 form restored wetlands was estimated using a combination of empirical data and modeled predictions. The model used to predict CH_4 emitted as ebullition or through plant stems did not account for the expected decrease in emissions associated with the sulphate-dominated water chemistry in the wetlands of the Prairie Pothole Region.

3.6 Consistency

The development of a protocol focused on mineral-soil wetlands is groundbreaking. But, to the extent possible, the protocol will be consistent with other systems that address biological sinks as per IPCC guidelines and the ISO 14064-2 standard. Ideally, the leadership in Alberta will lead to similar protocols throughout the Prairie Pothole Regions of Canada and the US and help spawn additional research in other regions on the role wetlands can play in mitigating GHG emissions and the impacts of climate change. It is important to note the experts involved in the development of the Wetlands Protocol are in a number of cases the same scientists who are working with Environment Canada to advance the specificity of GHG quantification from mineral-soil wetlands for Canada's National Inventory Report.

3.7 Measurement, Monitoring and Verification Requirements

Additional development and rationale described in Section 7

Monitoring of restored wetlands under the GHG Offset System will require the verifier to inspect the restoration project on a bi-annual basis. Monitoring will be primarily concerned with confirming the integrity of each earth plug for restored wetlands and inspecting the wetland margin and restored wetland basin for non-compliant land use. Survey equipment will be required to determine if the original construction elevation is maintained. In instances where the earth plug has washed out or eroded, repairs will be required to rebuild the earth plug to original construction elevation.

Using the guidance developed in the Ducks Unlimited Procedures Document, project developers will understand the procedures prescribed to allow reasonable level verification of the Wetlands Protocol projects.

3.8 Ownership

The current version of the Wetlands Protocol will focus on restoration of wetlands on privately-owned lands. The Wetlands Protocol formatted for submission to the review process of the Alberta Offset System will provide details needed to meet the requirements of reasonable level of verification.

3.9 Net Benefits

Wetlands provide a multitude of benefits including improved water quality, reduced impacts from flooding, mitigating the impacts of drought, and the provision of habitat for hundreds of species – including species at risk. Given the desire of the ABOS to help address climate change issues it is also important to note that wetlands can help mitigate the impacts of climate change by providing natural resiliency in the system to buffer the potential impacts of pending climate change. Many of the benefits of wetlands have been lost since settlement and the development of market-based instruments like carbon offsets can help provide those benefits now and for generations to come.

3.10 Estimated Reduction Potential

A large proportion of wetlands and associated uplands in the Prairie Pothole Region of Canada have been degraded as a result of landscape alteration and therefore it is reasonable to assume the vast majority wetlands in this region have been subjected to or are vulnerable to wetland loss. The Prairie Habitat Joint Venture Implementation Plan for Alberta includes an objective to restore 300,000 wetlands in Alberta. Even with the conservative coefficients used in the Wetlands Protocol, restoration of the planned numbers of wetlands has potential to generate a million carbon offsets annually. This potential will increase substantially if wetland restoration projects include implementation of complementary protocols on upland areas.

4 Protocol Technical Scientific Foundations

The technical scientific foundation of this protocol is provided primarily from peer-reviewed research in major scientific journals. A review of the science concerning wetlands restoration activities in terms of GHG sink, source, and flux potentials was conducted in the Technical Background Document. In this document, ClimateCHECK compiled the science related to the net GHG balance associated with the restoration of wetlands and addressed GHG dynamics for seasonal or semi-permanent wetlands on mineral soil. The Technical Background Document also summarized at the science related to using certain management practices and how these practices affect the GHG dynamics of mineral wetlands.

The technical scientific foundation of the proposed protocol will be described further in the following subsections (notable, the GHG source and sink potential of PPR wetlands as well as studies on GHG flux from zoned wetlands).

4.1 Definition and Delineation of Prairie Pothole Region Wetlands

The Prairie Pothole Region extends from northern Iowa to the northern reaches of the Prairie Provinces, and includes about 600 000 km^2 in Canada and about 300 000 km^2 in the United States (Gleason *et al.* 2008). According to the Environment Canada website (http://www.ec.gc.ca/media_archive/press /2005/051121_b_e.htm), the Canadian sector of the Prairie Pothole Region contains about 4.5 million hectares of wetlands. This same website reports that 80% of agricultural land in Canada is in the Prairie Pothole Region.

The characteristics of the wetlands of the Prairie Pothole Region present challenges for definition and delineation. In this semi-arid and cold climate region, annual variations in temperature and precipitation, for example, result in dramatic year-over-year fluctuation in number of flooded basins (Bautzen 2008, Zimpfer *et al.* 2008). In drier periods, agricultural practices are likely to encroach on wetland basins and margins. In addition, the wetlands are characterized by clay-rich mineral soils and by water chemistry often influenced by sulfur compounds (Driver and Peden 1977, Heagle *et al.* 2007). And, the water balance of these wetlands "is controlled by snowmelt runoff and snowdrift from the surrounding uplands, precipitation, evapotranspiration, groundwater exchange, and occasional "fill-spill" connections to other wetlands", and influenced by the clay-rich soil texture (van der Kamp and Hyashi 2009). Among the wetlands of the world, then, the wetlands of the Prairie Pothole Region have unusual characteristics of biology, biogeochemistry, hydrology, and hydrogeology.

The Procedures Document prepared by Ducks Unlimited Canada provides the detailed guidance to achieve identification and delineation of wetlands to be restored under the Wetlands Restoration Protocol.

4.2 Prairie Pothole Region Wetlands as Potential Sinks

The Sinks Table Foundation Paper (Environment Canada, 1998) introduced wetlands as possible carbon sinks under the Kyoto Protocol. Covering about 14% of Canada's land surface, wetlands contain more than 150Gt C (gigatonnes of carbon). Additionally, wetlands have the highest carbon density of all terrestrial ecosystems and are among the most productive, particularly at reducing the rate of organic matter turnover. Functional ecosystem benefits also include flood prevention, groundwater recharge, nutrient assimilation, and the degradation and storage of toxic chemicals.

Carbon storage in wetlands occurs in long-term and short-term reservoirs:

Short term: Plant and algal biomass and dissolved organic carbon (DOC) in the water column.

- Long term: Sequestration in sediments of DOC and undecomposed organic matter.

Carbon sequestration in wetland ecosystems is primarily achieved by a high rate of organic matter input and reduced rates of decomposition. Inputs of carbon to wetland ecosystems occur through the uptake of carbon dioxide via photosynthesis by vascular plants, nonvascular bryophytes, and algae. Other inputs of carbon to Prairie Pothole Region wetlands include; agricultural soil erosion and deposition, organic detritus such as leaf litter, and sediment loading from rivers.

Carbon sequestration potential in terms of riparian zone boundaries and GHG flux:

- The field-riparian boundary of wetlands is an area of increased soil respiration, and has been shown to be a zone where CH_4 and N_2O are consumed (show negative fluxes).
- Near riparian-stream boundaries, high soil moisture values also allow for the exchange of relatively oxygen rich water, where the production of 3 GHGs (CO_2, N_2O, and CH_4) is inhibited for a large portion of the hydrological year relative to other zones.

A study conducted by Rajendran *et al*. (2006) determined that water is a major driver of GHG emissions in Prairie Pothole Region wetlands, particularly altering production, consumption and transport of GHGs to the surface. It was found that GHG concentrations did not vary with depth at upper and middle slope positions, whereas they increased with depth at lower and riparian landscapes. In this study it was found that anaerobic conditions were characterised by a low oxygen concentration, high volumetric moisture content (VMC), and high N_2O/CH_4 concentrations. VMC for all slope conditions increased with depth and was highest for lower and riparian wetlands. However, N_2O surface emissions were not substantial in these positions, indicating N_2O at depth was oxidized in overlying soil.

Another study by Desjardins *et al*. (2005) ran simulations for five locations across Canada, for a 30-year time period, examining the potential trade-off between carbon sequestration and increased N_2O emissions of converting agricultural lands to grasslands (which have less primary productivity than wetlands). This study found that, even when converting agricultural soils to less productive grasslands, large reductions in net GHG emissions occurred. Therefore, if GHG flux from wetlands is accounted for, and shown to be negligible, it could be safely assumed that the carbon sequestration potential of carbon dense wetlands is greater than that of grasslands.

Gleason *et al.* (2002) also state that greater amounts of atmospheric carbon could be stored in wetlands in the Prairie Pothole Region through restoration programs as opposed to no-till cropland programs, even though the acreage of wetlands is much smaller. Further, their research suggests that restored wetlands emit less methane and nitrous oxide than farmed wetlands, with a reduction in these trace gases providing additional GHG benefits.

An important study to consider in relation to wetland restoration is an investigation conducted in collaboration with scientists from the Plains CO2 Reduction (PCOR) partnership (Gleason *et* *al,* 2005). This study found that restoration of previously farmed wetlands results in a rapid replenishment of soil organic carbon (SOC) previously lost to cultivation, at an average rate of 3 Mg ha^{-1} yr^{-1} (1.34 tons $acre^{-1}$ yr^{-1}). The main findings of the study indicated that restored prairie wetlands can act as significant carbon sinks. It was estimated that up to 4,944,000 ha (12.2 million acres) of potentially restorable land exists within the PPR. If restored, potential savings equate to 111,216,000 Mg (122.6 million tons) of SOC over a 10-year period. However, this is assuming that all potentially restorable wetlands are restored, which is highly unlikely.

This same study (Gleason *et al,* 2005) also found that additional carbon storage benefits may be gained via vegetative standing crop in restored wetlands. Although carbon stored in vegetation is often viewed as transient, the potential exists to treat this biomass carbon in the sophisticated manner used in afforestation protocols. If allowed, the carbon opportunity for this biomass is estimated at up to 27.2 million tons for the Prairie Pothole Region.

GHG emissions from the conversion of wetlands (swamps and bogs only) due to drainage and conversion to agriculture (International Union for the Conservation of Nature, Wetlands and Climate Change Report) for boreal/temperate regions are reported as follows:

- Drainage: 0.1–0.32 t C $ha^{-1}yr^{-1}$
- Agricultural use: 1–19 t C $ha^{-1}yr^{-1}$

This provides insight into the effects of detrimental wetland conversion but does not constitute the basis of a reduction co-efficient or for quantifying emissions reductions/removals from wetlands restoration.

4.3 Prairie Pothole Region Wetlands as Potential Sources

This section of the report will outline pertinent scientific literature that addresses the ability of Prairie Pothole Region wetlands to act as potential sources of GHGs. The three GHGs that will be examined in detail are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_20).

A study by Bridgham *et al*. (2006) found that with the exception of estuarine wetlands, CH_4 emissions from wetlands may largely offset any positive benefits of carbon sequestration in soils and plants in terms of future climate forcing. Bridgham's research also suggests that it will be difficult to accurately predict the role of wetlands as potential positive or negative feedbacks to anthropogenic global change without knowing the integrative effects of changing temperature, precipitation, atmospheric CO_2 concentrations, and the atmospheric deposition of nitrogen and sulphur on the carbon balance of North American wetlands.

When assessing the vulnerability of wetland carbon stocks to human activity and climate change, it is also crucial to identify the wetland areas most likely to be impacted by climate change and potentially prioritize these areas for protection. Due to the complex biogeochemistry of wetlands they can act as sinks for one gas and sources for another. Consequently, the biogeochemistry, and thus source and sink potential of wetlands, can also be greatly affected by anthropogenic impacts such as increased nutrient loading, draining, in-filling, flooding, burning, and vegetation change. This highlights the fact that close attention must be paid to upland areas, where potential nitrogen loading via the use of N-fertilizers can impact the GHG source potential of the underlying wetland.

A recent study examining the spatial and temporal variation in GHG emissions from two open water prairie wetlands (Phipps, 2006) lists potential sources of CO_2 from wetlands as those from autotrophic and heterotrophic respiration as well as from decomposition [I think that decomposition is included under heterotrophic respiration.]. Factors controlling the rate of CO_2 release from these sources are temperature, water table height, and quality and availability of organic substrates. For example, CO_2 emissions vastly increase during simulated drought (Freeman *et al*., 1993). A study by Funk *et al*. (1994) also found that CO_2 emissions nearly tripled when the water table was lowered below the peat surface in microcosm cores.

The link between water table height and GHG flux in peatlands is quite different from those trends seen in mineral wetlands (Phipps, 2006). In their most recent study (2006), Phipps *et al*. found that cumulative CO_2 emissions from the riparian zones of ponds located within the Prairie Pothole Region were 3.5 times greater than from open water. It is also important to note that this study found CO_2 flux to be inversely correlated to pH. The study ponds acted as sources of CO_2 when pH < 8.4 and as sinks for CO_2 when the pH > 8.4.

Although global methane emissions from natural wetlands contribute approximately 115 Tg of CH_4 to the atmosphere annually, the majority of this is from tropical wetlands and peatlands. The main factors regulating CH_4 emissions from temperate wetlands are water table position, soil temperature, quality and availability of substrate, and mode of gas to transport to the atmosphere (Walter and Heimann, 2000).[Ont. swamp riparian results confirm much of this.] These factors are not independent of each other but rather act in synergy at certain times of the year and especially during wet years. Interestingly, a study conducted on Prairie Pothole Region wetlands by Phipps *et al*. (2006) found that CH_4 emissions were negligible in the presence of high concentrations of sulphate.

Although research has shown that on a global scale (but not necessarily within the Prairie Pothole Region) wetlands tend to be a minor source of CO_2 and N_2O, and a major source of CH_4, it has been pointed out that mineral-soil wetlands have lower methane levels compared to peatlands. This can be attributed to higher rates of methane oxidation in marsh ecosystems (due to emergent vegetation and thick mats of benthic algae). Methane oxidation by thick algal mats can consume up to 90% of the potential methane flux (Wang *et al.* 1995). Studies have also noted a trade-off between methane and carbon dioxide emissions related to water levels and anaerobic conditions in wetlands (Alm *et al*. 1999)Results indicate that the magnitude of increase in CO_2 emissions from water-level drawdown far outweigh any potential benefits of decreased methane emissions. Again, this is important information to consider when developing a GHG management strategy for the Prairie Pothole Region.

4.4 Measures of GHG Flux in 'Zoned' Wetlands

A study by Philips *et al.* (2003) divided vegetative basins into five distinct zones (deep marsh, shallow marsh, wet meadow, low prairie, and cropland) to demonstrate that net GHG flux for cropped zone soils was significantly lower ($p<0.01$) than flux for deep marsh, shallow marsh and wet meadow zone soils. Average GHG flux measure by zone (mg CO_2 equivalent/m^2/day) was 283 for cropland, 677 for low prairie, 1067 for wet meadow, 2572 for shallow marsh, and 6686 for deep marsh. Methane, in terms of CO_2 equivalents, was the strongest indicator and predictor of total GHG flux per square meter. Given the general characteristics of Prairie Pothole Region wetlands, it may be possible to include data from the low prairie study when making estimations of the carbon sequestration potential and GHG flux of Prairie Pothole Region wetlands for restoration programs.

A follow-up study conducted by Philips *et al*. (2007), measured methane flux at the soil-atmosphere interface and demonstrated that fluxes vary significantly between deep marsh, shallow marsh, wet meadow, and low prairie zones of a wetland. The highest methane emissions being found near the water in the deep marsh (277,800 µg m^{-2} d^{-1} CH_4), which declines with distance from the water to -730 µg m^{-2} d^{-1} CH_4 in the pasture. Consequently, if the average depth of Prairie Pothole Region wetlands is accurately assessed, it may be beneficial to include this data when determining the GHG flux of methane in the Prairie Pothole Region region.

Measurements of GHG flux in zoned wetlands have also shown that nitrous oxide surface emissions from wetlands are, by and large, not substantial, with the majority of N_2O accumulating at depth and being reduced by overlying soil (Rajendran *et al.* 2006). However, while both N_2O and CH_4 are usually reduced and oxidized in overlying soils in dry years, in wet years they can be released into the atmosphere more readily. Therefore, it may be important to account for climatic conditions and trends in weather over a substantial period (i.e. the period during which PPR wetlands will be considered carbon sinks) when estimating GHG flux.

Additionally, anaerobic wetland soils usually have lower rates of carbon dioxide emissions than terrestrial soils (4 vs. 7 to 8 g C m^{-2} d^{-1}) (Raich and Potter, 1995). Emissions of nitrous oxide from wetlands in the Northern Hemisphere are also generally low (Groffman & Taylor, 1996), which supports the argument that Prairie Pothole Region wetlands could act as significant carbon sinks. However, nitrous oxide production may increase with fluctuating soil water content, high organic carbon availability, and high inorganic nitrogen availability (Freeman *et al*. 1997).

It is also important to note that naturally waterlogged soils act as sinks or negligible sources of nitrous oxide emissions of less than 0.04 kg N ha^{-1} y^{-1} (Martikainen *et al*. 1993). This should be taken into account when determining the ability of Prairie Pothole Region wetlands to act as carbon sinks, particularly because Prairie Pothole Region wetlands tend to be nitrogen-limited systems that have continuously waterlogged soils. Under saturated conditions (greater than 80 percent water-filled pore space, which is often the case in the PPR) nitrous oxide is consumed and nitrogen gas becomes the major end-product of denitrification, helping alleviate the amount of potent nitrous oxide being released from the sites. Considering that Prairie Pothole Region wetlands are usually nitrogen limited, it is extremely important to manage upland and riparian zones (particularly cropland) in order to avoid nitrogen runoff from N-fertilizer use into the relatively sensitive wetlands.

A recent study sanctioned by DUC that investigated the carbon dynamics of a Prairie Pothole Region wetland presented some interesting results. The study by Hartwig (2008) found large diurnal fluctuations in GHG flux at certain times of the year, reporting that as the season progressed, the maximum uptake or minimum emissions of GHGs occurred later in the day. This diurnal pattern was that the wetlands switched from acting as GHG sinks to a source of GHGs around 22:00h and then back to a sink at around 02:00h. This same study also found that the test pond (within a Prairie Pothole Region wetland) was a slight source of CO_2 throughout the green period, developed into a large source during the senescence period, a neutral source during September, and a GHG sink come early- and late-July.

In terms of nitrous oxide flux, a study by Adams (2007) examined the effects of potential changes in nitrogen loads to nitrous oxide efflux in Prairie Pothole Region wetlands. The study found that the majority of wetlands throughout the Prairie Pothole Region are N_20 sinks, while uplands are sinks early in the season, but later become sources. The environmental factors that were found to control N_20 flux were; soil temperature in the early growing season, and soil moisture mid-season. However, the same study also found that when Prairie Pothole Region wetlands were subjected to the land-use changes of agricultural development, N_2O emissions spiked due to the increased nitrogen availability from N-fertilizer use. The study noted that N_20 emissions in wetlands adjacent to or within agricultural developments were much greater than those that were naturally conserved.

Interestingly a study has also determined some positive benefits that could result from agricultural development. Nitrous oxide emissions can be mitigated by the growth of certain crops. This is due to the ability of some plants to efficiently reduce denitrification rates and thus N_2O from the soil (Simojoki, 2000). In terms of wetlands restoration within the Prairie Pothole Region, it will be highly important to examine the influence of past and present agricultural activities on N_20 flux and potentially even examine the crops used.

Considering the integral role of soil moisture in determining the flux of certain GHGs (particularly methane and nitrous oxide) it is also important to account for variations in the distribution of soil moisture in Prairie Pothole Region wetlands. A study conducted by Carlyle (2006) did just that, by examining the soil moisture of PPR wetlands at various topographies. Results of this study showed that topography was an important factor in determining not only the spatial pattern of soil moisture on the landscape, but also that the efficacy of this control changed in response to climatic variability. The study concluded that the natural soil moisture distribution within the PPR was one of high heterogeneity. Through the use of hillslope-scale soil moisture estimates it was also determined that the northern, wetter, area of the Prairie

Pothole Region would likely see the largest changes in soil moisture if the P-PET (precipitation minus potential evapotranspiration (dryness)) increases.

Overall, recent studies have indicated that GHG flux in Prairie Pothole Region wetlands is well within the range of fluxes measured from other sources such as peatlands and reservoirs. In a study by Phipps *et al.* (2006) it was found that GHG flux from Prairie Pothole Region wetlands was actually below the mean flux found in two years of a study in a Nova Scotia bog. However, this same study found that the two wetlands they studied were net sources of GHGs, with the dominant GHG being CO_2. It was also found that low sulphate concentrations increased the potential for CH_4 emissions and that fluctuations in wetland water levels gave rise to large changes in water chemistry and thus GHG flux in the wetlands (Phipps *et al.* 2006). Carbon dioxide emissions were found to be the largest contributor to total GHG emissions in 2005 (from the two sample wetlands within the Prairie Pothole Region). Additionally, CH_4 emissions were much lower in the wetlands when compared to both peatlands and reservoirs.

The complex seasonal variations and ability of the wetlands to act as either GHG sources or sinks has traditionally made estimations of GHG flux extremely difficult. However, with advancements in technology and more detailed studies (such as those conducted by Phipps *et al.* as well as Hartwig (2008) and Adams (2007)) it may be possible to make relatively accurate estimations of the source and sink potentials of wetlands within the Prairie Pothole Region. Furthermore, it is important to consider up-to-date studies and consistently monitor variations in the abilities of Prairie Pothole Region wetlands to act as potential GHG sinks from year to year, especially when estimating future GHG flux in restored Prairie Pothole Region wetlands.

As early as 1999, at the Oak Hammock Workshop in Manitoba, it was concluded that restoring degraded or drained wetlands in Canada's prairies would likely result in net carbon storage over the long term compared with the land use (usually marginal agriculture) before restoration. The assessment at that time was based on research conducted on restored Prairie Pothole Region wetlands in North Dakota where restored wetland carbon capacity was compared to similar carbon storage processes in marginal tilled soils. This study also highlighted the fact that restoration initiatives must be all encompassing, and include not only the wetland basin but the adjacent riparian zones and associated uplands. Additionally, emphasis was placed on the importance of incorporating the long-term impacts of climate change on the prairie environment and carbon storage in the prairie landscape.

Recent studies examining the GHG reductions associated with establishing permanent cover on agricultural land adjacent to riparian zones should also be considered in this report. Euliss *et al*. (2006) evaluated the potential for wetland restoration projects to serve as C sinks, and concluded that on a per land area basis, restoring wetlands is a land management practice 10-fold more effective in sequestering C than no-till cropping. In addition, a study by Well *et al*. (2005) looked at emissions of N_20 from N lost from agricultural land by runoff and leaching. This research found that the IPCC default emissions factor (EF5) of 0.015 kg N_20-N per ? fertilizer is not high enough to estimate N_20 emissions from riparian areas. The report also concludes that the "restoration of riparian buffers to lessen NO_3^- discharge to streams and oceans could increase global N_2O emission".

Using emissions calculations from field tests conducted by Goddard *et al*. (2006) in the Prairie Pothole Region, restored wetlands would have the following ranges of net methane and nitrous oxide fluxes:

- Methane upland emissions: 0-10 CH_4-C kg ha^{-1} y^{-1}
- Methane depression emissions: 100-200 CH_4-C kg $ha^{-1}y^{-1}$
- Nitrous oxide upland emissions: 0.5-1.5 N_20 O-N kg $ha^{-1}y^{-1}$
- Nitrous oxide depression emissions: 0-4 N_20 O-N kg $ha^{-1}y^{-1}$

Prairie and parkland wetlands store significantly more carbon than the surrounding agricultural land. Therefore, in terms of carbon sequestration potentials, it could be beneficial to restore agricultural lands to wetlands or riparian areas. Past studies in North Dakota, South Dakota, Minnesota and Iowa also indicate that pristine (non-farmed) wetlands store twice as much carbon compared to land that has been drained and converted to cropland (Euliss *et al*. 1999).

Given current conditions, it would take approximately 10 years for the shallow marsh zone of restored wetlands to return to "pristine" conditions and up to 20 years for the wet meadow zones to return to pristine conditions (Euliss *et al.* 1999). Another study by Euliss *et al*. (2005) confirmed that relative to reference wetlands, farmed wetlands have lost on average 10.2 (95% C.I. = 4.7 to 15.6) Mg OC ha^{-1} in the surface 15 cm of soil. Additionally, this research demonstrated that when semi-permanent wetlands are restored, carbon in the surface 15 cm is replenished at a rate of 3.05 Mg OC ha^{-1} $year^{-1}$. Using this rate as a guideline it would take an average of 3.3 years for carbon lost in the surface 15 cm to be replenished. If this estimate of carbon sequestration is considered conservative, it would take 5 years to accumulate 197 Tg of soil organic carbon.

The use of process-based models is one method that could also be used to quantify the benefits of wetland restoration practices on C dynamics. The wetland DNDC model was designed for both mineral and organic soils, where water table dynamics, soil properties, vegetation, and climate affect the C cycling and partitioning among GHGs. The advantage of using processed based models such as the Wetland-DNDC is the ability to test management strategies across climatic zones, hydrological regimes, soil properties, and forest types. Process based models also carry the advantage of being able to predict long-term cumulative carbon dynamics and provide a means to understand how different parts of the ecosystem respond to environmental drivers, allowing managers to improve strategic and tactical planning for managing wetland systems.

4.5 Reduction Coefficient

A recent manuscript by Badiou *et al*. (2010) summarizes the changes in SOC stored and emissions of CH_4 and nitrous oxide (N_2O) in wetlands across the Prairie Pothole Region of

Canada. This manuscript was first reviewed by the participants of the Wetlands Protocol Consultation workshop, and revisions were suggested. The participants of the Consultation Workshop agreed the revised manuscript would provide the reduction coefficients for the Wetlands Protocol. Further, the participants agreed that using the lower range of the coefficient derived from this research served to address the uncertainty associated with the Wetlands Protocol.

In this study, twenty-two locations were chosen across the Prairie Pothole Region of western Canada — roughly one third of these sites were in Alberta. At 18 locations, three ponds were chosen; one which had never been cultivated (reference wetland) and two which had been restored. At the remaining four sites only one reference and one restored wetland were monitored. In total, 62 wetlands were monitored, with wetlands at three of the 22 locations being monitored extensively for calculating the cumulative flux of GHGs. The restored wetlands were then divided into two age classes; 1) newly restored (restoration less than 5 years old as of 2003), and 2) long-term restored (restored for 5 years or more as of 2003). This resulted in 26 of the wetlands being grouped under the long-term restored class, and 14 in the newly restored class (with 22 reference wetlands being monitored).

The following methods were used to collect data for this study (brief overview only for informative purposes, Badiou *et al.* 2010):

1. Climate data, wetland depth, and water chemistry:
    - Precipitation and air temperature from Environment Canada weather stations located near (within 35km) of the monitoring sites
    - Water samples from the basin centre of each wetland during late spring/early summer and early fall 2005
    - Samples were analyzed for total phosphate, ortho-phosphate, ammonium, nitrate-nitrite, conductivity, hardness, alkalinity as well as major anions and cations
2. Soil organic carbon (SOC):
    - SOC density assessed at all but three of the 62 wetland basins (soil cores taken at 6 duplicate landscape positions extending from the upland landscape position to the wetland basin and centre position.
    - For each increment, % moisture and bulk density were determined
    - SOC values were then determined by combustion at 840 ˚C using a LECO® CR-12 Carbon System (LECO Corporation, St. Joseph, MI).
3. GHG emissions and cumulative fluxes:
    - GHG samples were monitored on three different dates at 19 of the sites
    - At three sites (where wetland basins were monitored intensively) samples were collected at a minimum of 7 and maximum of 17 sampling dates

- Soil gas sampling was conducted to determine GHG flux rates for each of the three wetlands situated at each of the three intensive monitoring sites
- in order to estimate an annual cumulative flux for each site a daily mean GHG flux was determined based on the measured samples from each site
- Further, cumulative fluxes of CH_4 and N_2O at the intensive sites were combined and expressed as CO_2 equivalents to determine the global warming potential (GWP) associated with these fluxes using a 100 year time horizon

In terms of cumulative GHG flux, results of this study showed that in the long-term restored and reference Prairie Pothole Region wetlands CH_4 emissions were always the most important contributor to the overall cumulative GHG flux for each site (Badiou *et al.* 2010). The study also showed a change of approximately 89 Mg ha^{-1} between intact reference wetlands and the grassland uplands of the restored wetland basins. With this difference representing the impact of wetland drainage and degradation on the carbon stored in wetlands (Badiou *et al* 2010). Badiou *et al*. (2010) speculate that the dramatic increase in the sequestration rate between the newly-restored wetlands is likely related to the re-establishment of wetland vegetation and function. However, when considering a 33 year sequestration period and a return to historical SOC densities, Badiou *et al*. (2010) estimate a mean annual sequestration rate for restored wetlands of 2.7 Mg C ha^{-1} yr^{-1}, which is similar to sequestration rates reported for other wetland and grassland ecosystems (Euliss *et al*. 2006, Nelson *et al*. 2008).

This carbon sequestration rate was based on SOC differences between reference wetlands (205 Mg/ha) and grassland uplands (116 Mg/ha) = 89 Mg/ha, assuming accumulation over a 33 year period (which is based on the time that it takes grasslands to re-establish equilibrium, Badiou *et al*. 2010). This is also supported by the fact that 55% of the lost SOC was recovered in the long-term restored wetlands (average age of restoration being 8 years). N_2O fluxes from these wetlands were also typically negligible, and in fact 1/3 of the cumulative fluxes calculated for N_2O from intensive sites were negative, meaning the wetlands were actually N_2O sinks.

Methane emissions from the wetlands were significant and increased with increasing water levels and decreasing sulfate concentrations (Badiou *et al*. 2010). Methane emissions through ebullition and transfer through aquatic plants can be very significant and were not included as a part of this study (which only looked at diffusive emissions directly from the soil or water to the atmosphere). In order to account for total methane emissions from wetlands in the PPR, Badiou *et al*. (2010) used total methane emissions estimates (6.65 Mg CO_2 eq/ha/yr) for North Dakota wetlands generated using the CASA model generated by NASA. Emissions from these wetlands are assumed to be representative of those across the Prairie Pothole Region. The median cumulative GHG fluxes from restored and reference wetlands in the Prairie Pothole Region study at the intensive monitoring sites were 1.8 and 1.6 Mg CO_2 eq/ha/yr, respectively (Badiou *et al*. 2010). When these results are compared to the estimated total CH_4 fluxes, the diffusive fluxes measured in the Prairie Pothole Region study comprise between 24 and 27% of the total methane emissions, suggesting that ebullition and emergent wetland plant mediated CH_4 flux accounts for between 73 to 76% of the total CH_4 emissions.

Based on these sequestration rates for restored Prairie Pothole Region wetlands and the estimated total methane emissions, Badiou *et al*. (2010) estimate that approximately 7.4% of net ecosystem production (NEP) (assuming changes in SOC are representative of NEP) was emitted back to the atmosphere as CH_4. However, the relationship between CH_4 emissions and NEP developed by Whiting and Chanton (1993), suggests that only 3% of NEP is re-emitted as CH_4. This would suggest that the total methane flux from the CASA model may over estimate total CH_4 emissions for the restored wetlands, meaning the coefficient for the Wetlands Protocol is likely conservative.

Accounting for the total methane emissions, wetland restoration is a net sink for C, sequestering **0.88 Mg C/ha/yr or (3.25 Mg CO_2 eq./ha/yr)**.

The calculation of the carbon offset generated through restoration activities is determined by applying the net sequestration coefficient (ClimateCheck, 2010) to the restored wetland basin area and margin defined in the Asbuilt survey geometry using the formula below:

NetSeq = Net sequestration coefficient 3.25 Mg CO_2eq ha^{-1} $year^{-1}$

WetMargin = Total wetland margin area in hectares.

WetBasin = Total wetland basin area in hectares.

Nyears = Duration of agreement with landowner in years.

Offset = [(WetMargin x NetSeq) + (WetBasin x NetSeq)] x Nyears

5 Protocol Operational Framework

5.1 Project Condition

The project condition for the Wetlands protocol is a restored, functional wetland. The details of the project condition including the; SSRs, scope, boundaries, definitions of practices, risk of non-permanence, ownership, and project planning/landowner negotiations will all be detailed in the following subsections.

5.1.1 Project Sources and Sinks (SS's)

Figure 3: Diagram of SSRs associated with the project condition for the proposed Wetlands Protocol, a functional wetland.

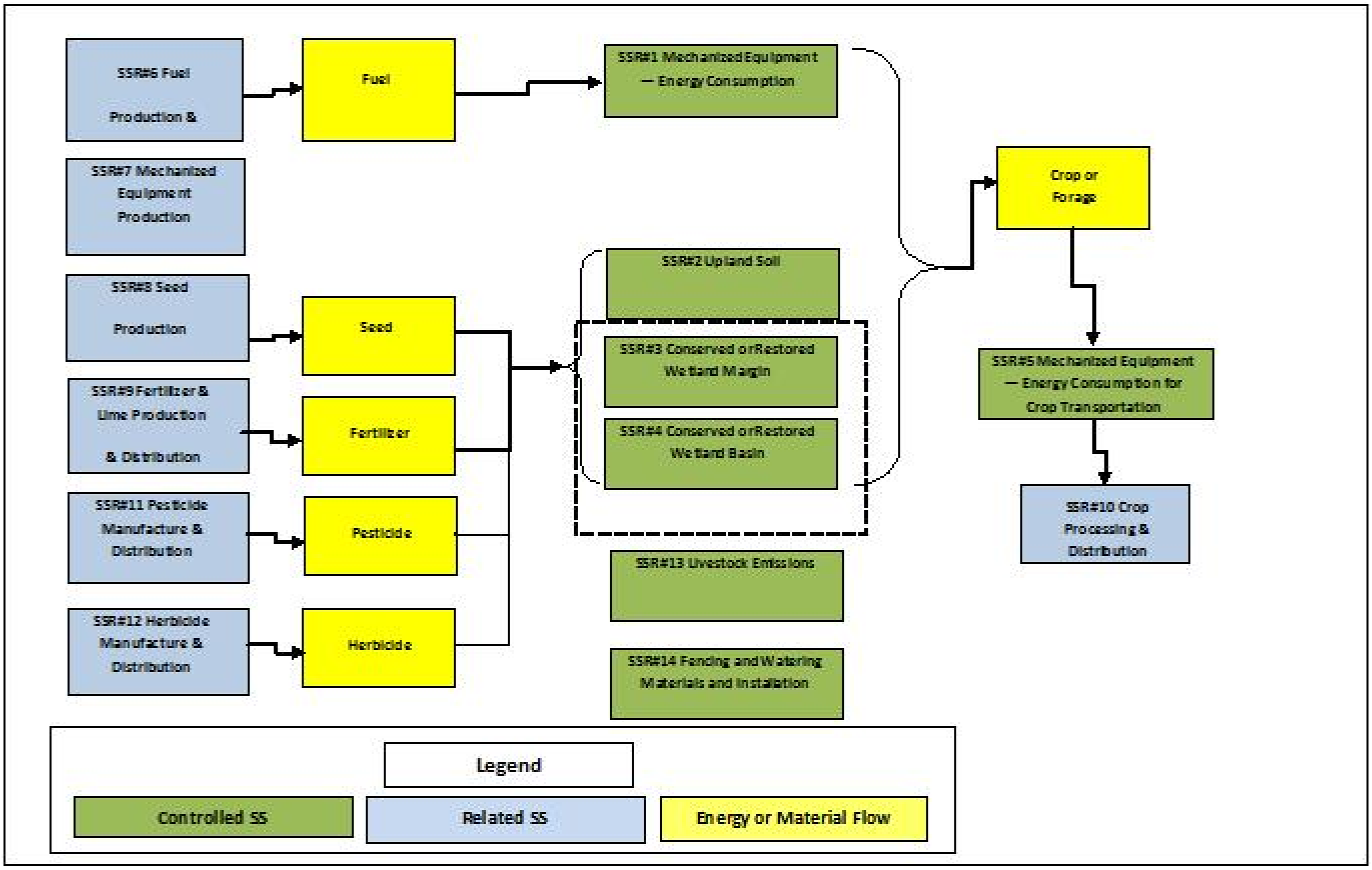


Table 3: Controlled, related, and affected SSs for the project condition of the proposed Wetlands Protocol, a functioning wetland.

SSR IDENTIFIER	SSR NAME	DESCRIPTION	CONTROLLED, RELATED OR AFFECTED
SS1	Mechanized Equipment – Energy Consumption for Farming Operations	GHG emissions of CO_2, CH_4 and N_2O are generated when mechanized equipment is used for hay harvest (swathing and baling) and onsite transportation of hay. This SSR includes emissions associate with equipment and energy needed, if any, to physically restore the natural landscape (i.e. 'plug' drainage passages).	Controlled
SS2	Upland Soil	GHG dynamics (net flux of CO_2, CH_4 and N_2O, and including net sequestration if	Controlled

		occurring) associated with upland soils. This soil may be cropped or in perennial forage.	
SS3	Conserved or Restored Wetland Margin	GHG dynamics (net flux of CO_2, CH_4 and N_2O, and including net SOC sequestration) associated with conserved or restored wetland margin.	Controlled
SS4	Conserved or Restored Wetland Basin	GHG dynamics (net flux of CO_2, CH_4 and N_2O) of the conserved or restored wetland.	Controlled
SS5	Mechanized Equipment – Energy Consumption for Crop Transportation	GHG emissions of CO_2, CH_4 and N_2O are associated with the offsite transportation of crop or crop products, including forages, to the point of sale or final use.	Controlled
SS6	Fuel Production and Transportation	GHG Emissions of CO_2, CH_4 and N_2O are generated from the upstream exploration, production processes and distribution of diesel and other fuels.	Related
SS7	Materials and Equipment Production and Distribution	GHG emissions of CO_2, CH_4 and N_2O are generated from the input of materials and energy in the manufacturing and distribution of materials and equipment.	Related
SS8	Seed Production and Distribution	GHG emissions of CO_2, CH_4 and N_2O are generated in the process of collecting, cleaning, storing and distributing seed for crops.	Related
SS9	Fertilizer and Lime Production and Distribution	GHG emissions of CO_2, CH_4 and N_2O are associated with the manufacturing and distribution of fertilizer and lime.	Related
SSR10	Mechanized Equipment – Energy Consumption for Crop Processing and Distribution	GHG emissions associated with the cleaning, handling and final distribution of crop products, including forages.	Related
SS11	Pesticide Manufacture and Distribution	GHG emissions of CO_2, CH_4 and N_2O are associated with the manufacture and off site transportation of pesticide	Related
SS12	Herbicide Manufacture and Distribution	GHG emissions of CO_2, CH_4 and N_2O are associated with the manufacture and off site transportation of herbicide.	Related
SS13	Livestock Emissions	GHG emissions of N_2O and CH_4 and are associated with the manure of grazing animals. Enteric emissions of CH_4 are	Controlled

		produced as a by-product of digestion that are exhaled or eructated from the grazing livestock.	
SS14	Fencing and Watering Materials and Installation	GHG Emissions of CO_2, CH_4 and N_2O are associated with the energy and materials required to fence the land and install watering facilities.	Controlled

5.1.2 Scope

The project condition applies to drained freshwater mineral wetlands (Lentic) in the Prairie and Parkland Ecoregions of Alberta. Prior to the construction of agricultural drainage infrastructure these Seasonal to Permanent wetlands were closed basins forming internally drained areas that under normal conditions were isolated from natural external drainage systems. The project condition applies to the restoration of the wetland margin and wetland basin areas.

The upland soils, although outside the direct boundaries of the Wetland Protocol, are "controlled" by the project and therefore should be managed accordingly. This upland area will generally be under one of two regimes; 1) a cropped system (which could best be managed using the Nitrous Oxide Emissions Reduction Protocol to best prevent N2O leaching and runoff into the wetland margin/basin), or 2) perennial forage (which may best be managed using the proposed "Rangeland Protocol" under the Alberta Offset System"). Mechanized equipment for farming operations (i.e. for hay harvesting and swathing/baling as well as on-site transportation of the hay on the project site) is also considered an SSR that is controlled by the project, and thus included within the scope of the project condition. This SSR also includes emissions associated with the use of mechanized equipment to physically restored the natural landscape (i.e. "plug" drainage passages, see Appendix B - Procedures Document) for further details. The other SSR that is considered controlled by the project is mechanized equipment energy consumption for crop transportation. This SSR includes the GHG emissions associated with the offsite transportation of crop or crop products, including forages, to the point of sale or final use.

5.1.3 Definitions of Practices

Definitions of practices for wetlands restoration are provided as a general overview in section 2.1 and covered in detail in Appendix B – Procedures Document.

5.1.4 Permanence and Reversibility

Additional development and rationale described in Section 7

The issue of permanence relates to the longevity of terrestrial carbon stocks (i.e. the potential reversibility of sequestered/protected carbon). Permanence is a unique feature of carbon stock management in land use and land use change projects, and risks of non-permanence (or reversal) are a major policy-related barrier to the inclusion of biological sinks in GHG and reporting and offset programs.

With respect to permanence, the Implementation Science Discussion Document noted that reversals in Wetlands projects can result both from human decisions concerning management of the landscape (e.g. land managers could choose to drain a restored wetland) and from natural climatic variations (e.g. climate conditions could result in drying of the wetland). Because of this, the Discussion Document recommended that an assessment of risk of reversal associated with the proposed Wetlands Protocol, using a process like the Voluntary Carbon Standard guidance, should be completed using data from the restoration projects of agencies such as Ducks Unlimited Canada.

A couple of assurance options are available to address the risk of reversal of wetland restoration activities.

First, 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 Reduced Till or 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. A similar approach might be valid for the proposed Wetlands Protocol, because in this case as well the risk of reversal is likely to vary with climate.

Alternatively, the Voluntary Carbon Standard offers an approach for addressing permanence:

- The Voluntary Carbon Standard utilizes the "risk buffer" approach; where the size of a permanence buffer is dependent on the risk rating of a project (Table 1).
- The risk buffer aims to list any threats to permanence and classify them as quantitative or qualitative.

The non-permanence risk analysis of the Voluntary Carbon Standard involves:

- Non-permanence risk analysis includes evaluating four separate risk factors: project risk, economic risk, regulatory and social risk, and natural disturbance risk.
- A risk assessment is conducted and then independently verified by a Voluntary Carbon Standard accredited entity.
- Future verification of the buffer is optional. However, the credibility and environmental integrity of the buffer approach rests on the fact that there will be a periodic "truing up" of the overall Voluntary Carbon Standard buffer pool. Incentives for periodic verification:

1. The buffer credits for a project can be drawn upon over time if future verification confirms the longevity of the project.
2. A project's overall risk rating can be lowered over time and a percentage of the original risk buffer can be released.
3. The recommended time period for re-verification is every five years, although projects may choose to be verified more or less frequently. Therefore, if a project fails to submit a verification report to the Voluntary Carbon Standard within five years from its latest verification, 50% of the credits associated with its buffer are automatically cancelled. After another five years, all of its remaining buffer credits will automatically be cancelled.
4. Although all the credits from the buffer pool may be cancelled if verification is not conducted, the VCUs (Voluntary Carbon Units) already issued to the projects that subsequently fail are not cancelled and do not have to be "paid back". This means that all VCUs generated under the Voluntary Carbon Standard protocols are considered secure and permanent.

Table 4: Factors Used in The Voluntary Carbon Standard Process to Assess Risk of Reversal of Emission Removals Associated with Biological Sink Projects. Taken from the Voluntary Carbon Standard.

Risk Factor	Estimated Risk Rating
Project Risk	
Risk of unclear land tenure and potential for disputes	High
Risk of financial failure	Medium
Risk of technical failure	Low-Medium
Risk of management failure	Low
Economic Risk	
Risk of rising land opportunity costs that endanger the future viability of the project	Medium
Regulatory and Social Risk	
Risk of political instability	Low
Risk of social instability	Low-Medium
Natural Disturbance Risk	
Devastating fire risk	Low-Medium
Risk of incidence of pest and disease attacks	Low
Risk of extreme climatic events (e.g. floods, drought, winds)	Low-Medium
Geological risk (e.g. volcanoes, earthquakes, landslides)	Low

The Implementation Science Discussion Document recommended that the decision concerning strategy to ameliorate risk of reversal associated with the proposed Wetlands Protocol should be based on the results of the assessment of risk of reversal using data from the restoration projects of agencies such as Ducks Unlimited Canada. And, based on the strategy defined, the procedures, systems, and controls used by agencies such as Ducks Unlimited to monitor permanence of restoration projects will inform the criteria used in the Wetlands Protocol to monitor permanence.

The approach to address permanence will be detailed in the Wetlands Protocol formatted for submission to the review process of the Alberta Offsets System.

5.1.5 Ownership

The Implementation Discussion Document identifies the need to define ownership of the offsets in the Wetlands protocol. Because of these, it proposes that the workshop decide whether: (1) the proposed Wetlands Protocol will be applicable only to private lands, and (2) the ownership criteria for the proposed Wetlands Protocol should be based on the experience and precedence which Ducks Unlimited and other similar conservation agencies have gained concerning legal agreements with funders and in restoration projects.

5.1.6 Verification

The guidance in the Procedures Document prepared by Ducks Unlimited Canada prescribes the documentation procedures and criteria of the Wetlands Protocol. The specific requirements for verification and verifiers will likely be detailed in the Wetlands Protocol formatted for submission to the review process of the Alberta Offsets System.

5.2 Baseline Condition

5.2.1 Selection and Justification of Baseline Scenario

Baseline selection and determination has decision-making components of for both implementation and quantification. Concerning the implementation component, determining the baseline scenario for the proposed Wetlands Protocol has two elements. First, an approach to select a baseline scenario must be identified. Second, the ‘business-as-usual’ scenario for wetlands needs to be established; namely, what would have happened to the wetland if no restoration project were originated under the proposed Wetlands Protocol.

A number of approaches to selecting a baseline scenario can be considered. These include historic benchmark, performance standard, comparison-based, and projection-based. These options are described in the “Guide for Protocol Developers” of Canada’s Offset System as follows:

<u>Historic Benchmark:</u>

Typically site-specific and can be constructed to reflect reductions in a base period (such as the average emissions of the previous three years). This approach assumes that past trends in emissions and/or carbon stock changes will continue into the future. Justification must be provided for this assumption.

Ducks Unlimited uses the historic benchmark approach for current restoration activities (Boychuk Pers. Comm., Pierce Pers. Comm.). Photogrammetric methods are used to analyze prospective wetlands by assessing the size and site characteristics recorded on aerial photographs from a number of years. Alternatively, inspection reports such as those described in Turner *et al.* (1987) and Bartzen (2008) from a number of years could be used to assess the baseline scenario for a wetland site proposed for restoration.

Performance Standard:

This approach assumes the typical emissions profile for the industry or sector is a reasonable representation of the baseline. An assessment of comparable activities within a given industry or sector is necessary.

The performance standard approach is the method of baseline determination preferred by CAR, so the Issues Paper for the proposed tidal wetland protocol outlines. Thus, CCAR (2009) presents options for performance standards to address wetland restoration.

For wetland restoration, CCAR (2009) proposes “the background net conversion rates of wetland area gains or losses could be used in the development of a performance standard to establish the ‘business as usual’ rate”. The performance standard approach in the CCAR Issues Paper is thus highly dependent on the availability of comprehensive and sophisticated datasets. Indeed, the Issues Paper emphasizes that datasets in the United States may need to be enhanced to develop performance standards. In Canada, datasets are less comprehensive and sophisticated than those in the United States (Dahl and Watmough 2007).

Alternatively, the data of Bartzen (2008) provides support for the conclusion that almost all (>90%) of the wetlands and uplands of the Prairie Pothole Region in Canada have been to some degree degraded (see Section 6.1 above). That is, according to the Alberta Environment definition, wetland loss could be considered as normative for the Prairie Pothole Region.

Comparison-based:

The comparison-based approach involves actual measurements of parameters from a control group (such as a plot of forested land, space heating natural gas consumption per square meter, etc.) to compare with the project. Emissions or removals from the control group are monitored throughout the project and compared with the emissions from the project site to determine the incremental reductions from the project. Such a control group can be used with more than one project.

GHG quantification protocols for forestry projects types tend to require monitoring of control plots to achieve comparison-based determination of the baseline scenario. But, this approach is not likely to be practical for the proposed Wetlands Protocol, where the projects are expected to be comprised of many small wetlands characterized by spatial and temporal heterogeneity.

Projection-based:

Projections of reductions in the future can use a variety of techniques, from simple straight-line growth assumptions to complex models. Forward-looking projections can be specified in terms of a set of constant parameters or can vary over time according to pre-defined procedures.

The Ducks Unlimited Inc Avoided Grassland Conversion Project uses a Projection-based approach as follows:

> The baseline scenario incorporates the probability of conversion of native grasslands in the Project Area to cultivation-based farming activities. DU's research indicates that the annual loss rate of the remaining native prairie grasslands will begin at 3% starting in 2008, and then gradually decline to 2% annually over the course of three decades as the biofuels initiatives mature and most potential ethanol production plants come online (Ducks Unlimited, 2008). Thereafter, DU's modeling of land use change assumes that loss rates will further decline as all suitable land is gradually converted.

Under the baseline scenario, this model predicts that 73.1% of the native prairie grassland in existence today will be lost in the next 99 years (Ringelman, 2007). The risk of conversion to cropland is based on spatial and economic risk assessment models (Ringelman, 2007). When the annual loss rate is applied to the Project Properties, it is projected that 19,225 of the 26,300 acres—73.1%—of native grasslands in this Project will be converted over 99 years.

The Terrestrial Carbon Group has proposed a form of projection-based baseline. This approach assumes that the *de facto* business as usual for all land is conversion to agriculture or other land use where the native function is lost as follows:

> Over the coming decades, vegetated land in developing nations will be increasingly threatened with conversion to agricultural and plantation use, and to human settlements and infrastructure. The exception will be land that is protected by law, protected by biophysical conditions, or protected by economic constraints. This increasing threat will be driven by the dynamic links between (a) population, (b) demand for food, fibre, fuel, carbon, and land, (c) prices for those commodities, and (d) land use decisions. The business as usual scenario is that most existing terrestrial carbon on unprotected land will be emitted. As land is taken out of production to be "protected" for carbon sequestration, land for other uses will become scarcer, more valuable, and under even more pressure for conversion.

The Terrestrial Carbon Group approach would be implemented as follows:

> Put simply, nations may emit an agreed volume of the original unprotected terrestrial carbon (an annual terrestrial carbon budget) each year with no penalty. If the nation emits less than its annual terrestrial carbon budget in a year, it can sell the difference as terrestrial carbon credits (and must add that volume of terrestrial carbon to its protected category, safeguarding the permanence of the avoided emissions). If the nation emits more than its annual terrestrial carbon budget in a year, it cannot participate in the system until it reverses the excess emissions. The fixed period could be set on a nation-by-nation basis to best reflect national business as usual scenarios. A nation can generate credits for any new terrestrial carbon it creates.

The Terrestrial Carbon Group approach is designed to be implemented at the national level, but the approach likely could be adapted to consider the Prairie Pothole Region as the area of implementation.

5.2.2 Additionality or Incrementality

The Implementation Discussion Document provided evidence that the GHG reductions and removals generated by the proposed Wetlands Protocol go beyond business as usual, and therefore are additional or incremental. It also justified the additionality of wetlands projects though discussion of several additionality tests, including surplus to regulation, investment barriers, technological barriers, institutional barriers, and not common practice. The Implementation Discussion Document did not assert that the GHG reductions and removals from the proposed Wetlands Protocol meet the test of financial additionality. Based on this, it was proposed that decision points for the workshop should include agreement with the justification of additionality as presented in the Implementation Discussion Document.

5.2.3 Baseline Sources and Sinks (SS's)

Figure 4: Diagram of SS's associated with the baseline scenario for the proposed Wetlands Protocol, a drained or degraded wetland.

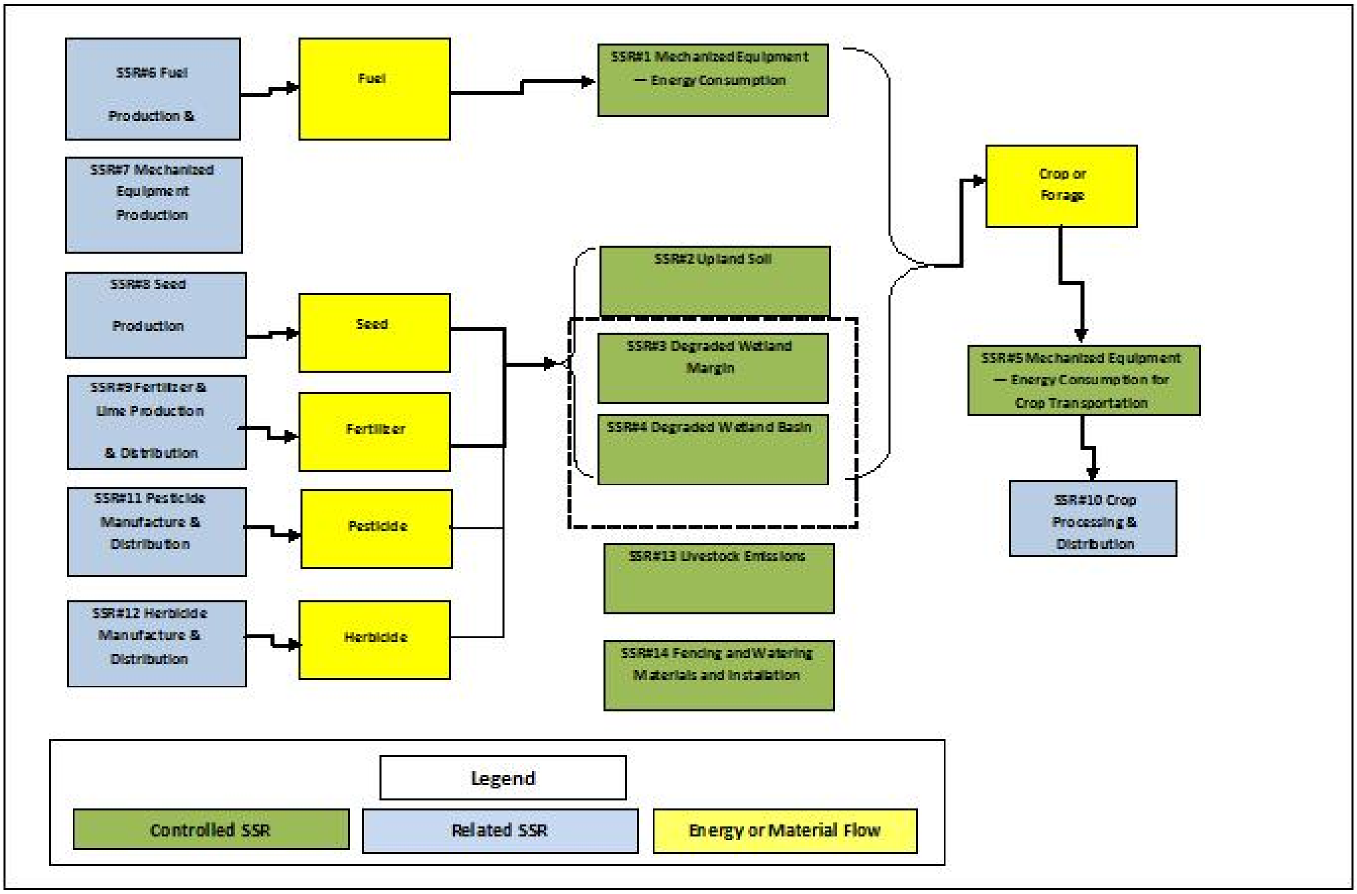


Table 5: Controlled, related, and affected SS's for the baseline scenario of the proposed Wetlands Protocol, a drained or degraded wetland.

IDENTIFIER	NAME	DESCRIPTION	CONTROLLED, RELATED OR AFFECTED
SS1	Mechanized Equipment – Energy Consumption for Farming Operations	GHG emissions of CO_2, CH_4 and N_2O are generated when mechanized equipment is used for cultivation, seeding, applying fertilizer, herbicide or pesticide, harvesting (swathing, combining, baling), and transporting crop products onsite. This SSR also includes emissions associated with equipment and energy needed, if any, to alter the natural landscape to drain	Controlled

		wetlands (i.e. create drainage passages).	
SS2	Upland Soil	GHG dynamics (net flux of CO_2, CH_4 and N_2O, and including net SOC sequestration if occurring) associated with upland soils. This soil may be cropped or in perennial forage.	Controlled
SS3	Degraded Wetland Margin	GHG dynamics (net flux of CO_2, CH_4 and N_2O) associated with degraded margin soils.	Controlled
SS4	Degraded Wetland Basin	GHG dynamics (net flux of CO_2, CH_4 and N_2O) associated with wetlands degraded and cropped.	Controlled
SS5	Mechanized Equipment – Energy Consumption for Crop Transportation	GHG emissions of CO_2, CH_4 and N_2O are associated with the offsite transportation of crop or crop products, including forages, to the point of sale or final use.	Controlled
SS6	Fuel Production and Transportation	GHG Emissions of CO_2, CH_4 and N_2O are generated from the upstream exploration, production processes and distribution of diesel and other fuels.	Related
SS7	Materials and Equipment Production and Distribution	GHG emissions of CO_2, CH_4 and N_2O are generated from the input of materials and energy in the manufacturing and distribution of materials and equipment.	Related
SS8	Seed Production and Distribution	GHG emissions of CO_2, CH_4 and N_2O are generated in the process of collecting, cleaning, storing and distributing seed for crops.	Related
SS9	Fertilizer and Lime Production and Distribution	GHG emissions of CO_2, CH_4 and N_2O are associated with the manufacturing and distribution of fertilizer and lime.	Related
SS10	Mechanized Equipment – Energy Consumption for Crop Processing and Distribution	GHG emissions associated with the cleaning, handling and final distribution of crop products, including forages.	Related
SSR11	Pesticide Manufacture and Distribution	GHG emissions of CO_2, CH_4 and N_2O are associated with the manufacture and off site transportation of pesticide.	Related
SS12	Herbicide Manufacture and Distribution	GHG emissions of CO_2, CH_4 and N_2O are associated with the manufacture and off site transportation of herbicide.	Related
SS13	Livestock Emissions	GHG emissions of N_2O and CH_4 and are	Controlled

		associated with the manure of grazing animals. Enteric emissions of CH_4 are produced as a by-product of digestion that are exhaled or eructated from the grazing livestock.	
SS14	Fencing and Watering Materials and Installation	GHG Emissions of CO_2, CH_4 and N_2O are associated with the energy and materials required to fence the land and install watering facilities.	Controlled

5.2.4 Baseline Determination

The consultation workshop determined that the historic benchmark approach is the most suitable approach for the restoration aspect of the protocol.

Historical imagery acquired during or shortly after peak hydro periods (Late April through mid-June) are deemed optimal for interpreting wetland features. General heuristic for selecting candidate historical years of photography would be to target years with normal to above normal precipitation accumulations over hydrologic winter (October 1st through March 31st). Comparison of the annual precipitation accumulations over hydrologic winter relative to station normals should indicate which years of historical imagery are likely to document normal to above normal runoff events. Climate data for active and historical stations can be accessed via the internet at the Canada's National Data and Information Archive (http://www.climate.weatheroffice.gc.ca/Welcome_e.html)

Alberta Sustainable Resource and Environment (ASRD) maintains the archive of all historical aerial photography captured for the Government of Alberta dating back to 1949. ASRD's Aerial Photo Record System (APRS) enables the query of the archive to determine the acquisition information of historical imagery for specific geographic locations. The most common scale of historical photography in the archive is 1:30,000, similar or larger scale photography is appropriate for interpreting Prairie wetlands and drainage features. Either digital scans or hard copy prints can be ordered and purchased through the website on a unit cost basis. APRS can be accessed via the internet at http://www.srd.alberta.ca/MapsFormsPublications/AirPhotoDistribution/Default.aspx).

In areas where suitable provincial historical aerial photography is lacking, additional archival photo may be available in the National Air Photo Library (NAPL) available online at: http://airphotos.nrcan.gc.ca/photos_e.php. Geographic query is available to determine the availability of historical photo collected by the Government of Canada for specific areas of interest.

Additionally, the Implementation Discussion Document noted that no regulations exist in Canada to protect wetlands from drainage or degradation, that the main anthropogenic threats to Prairie Pothole Region wetlands are drainage and land clearing, and that overgrazing and cultivation of riparian zones can directly impact the amount of vegetated habitat available to sequester carbon, but also has a negative impact on the remaining wetland due to the nutrient loading associated with surface runoff or groundwater discharge.

Based on this, the following decision point for the workshop regarding baseline scenarios was proposed and agreed upon:

- The policy or implementation premise regarding 'business as usual' for wetlands in the Prairie Pothole Region is that, in the absence of a restoration project, the vast majority wetlands would be degraded or destroyed.

6 Consultation Workshop

A Consultation Report was formulated from discussions and decisions involved a technical expert group at the consultation workshop. The report describes the development to date of the Wetlands Restoration Protocol. The process for development so far has included two Science Discussion documents – one focussed on Quantification and one on Implementation – as well as a Consultation Workshop.

The purpose of the workshop was to engage key scientific researchers, technical experts and project developers at home and abroad, to provide advice and agreement on the best available quantification methodologies to assess GHG emissions.

The general process followed during the Consultation Workshop can be summarized as follows:

- Use a combination of a literature and existing protocol review in the form of a science discussion papers, share recent research results, researcher experience and group discussion and evaluation of ideas and recommendations to achieve the workshop outcomes.
- The first day was spent setting the foundation by setting the context for carbon offsets and protocols, examining the state of the science and baselines; the quantification approaches and coming to consensus the framework of the protocol; the second was focus on identifying and addressing quantification and implementation issues as well as identifying science gaps for future research.

The Consultation Workshop for the Wetlands Protocol was held on the 17th to 18th of March 2010 at the Airport Delta Hotel in Edmonton. Details of the Consultation Workshop are posted on the website: http://carbonoffsetsolutions.climatechangecentral.com/offset-protocols/alberta-protocol-development-workshops

The participants of the Consultation Workshop comprised representatives of government and university research organizations, industry associations, not for profits, and government agencies. In addition to the Overview Committee, about 70 individuals received invitations to the Workshop. Of those invited, 43 individuals responded and thus received the Implementation and Quantification Discussion Documents for review and comments. The participants attending the Consultation Workshop numbered XX attended.

Table 6: Names and Affiliations of Participants in the Consultation Workshop.

Name	Affiliation
Steering Committee	
Cynthia Edwards	Ducks Unlimited Canada
Tanya Maynes	Climate Change Central
Pascal Badiou	Ducks Unlimited Canada
Rick Bourbonniere	Environment Canada
Tom Goddard	Alberta Agriculture and Rural Development
Bob MacFarlane	Prairie Habitat Joint Venture
Leslie Wetter	Ducks Unlimited Canada
Rob Janzen	ClimateCHECK
Contractors and Workshop Facilitator	
Amanda Stuparyk	Climate Change Central
Fiona Law	CompuTouch
Canadian Researchers	
Angela Bedard-Haughn	University of Saskatchewan
Irena Creed	University of Western Ontario
Lee Foote	University of Alberta
Roger Bryan	Institute of Agriculture, Forestry and the Environment
Suzanne Bayley	University of Alberta
Industry And Association Representatives	
Barry Bishop	Ducks Unlimited - Canada
Brian Ilnicki	Land Stewardship Centre of Canada
Chad Croft	Alberta Conservation Association
Cynthia Edwards	Ducks Unlimited - Canada
David Browne	Canadian Wildlife Federation
Don McCabe	Soil Conservation Council of Canada
Jay Anderson	EarthEcon
Lisette Ross	Ducks Unlimited - Canada
Lyle Boychuk	Ducks Unlimited - Canada
Per Andersen	Nature Conservancy of Canada
Sharon McKinnon	Crop Working Group
Government	

Jason Cathcart	Alberta Agriculture and Rural Development
Mike Watmough	Canadian Forest Service
Marian Weber	Alberta Research Council
Rob Hamaliuk	Alberta Environment
Robyn Kuhn	Alberta Environment
Sheilah Nolan	Alberta Agriculture and Rural Development
Sid Carlson	Alberta Research Council
Tony Brierley	Agriculture and Agri-food Canada

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

[2] Only participants with a graduate degree in an appropriate science discipline were given the privilege to vote on options to develop the Wetlands Protocol.

The decisions of the Consultation Workshop were based on the preparation provided in the Implementation and Quantification Discussion Documents, the presentations at the Workshop, the discussions within the working groups, and the consensus of the convened participants. The agenda of the Workshop, the presentations to the Workshop participants from the science experts, and the Record of Discussion are available at the website: http://carbonoffsetsolutions.climatechangecentral.com/offset-protocols/alberta-protocol-development-workshops

7 Revisions to Technical Seed Document to Account for Ongoing Development Prior to First Round Technical Review of the Protocol

Revisions have been made to the Wetlands Restoration Protocol according to comments and requests from Alberta Environment before the First Round Technical Review. The appropriate changes, clarifications, and justifications made to the Wetlands Restoration Protocol by the Technical Working Group are listed below.

Alberta Environment identified a number of concerns including the need for:

1. Clear understanding of the activity generating the reductions;
2. Alberta context for the science and baseline information;
3. How permanence and leakage of emissions reductions would be addressed;
4. The types of records available to support the reduction/removal activity; and
5. Potential barriers and the capacity to implement projects (including ability to prove that projects were not required by wetland mitigation requirements required under the Water Act).

7.1 Activity to Generate Reductions

The protocol applies only to the restoration of Class III, IV, and V wetlands on private lands where there is evidence of a drainage ditch and aerial photos confirm the area was previously a wetland ecosystem. The protocol development team will assess whether an eligibility date (wetlands drained before date X) is appropriate to prevent gaming by draining and restoring wetlands for offset credits. Further, wetland restoration will be through the construction of earth plugs (to reverse the drainage structure) to impound water to allow the wetland to re-establish.

7.2 Alberta Context of Science

In response to an issue raised during the technical review concerning how CO_2 flux was measured and incorporated into the protocol; Ducks Unlimited confirmed that the project, baseline, and coefficients are based on a Canadian study of 62 prairie pothole wetlands, of which, some 29 were located in Alberta. Further, the derived coefficient accounts for seasonality, diurnal fluctuations, and periodic drying of wetlands. CO_2 was measured; however in terms of developing a sequestration coefficient the change in soil organic carbon (SOC) was used. This is because CO_2 is consumed through photosynthesis and released through respiration, but what we are interested in is the net change between these two which we measured as change in SOC. So carbon sequestration is included in the protocol and in the net coefficient.

7.3 Permanence and Leakage

The Wetlands Restoration Protocol is designed to address two types of risks to permanence of the net sequestration achieved by reversal of drainage of freshwater mineral soil wetlands in the Prairie Pothole Region. These two types of risks to permanence are: (1) reversal due to termination of the practices prescribed by the Wetland Restoration Protocol; and, (2) reversal due to factors beyond the control of the Project Developer.

The Wetlands Restoration Protocol includes two elements to address the risk of reversal due to termination of Protocol requirements. First, the protocol requires projects to be administered by one of three types of land use agreements — purchase by conservation organization, Conservation Easement, or 30-Year Wetlands Restoration Agreement. In the experience of Ducks Unlimited Canada, the primary Wetlands Restoration Agency in Alberta, these types of agreements are not defaulted. Since the 1990's, Ducks Unlimited Canada has engaged in more than 600 conservation easement projects in Canada. There are no breaches of these agreements to date. This means the management conditions prescribed by the Wetlands Restoration Protocol are expected to be in place for at least the term of the 30-Year Wetlands Restoration Agreement. Second, the Protocol restored wetlands (and existing wetlands on project participant's land) are protected according to the restrictions of the Alberta Water Act. The design of the Wetlands Restoration Protocol minimizes the risk of deliberate reversal of the project conditions prescribed by the protocol.

The major factor beyond the control of the Project Developer to consider is the risk of reversal due to long-term changes in water regime as a result of climate change. The Wetlands Restoration Protocol incorporates elements of conservativeness and discount to address the risk of increased water deficits in the Prairie Pothole Region of Alberta.

In part, the approach to derivation of the net sequestration coefficient used in the protocol addresses the risk associated with climate change. That is, the rate of soil organic carbon sequestration measured in the restored wetlands, which provide the basis for the coefficient, integrates the variability of water dynamics at the research sites. And, the CH_4 measurements and modeling used to adjust the soil organic carbon values to derive the net coefficient were recorded for submersed conditions. If submersed conditions become less prevalent in wetlands in the Prairie Pothole Region, rate of carbon sequestration may decrease, but CH_4 emissions may also decrease. Thus, the conservativeness in the net sequestration coefficient partly addresses this risk to permanence.

The conservativeness elements of the Wetlands Restoration Protocol and the restrictions of the Alberta Water Act provide substantive measures to deal with risks of intentional and environmental reversals of net carbon sequestration in freshwater mineral soil wetlands of the Prairie Pothole Region.

Two types of leakage are potentially associated with the restoration activity eligible under the Wetlands Restoration Protocol. First, there is potential for the activity of restoration of wetlands to increase the risk of degradation or drainage of other wetlands. Since most wetlands in the Prairie Pothole Region are considered to be already at least vulnerable to degradation or drainage, it is unlikely that the implementation of the Wetlands Restoration Protocol would increase the risk for the remaining wetlands to be drained. Second, there is potential for restoration of wetlands and associated uplands to result in the loss of cropland, and this potential loss could pressure conversion of grassland or forest land into cropland in other areas of the Prairie Pothole Region. Although the wetland areas and some of the upland areas will be removed from agricultural production (i.e. some uplands under Purchase Agreements or Conservation Easements may be left idle to maximize wildlife habitat), much of the uplands area are expected to be used for grazing, haying, and perhaps even for cropping. As the majority of the agricultural land in Alberta falls within the Prairie Pothole Region, it is unlikely that sufficient cropland could be idled under the Wetlands Restoration Protocol to influence land use patterns.

Despite the limited likelihood of leakage, the Wetlands Restoration Protocol incorporates elements to further minimize the risk of leakage. First, participants in the projects under the Wetlands Restoration Protocol shall enrol entire quarter sections into the project. This means that the entire quarter section on which the restored wetland(s) is (are) situated shall be subject to the post-restoration management prescribed by the Wetlands Restoration Protocol. Second, participants in the protocol projects have the option, in the 30-Year Wetlands Restoration Agreement, to continue raising crops.

7.4 Records Available and Documentation Prescribed

It should be reiterated that the protocol will only apply to wetland restoration projects on private lands. Ducks Unlimited Canada maintains an extensive database of all restoration projects undertaken and will be working with Alberta Environment to develop a means of tracking wetland mitigation projects. The protocol is further proposing to have farms sign up at a quarter section or farm level. This means that all wetland bodies on a farm will be registered in the Alberta Environment database and will be tracked, even if a farmer/land owner is only restoring one wetland on his or her property. This will help assess long term leakage and program performance. The responsibility is ultimately the regulator's as there could be multiple wetland restoration agents.

In response to concern raised by Alberta Environment on the rigour of monitoring, maintenance and inspection of the restored wetlands; Monitoring for the projects will include a bi-annual site inspection to check the integrity of the earth plug. Regulatory quality records must also be maintained for all projects, and AENV approvals are provided for wetlands required under the mitigation requirements. Records are detailed in several places in the revised protocol and appear to be sufficient for tracking and verification purposes.

Projects must be undertaken by a Wetland Restoration Agency approved by Alberta Environment, which assures the Agency must be able to demonstrate the capability and capacity to regulatory quality data handling and specific subject matter expertise to receive their designation. The protocol developers will be providing clarification on professional expertise and designations that have appropriate expertise to develop these projects and sign-off. Specific qualifications are still being discussed.

Minimum information required to support this activity is:

1. The name, contact information, and statement of qualifications of the Project Developer;
2. The name, contact information, and statement of credentials of the Wetlands Restoration Agency, including the credentials of participating QWAES, if any;
3. The name and contact information of the individual landowner(s) enrolled in the project;
4. The year the project was initiated;
5. The number, sizes, and locations of the degraded wetland areas enrolled in the project, including
    a. Legal land location (preferably GPS coordinates) of each degraded wetland;
    b. Field area substantiated with aerial photographs and a Wetlands Restoration Agency field visit;

c. Evidence, substantiated by a Wetlands Restoration Agency, attesting to the depth of the wetland basin;
d. An interim restoration plan assembled in a GIS environment;
e. A survey, conducted by a Wetlands Restoration Agency, of the Asbuilt elevation of all earth plugs following construction; and
f. Assemble all data into a standardized central repository (geospatial data archive) for future monitoring applications;

6. The plans for wetland and upland management, as well as the records of implementation of these plans.

The definitive reference for the restoration procedures and records prescribed by the Wetlands Restoration Protocol is the Procedures Manual (Boychuk 2010) of Ducks Unlimited Canada. The Procedures Manual is included in Appendix A of this protocol.

Alberta Environment requires that Project Developers maintain appropriate supporting information for the project, including all raw data for the project for a period of 7 years **after** the end of the project credit period. Where the Project Developer is different from the person implementing the activity, as in the case of an aggregated project[2], the individual landowner and the Wetlands Restoration Agency, must maintain sufficient records to support the Offset Project. The Project Developer and the Wetlands Restoration Agency must keep the information listed below and disclose all information to the verifier and/or government auditor upon request.

<u>Record Keeping Requirements:</u>

- Raw field measurements (proxy basin depth, size of degraded wetland, GPS co-ordinates for the interim restoration plan, notes on the viability of the site for restoration, dimensions of the earth plug, survey geometry, QWAES general notes, management data, independent variable data, and static factors within the measurement boundary);
- Digital scans and copies of all historical and present aerial photographs used;
- Topographic survey and earth plug construction data (including notes on; the earth plus location(s), the earth dam(s) geodetic elevation, flood contours, transect across the deepest portion of the wetland basin, the edge of the toe slope, earth plug construction, Asbuilt elevation of the earth plugs after restoration);
- A record of the Asbuilt survey/plan (electronic and hard copies);
- Completed interim plan (electronic and hard copies);

[2] Please see Alberta's Technical Guidance for Offset Project Developers http://environment.alberta.ca/02278.html

- Climate data records (if available and/or necessary);
- Light Detection and Ranging (LiDAR) imagery records (if used to identify potential drained wetland targets);
- GIS records (background data, potential scope of restoration information);
- A record of all adjustments made to raw data with justifications;
- All data and analysis used to support estimates and factors used for quantification;
- A record of changes in static factors along with all calculations for non-routine adjustments;
- Field visit activity logs, including assessment of wetland and upland; and
- Initial and annual verification records and audit results.

The following series of sub-sections are meant to provide examples of information that could be used to provide evidence for the data requirements of projects carried out according to the Wetlands Restoration Protocol. While these sub-sections provide illustrations of the potential sources and records of data, the Project Developer and Wetlands Restoration Agency will need to ensure the documentation collected will meet the requirements of verification.

Operational Records -- Wetland Restoration

The Project Developer and Wetlands Restoration Agency will prepare plans and maintain records detailing drained wetland target identification and the restoration procedures performed will be the primary target of the verifier's efforts to ensure the protocol has been implemented correctly. These records align with the reporting the Wetlands Agency needs to provide in fulfilling its role in the Alberta Wetlands Loss Compensation Program. These records should be maintained by the Project Developer and aggregator (if applicable), as well as the Wetlands Restoration Agency.

All records collected as part of the implementation of the restoration should be retained by all participants in the project (land owner, Project Developer, Wetlands Restoration Agency), and must be made available to the third party verifier. These records must be linked to the exact restoration procedures to support data management processes and systems designed and implemented according to scale of the wetland or digital field map as required.

These records include:

- Record of Assessment of Viability of Wetland for Restoration
    - Establish location of the historical basin edge, involving analysis of historical aerial photography and other concrete evidence, such as land-use management record or purchase agreements, with details of the previous ecological landscape;

- If no definitive photogrammetric evidence, evidence of hydric soils via comprehensive soil sampling; and laboratory testing;
- Measurement of maximum depth of basin (represents proxy for depth/permanence class);
- Evidence that the surface or ground water was removed artificially that the spill elevation has been lowered, and that the restored wetland depth has the potential to be restored to a Class 3-5, lentic wetland;
- Assessment of the earth plug size and shape (to ensure it can manage the volume stored and outflow around the plug when water levels exceed full supply);
- Examine the back-flood area behind the earth dam and assess the potential of flooding adjacent properties upstream or the potential of causing downstream damages in the event of an earth plug failure;
- Determine the potential of a washing out of the structure from large meteorological events (examine the wetland morphology); and
- Determine the willingness of the landowner to change land use.

- Record of Project Planning and Landowner Negotiation
    - Obtain the consent of the landowner to conduct a visual change comparison (look at recent aerial photography);
    - Inspect the potential wetland restoration site on the ground the confirm the presence of a drain and the viability of restoration;
    - Conduct a field visit to confirm the definition of elements in the plan and to determine the viability of each site for restoration;
    - Assemble an interim restoration plan in a GIS environment, field notes and handheld GPS can be used to acquire additional data in the field, which will later be incorporated into the final interim plan), which includes;
    - Delineation of restored wetland basin extent derived from the historical benchmark aerial photography and wetland basin area — select photos (from ASRD's Aerial Photo Record System, the National Air Photo Library (NAPL), or otherwise) from years with normal to above normal precipitation accumulations over hydrologic winter (October 1st through March 31st);
    - Delineation of the wetland margin surrounding the wetland basin and wetland margin area.
    - Approximate locations of earth plugs.
    - Property lines and cadastral boundaries and appropriate labeling of legal land locations.

  - Identification and location of any potential obstacles to restoration (i.e. buildings) or hydrologic features that could influence the contributing area of restored wetlands (i.e. culvert locations).
  - Gain permission from the landowner to proceed with the restoration after incorporation of the field observations into the interim plan;
- Record of Topographic Survey and Earth Plug Construction
  - Final visit to the site by Wetland Restoration Agency to formally survey the project area and construct earth plugs;
  - Establish the earth plug location, spill elevation, and construction dimensions for each restored wetland;
  - Establish the flood contour (wetland basin) topographically upstream of the earth plug spill elevation and demarcates the boundary on the ground;
  - Generate a transect across the deepest portion of the wetland basin to establish maximum depth between basin bottom and the flood contour (This requirement confirms the permanence class of the restored wetland);
  - Traverse and demarcate the edge of the toe slope around the restored wetland to establish the wetland margin area;
  - Meet with the landowner on site to confirm the build prior to construction of the earth plugs;
  - Supervise the construction of the earth plugs to insure they are in accordance to survey; and
  - Survey the Asbuilt elevation of the plugs following construction.
- Record of Asbuilt Survey Plan
  - The Project Developer and the Wetland Restoration Agency (WRA), including legal name, address, and contact information of person responsible for project;
  - Wetland restoration project identification number;
  - Landowner name;
  - Legal Land Location;
  - Date of survey and construction;
  - Earth dam location and coordinates;
  - Earth dam geodetic elevation in meters;
  - Surveyed wetland basin boundary and area in hectares;
  - Surveyed wetland margin boundary and area in hectares; and
  - Total wetland area (basin and margin) in hectares.
- Record of Report to Geospatial Archive

  - This record will comprise the project data required for the Alberta Wetlands Loss Compensation program.

Operational Records -- Wetland and Upland Management

Management of the wetland according to the requirements of the Wetlands Restoration Protocol involves maintenance of the earth plug, and termination and prevention of burning, clearing, and cultivating of the wetland margin.

In projects administered under Conservation Easements, which prescribe 'no break, no drain' management, the land use agreement frames the management of the margin outside the full supply level and of the upland associated with the wetland.

For projects under 30-Year Wetland Restoration Agreements, which leave upland management to the discretion of the land owner, Project Developers must provide the plan to ensure management in the margin outside of the fully supply level and of the associated upland supports wetland function. This plan shall require landowners to maintain perennial cover by establishing grassland or forest land. Alternatively, if the land owner grows cultivated crops, the plan shall require landowner to fulfill the requirements of the 4R nitrogen management plan prescribed in the Agricultural Nitrous Oxide Emissions Reductions Protocol, and to use zero till as prescribed in the Tillage Quantification Protocol.

The operational records concerning wetland and upland management will include:

- Detailed wetland, margin, and upland management plans, signed by Wetlands Restoration Agency and land owner. In the case of annual cropping, the plans will include the Nitrogen Management Plans (with signature of Approved Professional Advisor) as required by the Agricultural Nitrous Oxide Emissions Reductions Protocol;
- Annual activity logs of all farming activity (cropping, grazing, haying) on wetland margins and associated uplands. These activity logs will be supported by purchase invoices for agricultural inputs and sales records of agricultural products; and
- Bi-annual inspection records for wetland and upland by Wetlands Restoration Agency (This inspection is required as part of the role of the Wetlands Restoration Agency in the Alberta Wetlands Loss Compensation program). The inspection records will include
  - Inspection plan for earth dam integrity;
  - Inspection plan for wetland margin and restored wetland basin;
  - Inspection plan and list of survey equipment for ensuring the original construction elevation is maintained;
  - Repair plan in instances where the earth dam has washed out; and
  - In addition to the records above, time-stamped digital photographs of the wetland are helpful for determining whether the integrity of the earth dam(s)

have been compromised or when the elevation has been altered due to a wash out or other similar effect.

7.5 Additionality

An excerpt from the "Intent to Develop a Protocol" document summarizes the rationale for additionality of the projects eligible under the proposed Wetlands Restoration Protocol:

> Wetlands in Canada continue to be threatened by degradation and loss. The policy or implementation premise regarding 'business as usual' for wetlands in the Prairie Pothole Region is that, in the absence of a restoration project, the vast majority wetlands would be degraded or destroyed. The GHG reductions and removals generated by the proposed Wetlands Protocol go beyond business as usual because the practices of wetland restoration are surplus to regulation, investment barriers, technological barriers, institutional barriers, and are not common practice. No legislation in Alberta requires land owners to restore previously drained wetlands. However, existing wetlands are protected under the Alberta Water Act. The restoration of wetlands will not be double counted with wetlands that are required to be replaced through regulations or requirements for wetland mitigation. The focus will be on wetlands for which there are currently no requirements to restore. Currently there is very little commercial interest in restoring drained wetlands except for conservation organizations, like DUC, or landowners who have an interest in restoring water for livestock or lifestyle purposes. There is substantial potential for restoration of wetlands in Alberta. The Project Developers working under the auspices of the Wetlands Protocol will be responsible for ensuring that wetlands restored to generate offsets are not otherwise required by law.

8 References

The publications listed below represent the breadth and depth of scientific knowledge referenced to develop the technical foundation of the Wetlands Protocol. These publications provide the evidence deliberated in the Technical Background Document, support the considerations integrated in the Science Discussion Document, contribute to the decisions recorded in the Consultation Workshop Report, and some are referenced in this Technical Seed Document.

Adams, J. 2007. Effects of potential changes in nitrogen loads to nitrous oxide efflux from prairie potholes. Honours Thesis. Department of Biology.

Alberta Environment. 2007a. Guide to the Code of Practice for Pipelines and Telecommunication Lines Crossing a Body of Water. http://www3.gov.ab.ca/env/water/legislation/cop/pipeline.pdf.

Alberta Environment. 2007b. Provincial wetland restoration / compensation guide. ISBN 978-0-7785-5479-0 (On-line). http://environment.alberta.ca/documents/Provincial_Wetland_Restoration_Compensation_Guide_Feb_2007.pdf.

Alberta Water Council. 2008. DRAFT. Recommendations for a new Alberta wetland policy. www.AWChome.ca.

Austen, E. and A. Hanson. 2008. Identifying wetland compensation principles and mechanisms for Atlantic Canada using a Delphi approach. Wetlands. 28: 640–655.

Badiou, P., D. Pennock, and R. McDougal. 2008. Personal Communication. PowerPoint presentation to summarize results of Agriculture and Wetlands Greenhouse Gas Initiative research results Carbon sequestration and greenhouse gas emissions in Canadian prairie wetlands.

Badiou, P., R. McDougal, D. Pennock, and B. Clark. 2010. Greenhouse Gas Emissions and Carbon Sequestration Potential in Restored Wetlands of the Canadian Prairie Pothole Region. Submitted to J Wetland Ecol Manag.

Bartzen, B. 2008. Wetland characteristics and abundance of breeding ducks in prairie Canada . M.Sc. Thesis. University of Saskatchewan, Saskatoon.

Bedard-Haughn, A., F. Joengbloed, J. Akkerman, A. Uijl, E. de Jong, T. Yates, and D. Pennock. 2006. The effects of erosional and management history on soil organic carbon stores in ephemeral wetlands of hummocky agricultural landscapes. Geoderma. 135: 296-306.

Boychuk, L. Personal Communication. Manager of GIS and Inventory Programs. Ducks Unlimited Canada.

CCAR. 2009. Greenhouse Gas Mitigation Typology Issues Paper Tidal Wetlands Restoration. Prepared for California Climate Action Registry by Philip Williams & Associates Ltd with Scieence Applications International Corporation (SAIC). http://www.climateregistry.org/resources/docs/protocols/issue-papers/Tidal-Wetlands.pdf.

Corps of Engineers— Environmental Laboratory. 1987. Wetlands delineation manual. Technical Report Y-87-1. http://el.erdc.usace.army.mil/wetlands/pdfs/wlman87.pdf.

Cox, K.W., and A. Grose. 2000. Wetland mitigation in Canada: A framework for application. Issues Paper, No. 2000-1. North American Wetlands Conservation Council. ISBN: 0-662-28513-1.

Dahl, T.E. 1990. Wetlands losses in the United States 1780's to 1980's. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. Jamestown, ND: Northern Prairie Wildlife Research Center Online. http://www.npwrc.usgs.gov/resource/wetlands/wetloss/index.htm (Version 16JUL97).

Dahl, T.E. 2006. Status and trends of wetlands in the conterminous United States 1998 to 2004. Fish and Wildlife Service, US Department of the Interior, Washington, D.C. 112 pp. http://www.fws.gov/wetlands/_documents/gSandT/NationalReports/StatusTrendsWetlandsConterminousUS1998to2004.pdf.

Dahl, T.E. and M.D. Watmough. 2007. Current approaches to wetland status and trends monitoring in prairie Canada and the continental United States of America. Can. J. Remote Sensing. 33, Suppl. 1: S17-S27.

Driver, E.A. and D.G. Peden. 1977. The chemistry of surface water in prairie ponds. Hydrobiologia. 53: 33-48.

Ducks Unlimited Canada. 2008. The impacts of wetland loss in Manitoba. A brochure to describe the results of research in the Broughton's Creek watershed, published with participation of Agriculture and Agri-Food Canada, Environment Canada, and Natural Resources Canada.

Ducks Unlimited. 2009. Ducks Unlimited Avoided Grassland Conversion Project in the Prairie Pothole Region. Climate, Community, and Biodiversity Alliance Report. Prepared by Ducks Unlimited, Inc., New Forests, Inc. Equator, LLC. http://www.climate-standards.org/projects/files/20090323_du_agc_ccba_final_for_release.pdf.

Environment Canada. 1998. National sinks Table foundation Paper. Pollution Data Branch, Hull. http://www.ec.gc.ca/pdb/ghg/Related_Docs/sinks_found_e.cfm.

Environment Canada. 2008. National Inventory Report. Greenhouse Gas Sources and Sinks in Canada. 1990 – 2006. http://www.ec.gc.ca/pdb/GHG/inventory_report/2006_ report/tdm-toc_eng.cfm.

Euliss Jr., N.H., R.A. Gleason, A. Olness, R.L. McDougal, H.R. Murkin, R.D. Robarts, R.A. Bourbonniere, and B.G. Warner. 2006. North American prairie wetlands are important non-forested land-based carbon storage sites. Sci. Total Environ. 361:179-188.

Euliss Jr., N.H., L.M. Smith, D.A. Wilcox, and B.A. Browne. 2008. Linking ecosystem processes with wetland management goals: Charting a course for a sustainable future. Wetlands 28: 553-562.

Gleason, R.A., M.K. Laubhan, and N.H. Euliss Jr., Eds. 2008. Ecosystem services derived from wetland conservation practices in the United States Prairie Pothole Region with an emphasis on the U.S. Department of Agriculture Conservation Reserve and Wetlands Reserve Programs: U.S. Geological Professional Paper 1745, 58 p.

Gleason, R.A., Euliss Jr., N.H., McDougal, R.L., Kermes, K.E., and E.N. Steadman. 2005. Potential of restored prairie wetlands in the glaciated North American prairie to sequester atmospheric carbon. Plains CO_2 Reduction (PCOR) Partnership.

Heagle, D.J. M. Hayashi, G. van der Kamp. 2007. Use of solute mass balance to quantify geochemical processes in a prairie recharge wetland. Wetlands. 27: 806-818.

Helgason, B.L. 2005. GHGFarm Version 1.0. An assessment tool for estimating net greenhouse gas emissions from Canadian farms. Agriculture and Agri-Food Canada, Lethbridge.

Houlahan, J.E. and C.S. Findlay. 2004. Estimating the 'critical' distance at which adjacent land-use degrades wetland water and sediment quality. Landscape Ecology. 19:677-690.

Jin, X., S. Wang, and Y. Zhou. 2008. Dynamic of organic matter in the heavy fraction after abandonment of cultivated wetlands. Biol. Fertil. Soils. 44: 997-1001.

Merbach, W., T. Kalettka, C. Rudat, and J. Augustin. 2002, Trace gas emissions from riparian areas of small eutrophic inland waters in northeast Germany, *in* Broll, G., Merbach, W., and Pfeiffer, E.V., eds., Wetlands in Central Europe: Soil organisms, soil ecological processes, and trace gas emissions. Berlin, Springer, p. 235–244.

Mitsch, W.J. and J.G. Gosselink. 2007. Wetlands, 4th ed., John Wiley & Sons, Inc., New York, 582 pp.

Myers, E.C. 2006. Climate Change and Forestry: A REDD Primer, The Ecosystem Marketplace, http://www.ecosystemmarketplace.com/pages/article.news.php?component_id=5797&component_version_id=8792&language_id=12.

Nelson, J. D. D., J. J. Schoenau, and S. S. Malhi. 2008. Soil organic carbon changes and distribution in cultivated and restored grassland soils in Saskatchewan. Nutr. Cycl. Agroecosyst. 82:137-148.

Offset Quality Initiative. 2008. Ensuring Offset Quality, Integrating High Quality Greenhouse Gas Offsets into North American Cap-and-Trade Policy. http://www.offsetqualityinitiative.org/pdfs/OQI_Ensuring_Offset_Quality_Exec_Sum_7_08.pdf.

Pena, N. 2009. Including peatlands in post-2012 climate agreements: Options and rationales. Report by Joanneum Research commissioned by Wetlands International. http://www.wetlands.org/LinkClick.aspx?fileticket=vDxo4SgYVXM%3d&tabid=56.

Philips, R.L., Beeri, O., and E.S. DeKaiser. 2003. Soil trace gas flux for wetland vegetation zones in North Dakota prairie pothole basins. American Geophysical Union, Fall Meeting 2003, Abstract #B22A-0791.

Philips, R.L. and O. Beeri. 2007. The role of hydropedologic vegetation zones in greenhouse gas emissions for agricultural wetland landscapes. Catena. 72: 386-394.

Pierce, J. Personal Communication. Wildlife Biologist — Natural Advantage. Ducks Unlimited Canada.

Pritchard, D. 2009. Reducing emissions from deforestation and forest degradation in developing countries (REDD) - the link with wetlands. http://www.field.org.uk/files/WetlandsREDD_FINAL_26.3.pdf.

Ramsar Secretariat (2008): Additional information on climate change and wetlands issues. COP10 Information Paper DOC 25. http://www.ramsar.org/cop10/cop10_doc25_e.pdf.

Scholz, I. and L. Schmidt. 2008. Reducing Emissions from Deforestation and Forest Degradation in Developing Countries: Meeting the main challenges ahead. Briefing Paper 6/2008. German Development Institute.

Society of Wetland Scientists. 2000. Position paper on the definition of wetland restoration. http://www.sws.org/documents/positionpapers/restoration.pdf.

Stewart, R. E., and H. A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. Resource Publication 92, Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, Washington, D.C. www.npwrc.usgs.gov/resource/ wetlands/pondlake/ index.htm.

Terrestrial Carbon Group. 2008. How to include terrestrial carbon in developing nations in the overall climate change solution. terrestrialcarbon.org. ISBN 978-0-646-49550-7.

The Royal Society (2008): Biodiversity-climate interactions: adaptation, mitigation and human livelihoods. Report of an international meeting, London June 2007. The Royal Society, London. http://royalsociety.org/displaypagedoc.asp?id=29026.

Turner, B.C., G.S. Hochbaum, F.D. Caswell, and D.J. Nieman. 1987. Agricultural impacts on wetland habitats on the Canadian Prairies, 1981 – 1985. Transactions of the North American Wildlife and Natural Resources Conference. 52:207-215.

U.S. Fish and Wildlife Service and Canadian Wildlife Service. 1987. Standard operating procedures for aerial waterfowl breeding ground population and habitat surveys in North America. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA and Environment Canada, Canadian Wildlife Service, Ottawa, Ontario, Canada.

van der Kamp, G. and M. Hayashi. 2009. Groundwater-wetland ecosystem interaction in the semiarid glaciated plains of North America. Hydrogeology Journal. 17: 203-214.

Voldseth, R. A., W. C. Johnson, T. Gilmanov, G. R. Guntenspergen, and B. V. Millett. 2007. Model estimation of land-use effects on water levels of northern prairie wetlands. Ecological Applications 17:527-540.

Watmough, M. D., and M. J. Schmoll. 2007. Environment Canada's Prairie & Northern Habitat Monitoring Program Phase II: Recent habitat trends in the PHJV. Technical Report Series No. 493. Environment Canada, Canadian Wildlife Service, Edmonton, Alberta, Canada.

Wetlands International. 2008. Sustaining and restoring wetlands: An effective climate change response. http://www.wetlands.org/Portals/0/publications/Brochure/wetlands_adaptation_press19aug.pdf.

Zimpfer, N.L., G.S. Zimmerman, E.D. Silverman, and M.D. Kone. 2008. Trends in Duck Breeding Populations, 1955-2008 - Administrative Report. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Laurel, Maryland.

9 Appendix 1 — Procedures Manual for Wetland Restoration

The purpose of this manual is to provide practical and repeatable technical guidelines necessary to define the extent of restored wetlands within the Alberta Offset System. Restored wetland area delineated using this methodology will serve as the basis to apply coefficients necessary to quantify GHG emission reductions associated with restoration of wetlands in the PPR in Alberta. The application of the method will generate appropriate data to verify the location and extent of restored wetlands while establishing a baseline for compliance monitoring throughout the lifespan of the agreement with the landowner.

It is the objective of the manual to:

1. Present heuristic guidelines for establishing a historical benchmark and determining physical wetland restoration opportunities.
2. Present appropriate survey methods and specifications to accurately delineate restored wetlands for incorporation into the wetland protocol.
3. Establish a framework for capturing the 'Asbuilt' condition of restored wetlands appropriate to determine the carbon sequestration value of restored wetland within the protocol.
4. Provide monitoring guidelines for insuring compliance on the restoration projects under the protocol

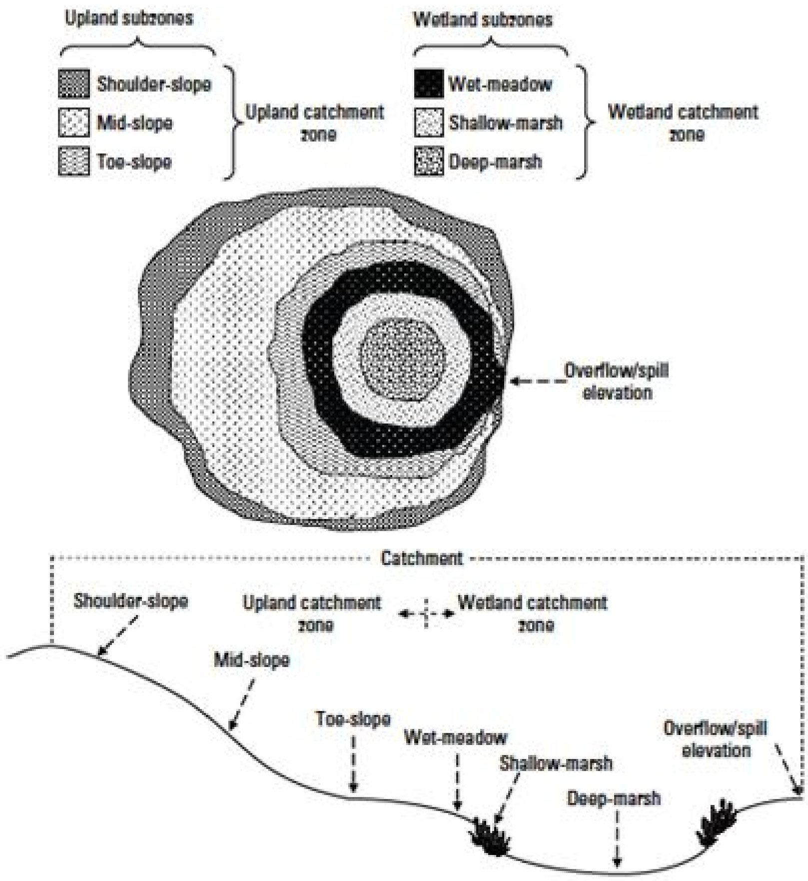
Scope

The scope of the procedures document applies to drained freshwater mineral wetlands (Lentic) in the Prairie and Parkland Ecoregions of Alberta. Prior to the construction of agricultural drainage infrastructure these Seasonal to Permanent wetlands were closed basins forming internally drained areas that under normal conditions were isolated from natural external drainage systems.

Wetland Definition

The functional definition of wetland basin within the scope of this manual is based on a geomorphic description that incorporates both topographic and vegetative indicators. Gleason et al. 2008 characterizes the entire wetland catchment or contributing area by distinguishing between upland and wetland zones. The **wetland basin** is defined as the entirety of the wetland zone extending outward from the deepest portion of the wetland to the outer perimeter of the wet meadow zone. The wetland basin is comprised of the Deep Marsh, Shallow Marsh, and Wet-meadow wetland subzones and is subject to change in extent and composition in response to variable hydrologic conditions. As a functional definition within this manual the term **wetland** includes the wetland basin as well as the wetland margin that corresponds with outflow/spill elevation. (Figure 1) This topographic definition of **wetland** includes the wetland basin which is frequently inundated or saturated extending outward to the surrounding flood plain which is infrequently flooded or saturated in response to large meteorological events.

Figure 5: Wetland Definition



Adapted from Gleason et al. 2008.

The wetland water balance is controlled by redistribution of snow from adjacent uplands, incident precipitation, local runoff, evapotranspiration , groundwater exchange , and antecedent status of soil and depressional storage (Fang and Pomeroy, 2008; van der Kamp and Hayashi, 2009). Dependant on water balance, wetlands will vary from shallow and seasonal to deeper and relatively permanent (Pomeroy et el., 2009).

Drained Wetland Targets

A drained wetland occurs when surface or ground water has been removed by artificial means such that the area will no longer support hydrophytic vegetation (CE, 1987). The construction of drainage infrastructure into the wetland basin in effect lowers the spill elevation, altering the depressional storage capacity of the wetland, disrupting the natural flood regime of the wetland basin. This hydrologic disturbance alters the extent and duration of flooding and consequently removes the anaerobic soil conditions which support the hydrophytic communities within the wetland basin (CE, 1987).

From a wetland definition perspective the identification of drained wetlands remotely or in the field is difficult given that two primary indicators of wetland have been removed from the depression. Hydrologic indicators are only present for brief periods during large meterologic events and vegetation indicators can no longer persist in the altered hydrologic condition or have been directly removed by annual cultivation. Often, the only remaining indicator available to confirm the historical presence or to define historical wetland extent would be the presence and extent of hydric soils (CE, 1987). Comprehensive soil sampling as a means to locate drained wetlands is viewed as impractical for operational restoration. The practical alternative is to rely on historical aerial photography and field observations to determine the historical presence of a wetland basin and to estimate historical wetland extent (restoration potential).

The removal of key wetland indicators from the basin poses similar challenges for determining the permanence class achievable through restoration. Traditional field classification or typing of the wetland is not possible due to disruption of the hydrologic regime and consequently the removal of vegetation indicators. Thus, maximum depth of the wetland measured at the deepest portion of the basin represents a proxy for estimating the permanence class of restored wetlands. Table 1 presents the depth/permanence class relationship for establishing permanence of restored wetlands within the GHG Offset Protocol.

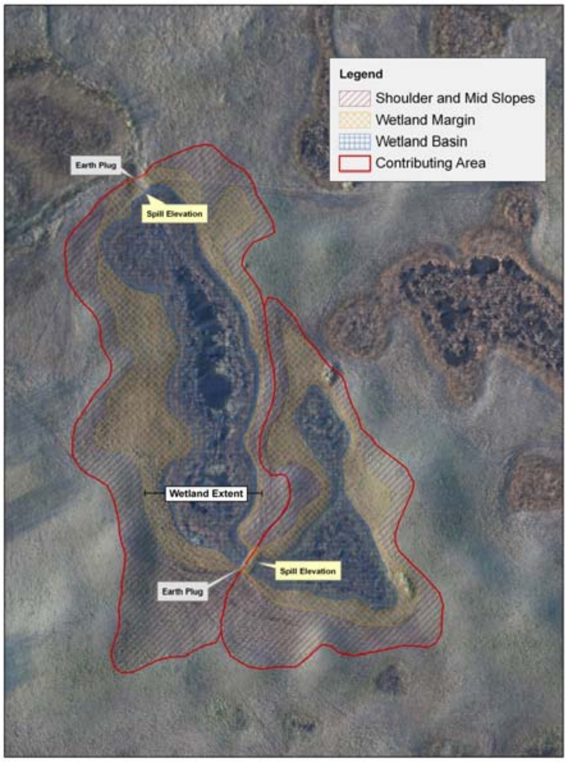
Table 7: Restored Wetland Maximum Depth and Permanence Classification

Depth (m)	**Steward and Kantrund Class**
0 - 0.10	Class I Ephemeral Pond
0.10 - 0.30	Class II Temporary Pond
0.30 - 0.60	Class III Seasonal Pond
> 0.60	Class IV & Class V Semi-Permanent/Permanent Pond

Intent of Wetland Restoration and Site Suitability

Intent of wetland restoration is to re-establish as close to possible the natural flood regime of the wetland. Construction of appropriately sized earth plugs at specific locations, graded to historical basin elevation will re-establish the flood regime of the wetland (Appendix A). The re-establishment of the flood regime over a period of years will recreate anaerobic soil conditions and consequently re-establish the hydrophytic communities adapted to thrive in these environments. Figure 2 graphically illustrates the intent of restoration in conjunction with the wetland definition previously discussed.

Figure 6: Restored Wetlands



The viability of physical restoration must consider:

1. The location of the historical basin edge estimated through analysis of historical aerial photography, confirmed in the field using expert judgment by a qualified wetland restoration technician.
2. The depth of the drained wetland, expert judgment is required to determine if the restored wetland depth has the potential to be restored to Seasonal, Semi-permanent or Permanent wetland class as defined by (Stewart and Kandrund 1971).
3. The dimensions of earth plug required to re-establish hydrology at the historical basin margin confirmed in the field by a qualified wetland restoration specialist. The earth plug must be appropriately sized to manage the volume stored at full supply level at the historical basin margin.
4. The morphology of the wetland's contributing area and the potential for large meteorological events for washing out the structure. The earth plug must be appropriately sized to manage the volume stored anticipated to accumulate in large events. Furthermore, the earth plug must be appropriately shaped to allow outflow around the plug when stored water levels exceed full supply.

5. The size of the backflood area behind the earth dam and the potential to flood adjacent properties upstream and the potential to cause downstream damages in the event of earth plug failure.
6. The size of the wetland margin and the willingness of the landowner to change land use in conjunction with restoration of the basin area.

Wetland Restoration Workflow

The following sections build on existing operational procedures from a qualified Wetland Restoration Agent. The intent of following sections is to provide general workflow guidelines for:

- Identifying potential sites for physical restoration (historical to current conditions)
- Assembling the initial project plan and negotiating with the landowner.
- Conducting the field survey and documenting the construction of the restoration project.
- Compiling appropriate data for submission to the verifier for future compliance monitoring.

Locating Physical Restoration Opportunities

The most cost effective means of locating drained wetlands is through comparative analysis of historic and recent aerial photography. Visual comparison of a historical baseline captured prior to hydrologic impact is required to determine the historic location and extend of drained wetland basins.

Selection of the Historical Benchmark

Historical imagery acquired during or shortly after peak hydro periods (Late April through mid-June) are deemed optimal for interpreting wetland features. General heuristic for selecting candidate historical years of photography would be to target years with normal to above normal precipitation accumulations over hydrologic winter (October 1st through March 31st). Comparison of the annual precipitation accumulations over hydrologic winter relative to station normals should indicate which years of historical imagery are likely to document normal to above normal runoff events. Climate data for active and historical stations can be accessed via the internet at the Canada's National Data and Information Archive (http://www.climate.weatheroffice.gc.ca/Welcome_e.html)

Alberta Sustainable Resource and Environment (ASRD) maintains the archive of all historical aerial photography captured for the Government of Alberta dating back to 1949. ASRD's Aerial Photo Record System (APRS) enables the query of the archive to determine the acquisition information of historical imagery for specific geographic locations. The most common scale of historical photography in the archive is 1:30,000, similar or larger scale photography is appropriate for interpreting Prairie wetlands and drainage features. Either digital scans or hard copy prints can be ordered and purchased through the website on a unit cost basis. APRS can be accessed via the internet at http://www.srd.alberta.ca/MapsFormsPublications/AirPhotoDistribution/Default.aspx).

In areas where suitable provincial historical aerial photography is lacking, additional archival photo may be available in the National Air Photo Library (NAPL) available online at: http://airphotos.nrcan.gc.ca/photos_e.php. Geographic query is available to determine the availability of historical photo collected by the Government of Canada for specific areas of interest.

Project Planning and Landowner Negotiations

With the consent of a willing landowner visual change detection comparing historical photography to recent aerial imagery will identify wetlands that have been converted to annual cultivation on a prospective property. The interpreter attempts to identify wetlands that were present in the historical photograph and are now absent in the current imagery. The interpreter will also attempt to determine if observed change is transitory (i.e. cultivation of ephemeral wetland) or more permanent due to hydrologic alteration which is indicated by the presence of drains breaching the wetland basin. Often large drainage works or recently constructed (or maintained) drains will be visible in the current photography making it possible to confirm the drainage of wetland basins remotely. However, it is more common for drains to appear subtlety in gentle topography or to be masked by often years (decades) of annual cultivation. Regardless of the circumstances, potential wetland restoration sites must be inspected on the ground by a qualified restoration technician to confirm the presence of a drain and to establish the viability of restoration.

Light Detection and Ranging (LiDAR) “Bare Earth” imagery in conjunction with historical air photos also has the potential to identify drained wetlands. Similar visual change detection techniques using derivative hill shade surfaces and historical aerial photographs can be used to determine the extent of historical wetlands and can be very effective at identifying drainage features. Historical wetland basin margins can be identified visually and defined from LiDAR elevation surfaces via “contouring” with reasonable precision. However, the significant cost associated with purchase of LiDAR is viewed as impractical for identification of drained wetlands within the protocol.

Creation of digital plans within a Geographic Information System (GIS) is an effective means of compiling appropriate background data; estimating the potential scope of restoration; communicating project extent to landowners; and efficiently adapting the plan to meet landowner requirements. Prior to the initial field visit a technician is required to assemble an interim restoration plan in a GIS environment. The elements of the interim plan are:

1. Delineation of restored wetland basin extent derived from the historical benchmark aerial photography and wetland basin area.

2. Delineation of the wetland margin surrounding the wetland basin and wetland margin area.
3. Approximate locations of earth plugs.
4. Property lines and cadastral boundaries and appropriate labelling of legal land locations.
5. Identification and location of any potential obstacles to restoration (i.e. buildings) or hydrologic features that could influence the contributing area of restored wetlands (i.e. culvert locations).

Field visit is required to confirm the definition of elements in the plan and to determine the viability of each site for restoration following the guidelines. Field notes and hand held GPS can be used to acquire additional data in the field which will later be incorporated into the final interim plan. Following incorporation of the field observations into the interim plan the area affected by restoration can be communicated to the landowner to gain permission to proceed with the build.

Topographic Survey and Physical Earth Plug Construction

The final visit to the site is conducted by the wetland restoration technician and a survey technician to formally survey the project and construct earth plugs. Working from the completed interim plan the survey technician is required to conduct the following tasks to survey specifications in Appendix B:

1. Establish the earth plug location, spill elevation, and construction dimensions for each restored wetland.
2. Establishes the flood contour (wetland basin) topographically upstream of the earth plug spill elevation and demarcates the boundary on the ground.
3. Generate a transect across the deepest portion of the wetland basin to establish maximum depth between basin bottom and the flood contour. This is a requirement to confirm the permanence class of the restored wetland.
4. Traverse and demarcate the edge of the toe slope around the restored wetland to establish the wetland margin area.
5. Meet with the landowner on site to confirm the build prior to construction of the earth plugs.
6. Supervise the construction of the earth plugs to insure they are in accordance to survey.
7. Survey the Asbuilt elevation of the plugs following construction.

Following construction, both the ditch plug and wetland margin are to be seeded with varieties approved for use in wetland restorations as listed in Appendix C.

Compilation of Asbuilt Survey Plan

Following completion of restoration activities on the ground the survey technician is responsible for compiling an Asbuilt plan to formally document the restoration project. Survey geometry gathered in the field is compiled into a standardized plan that contains specific content and plan free information to authenticate the restoration. The Asbuilt plan is to be submitted to the verifier as a requirement under GHG Offset Protocol.

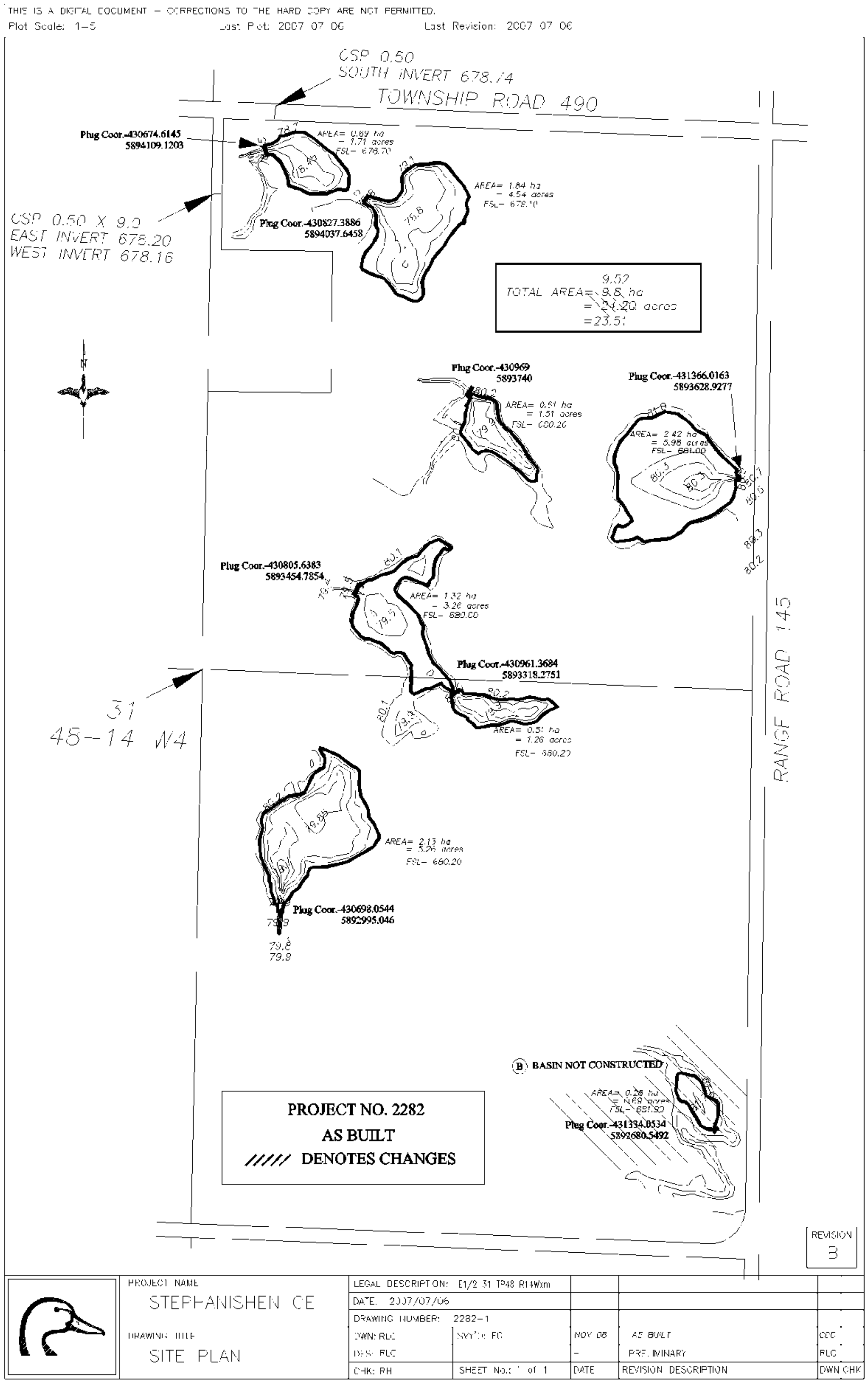
The following plan free information is required in the Asbuilt plan:

- The project proponent or the Wetland Restoration Agency (WRA)
- Wetland restoration project identification number
- Landowner name
- Legal Land Location
- Date of survey and construction

The following content is to be contained within the body of the Asbuilt Plan:

- Earth dam location and coordinates
- Earth dam geodetic elevation in meters
- Surveyed wetland basin boundary and area in hectares.
- Surveyed wetland margin boundary and area in hectares
- Total wetland basin area and wetland margin area in hectares

Figure 7: Representative Asbuilt Plan



Determination of Carbon Offset

The calculation of the carbon offset generated through restoration activities is determined by applying the net sequestration coefficient (ClimateCheck, 2010) to the restored wetland basin area and margin defined in the Asbuilt survey geometry using the formula below:

NetSeq = Net sequestration coefficient 7.3 – 11.8 Mg CO_2eq ha^{-1} $year^{-1}$

WetMargin = Total wetland margin area in hectares.

WetBasin = Total wetland basin area in hectares.

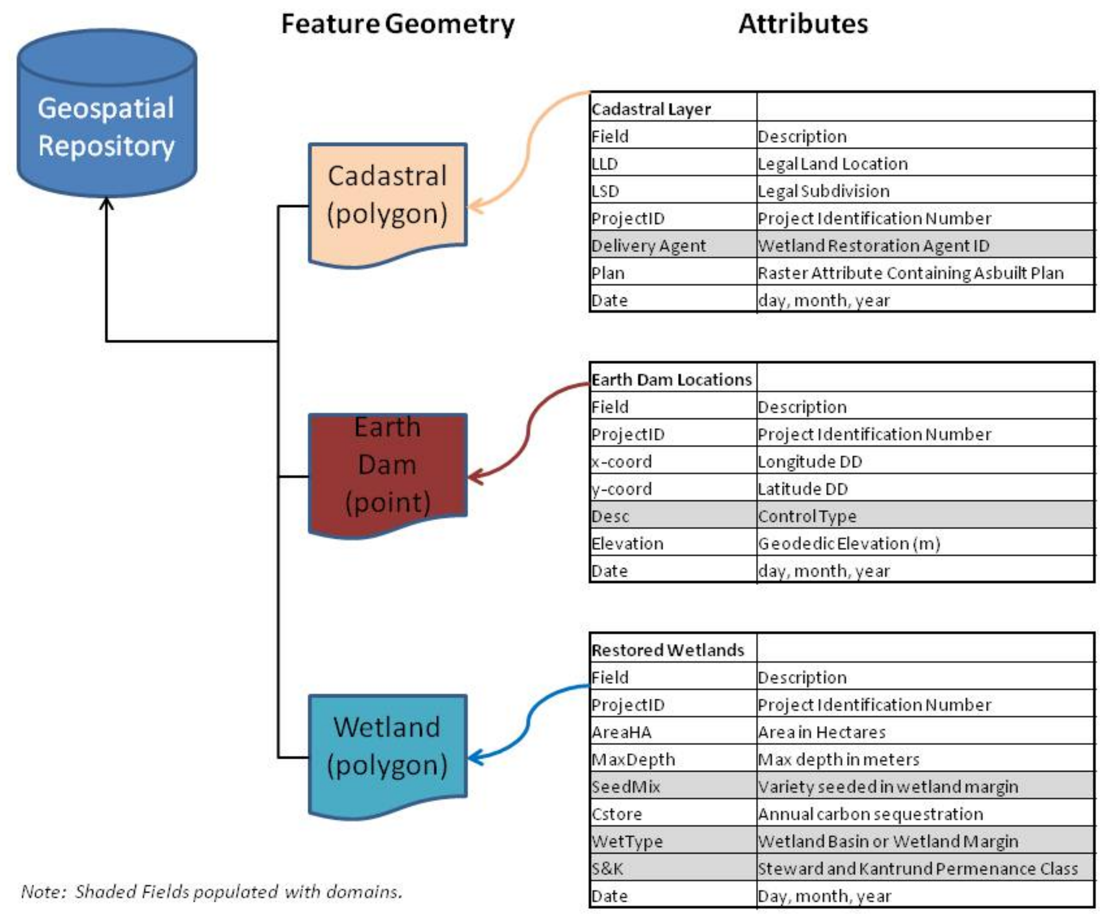
Nyears = Duration of agreement with landowner in years.

Offset = [(WetMargin x NetSeq) + (WetBasin x NetSeq)] x Nyears

Compilation of Geospatial Data Archive

As a baseline for monitoring the project throughout the lifespan of the agreement the delivery agent is required to submit standardized data to the verifier. The assembly of all project data into a standardized central repository will facilitate efficient retrieval of relevant information for future monitoring applications. Ancillary data and survey geometry are to be compiled and submitted in accordance with the following data model for incorporation into a provincial data repository:

Figure 8: Data Schema for Restored Wetland Information



Cadastral Layer	
Field	Description
LLD	Legal Land Location
LSD	Legal Subdivision
ProjectID	Project Identification Number
Delivery Agent	Wetland Restoration Agent ID
Plan	Raster Attribute Containing Asbuilt Plan
Date	day, month, year

Earth Dam Locations	
Field	Description
ProjectID	Project Identification Number
x-coord	Longitude DD
y-coord	Latitude DD
Desc	Control Type
Elevation	Geodedic Elevation (m)
Date	day, month, year

Restored Wetlands	
Field	Description
ProjectID	Project Identification Number
AreaHA	Area in Hectares
MaxDepth	Max depth in meters
SeedMix	Variety seeded in wetland margin
Cstore	Annual carbon sequestration
WetType	Wetland Basin or Wetland Margin
S&K	Steward and Kantrund Permenance Class
Date	Day, month, year

Submission of geospatial data to the provincial repository requires that each feature class conform to GOA metadata standards as defined by “Information Sharing Initiative, Phase II, Geospatial Metadata Best Practices” v. 1.5 (ASRD, 2009). Geospatial data submitted to the repository must also be projected from survey coordinates to GOA provincial standard reference system below:

Projection: Transverse Mercator (AB 10TM)

False Easting: 500000

False Northing: 0

Central Meridian: -115 00 00

Scale Factor: .9992

Latitude of Origin: 0 00 00

Linear Unit: Meters

Prime Meridian: Greenwich (0)

Datum: North American 1983

Spheroid: GRS1980

Monitoring Requirements

Monitoring of restored wetlands under the GHG Offset System will required the verifier to inspect the restoration project on a bi-annual basis. Monitoring will be primarily concerned with confirming the integrity of each earth dam and inspecting the wetland margin and restored wetland basin for non-compliant land use. Survey equipment will be required to determine if the original construction elevation is maintained. In instances where the earth dam has washed out or eroded, repairs will be required to rebuild the earth plug to original construction elevation.

References

Alberta Sustainable Resource Development, 2009. "Information Sharing Initiative, Phase II, Geospatial Metadata Best Practices" v. 1.5, Sustainable Resources and Environmental Management, Geographic Information Management Working Group. Government of Alberta.

Alberta Sustainable Resource Development, 2008. "File GeoDatabase Specifications" v. 1.0., Geographic Information Office (GIO), Strategic Support and Integration Division.

Alberta Sustainable Resource Development, 2007. Alberta Survey Control Products Manual. Lands Division, Lands Dispositions Branch, Geodetic Control Unit. Government of Alberta.

ClimateCheck, 2010. Progress Report: Results of Consultation Workshop for Wetlands Conservation and Restoration Protocol. Submitted to Climate Change Central and Ducks Unlimited Canada. April, 30, 2010.

Fang, X and Pomeroy, J. W. 2008. Drought Impacts on Canadian prairie wetland snow Hydrology. *Hydrological Processes* **22**: 2594-2609.

Gleason, R.A., M.K. Laubhan, and N.H. Euliss Jr., Eds. 2008. Ecosystem services derived from wetland conservation practices in the United States Prairie Pothole Region with an emphasis on the U.S. Department of Agriculture Conservation Reserve and Wetlands Reserve Programs: U.S. Geological Professional Paper 1745, 58 p.

Pomeroy, John; Fang, Xing; Westbrook, Cherie; Minke, Adam; Guo, Xulin; Brown, Tom. 2009. *Prairie Hydrological Model Study Final Report*; Centre for Hydrology Report #7; University of Saskatchewan; Saskatoon, Saskatchewan. December 21, 2009.

U.S Army Corps of Engineers. 1987. Wetlands Delineation Manual Final Report. Technical Report Y-87-1, January, 1987. Waterways Experiment Station, Vicksburg, MS.

Van der kamp, G. Hyashi, M. 2009. Groundwater-wetland ecosystem interaction in the semiarid glaciated plains of North America. *Hydrogeology Journal* **17**: 203-214.

Procedures Document - Appendix A Earth Plug Construction Guidelines

In preparation. This material will be included in the Wetlands Protocol formatted for submission to the review process of the Alberta Offset System.

Procedures Document - Appendix B Survey Specifications

Provincial standards and specification for vertical survey do not currently exist in Alberta. The following specifications are general guidelines references common terminology used to establish survey benchmarks as stated in the ALBERTA SURVEY CONTROL PRODUCTS MANUAL.

Intent of Survey is to compile GPS observations that comply with the vertical and horizontal measurement standard of a second order benchmark derived from geodetic benchmarks. Compilation of survey observations must achieve decimetre accuracy at a 95% confidence interval for both the vertical and horizontal axis. Survey coordinates are to be collected in the native UTM coordinate system below:

UTM Zone 12

Projection: Transverse Mercator

False Easting: 500000

False Northing: 0

Central Meridian: -111 00 00

Scale Factor: .9996

Latitude of Origin: 0.0000

Linear Unit: Meters

Prime Meridian: Greenwich (0)

Datum: North American 1983 (CSRS)

Vertical Datum: CGVD28

UTM Zone 11

Projection: Transverse Mercator

False Easting: 500000

False Northing: 0

Central Meridian: -117 00 00

Scale Factor: 0.9996

Latitude of Origin: 0.0000

Linear Unit: Meters

Prime Meridian: Greenwich (0)

Datum: North American 1983 (CSRS)

Vertical Datum: CGVD28

Procedures Document - Appendix C Approved Seed Varieties

Variety	Composition
Alberta Native Mix	37% Green Needle 33% Western Wheatgrass 20% Northern Wheatgrass 10% Slender Wheatgrass
Ranchmaster II	50% Meadow Bromegrass 25% Pubescent Wheatgrass 15% Tall Fescue 5% Slender Wheatgrass 5% Alfalfa

10 Appendix 2 — Consultation Workshop Decisions by Polling

On both days of the workshop, workshop participants were given the opportunity to vote on the decision points indentified in the Implementation and Quantification Discussion Documents. In total, xx participants voted. The text in the boxes represents the final voting question, as some decision points were modified from the Discussion Documents during the workshop.

Day 1 Decisions:

In the proposed Wetlands Protocol, the **wetland basin** will be defined as the area extending from the centre of the wetland to the outer edge of the wet meadow zone. It is understood that the size and location of the wetland basin fluctuates within and among years depending on hydrologic condition (wet/dry periods), according to Gleason et al. (2008) (Figure 1) up to and including the overflow/spill elevation.

VOTING – 94% Acceptable; 6% Acceptable with more work

In the proposed Wetlands Protocol, the wetland margin will be defined as the area extending from the outer edge of the wetland basin to the outer edge of the toe slope.

VOTING – 82% Acceptable; 18% Acceptable with more work

In the proposed Wetlands Protocol, the **wetland** will be defined to include the area of the wetland basin and wetland margin.

VOTING – 94% Acceptable; 6% This option is a no-go

In the proposed Wetlands Protocol, the **upland** will be defined as the area contributing surface runoff to the wetland zone and is composed of the landscape that is upgradient of the toe slope, but does include the foot slope.

VOTING – 79% Acceptable; 21% Acceptable with more work

The proposed Wetland Protocol will define wetland loss as including infilling, altering, or physically draining the wetland, any transitory or permanent degradation of the wetland basin and/or margin, and any type of interference with the hydrology to and from the wetland.

VOTING – 81% Acceptable; 19% Acceptable with more work

The premise of the Wetlands Restoration Protocol is consistent in logic with recent policy developments in compliance and voluntary GHG programs across the world.

VOTING – 67% Acceptable; 33% Acceptable with more work

Initially, the proposed Wetlands Protocol will be applicable only to private lands.

VOTING – 56% Acceptable; 33% Acceptable with more work; 11% This option is a no-go

Day 2 Decisions:

Scientific evidence exists to develop a protocol to quantify net GHG emissions reductions and removals associated with functional prairie wetlands to create real and verifiable offsets.

VOTING – 75% Acceptable; 25% Acceptable with more work

Existing practice concerning wetland restoration in the Prairie Pothole Region allows the development of a GHG quantification protocol to create real and verifiable offsets.

VOTING – 71% Acceptable; 29% Acceptable with more work

A large proportion of wetlands and associated uplands in the Prairie Pothole Region of Canada have been degraded as a result of landscape alteration and therefore it is reasonable to assume the vast majority wetlands in this region have been subjected to or are vulnerable to wetland loss.

VOTING – 82% Acceptable; 18% Acceptable with more work

For restoration, the most suitable approach for determination of the baseline for the proposed Wetlands Protocol would be – Historical – 85%, Performance Standard 5%, Projection based 10%

For conservation, the most suitable approach for determination of the baseline for the proposed Wetlands C&R Protocol would be – Historical – 6%, Performance Standard 11%, Projection based 83% (NOTE: Conservation will not be included at this stage of protocol development)

For the Wetlands C&R Protocol definition and delineation of Prairie Pothole Region Wetlands should be classified according to Stewart and Kantrud (1971) per Class III through Class V wetlands.

VOTING – 94% Acceptable; 6% Acceptable with more work

The SSs identified and described for the baseline scenario (Figure 1, Table 1) of the proposed Wetlands C&R Protocol are complete and accurate.

VOTING – 71% Acceptable; 29% Acceptable with more work

The SSs identified and described for the project condition (Figure 2, Table 2) of the proposed Wetlands C&R Protocol are complete and accurate.

VOTING – 75% Acceptable; 19% Acceptable with more work; 6% This option is a no-go

The decisions stated and justification provided to include or exclude SSs of the baseline scenario and project conditions are complete and accurate (table 3 of the Quantification SDD).

VOTING – 88% Acceptable; 12% Acceptable with more work

The research results reported by Euliss et al. (2006) and Bedard-Haughn et al. (2006) provide a range of gross sequestration values for restored wetlands, and thereby establish a context within which the sequestration coefficient of the proposed Wetlands C&R Protocol should be derived.

VOTING – 88% Acceptable; 12% Acceptable with more work

The credibility of the participants in the AWGI, the design and extent of the research, and the peer-reviewed results of the project provide sufficient basis to recommend the net sequestration coefficient of 1.4 - 2.0 Mg C ha-1 year -1 (during the net accumulation period) for consideration at the Consultation Workshop.

VOTING – 47% Acceptable; 47% Acceptable with more work; 6% This option is a no-go

The net sequestration coefficient will be defined in the lower quartile of the scientifically-defensible range.

VOTING – 72% Acceptable; 28% Acceptable with more work

Initially, a scientifically-defensible range will be defined by publication of the results of the AWGI project and other existing relevant literature.

VOTING – 95% Acceptable; 5% Acceptable with more work

The procedures, systems, and controls used by Ducks Unlimited (outlined in the "Project Guidance" document circulated) in wetland restoration projects in the Prairie Pothole Region of Canada should be used as the frame of reference to develop the wetland delineation approach for the proposed Wetlands C&R Protocol.

VOTING – 88% Acceptable; 12% Acceptable with more work

A qualified and experienced specialist should be required to approve the delineation (and classification) of wetlands included in all projects under the proposed Wetlands C&R Protocol.

VOTING – 80% Acceptable; 20% Acceptable with more work

To demonstrate that wetland restoration is not 'business-as-usual', the proposed Wetlands Protocol fulfills the following tests:

VOTING

a. Surplus to regulation: 100% Agree; 0% Disagree

b. Investment barriers: 100% Agree; 0% Disagree

c. Technological barriers: 100% Agree; 0% Disagree

d. Institutional barriers: 93% Agree; 7% Disagree

e. Not common practice: 100% Agree; 0% Disagree

The proposed Wetlands C&R Protocol should be designed to allow project proponents to use complementary protocols to generate GHG reductions and removals in the wetland margin and associated upland.

VOTING – 89% Acceptable; 11% Acceptable with more work

The procedures, systems, and controls used by agencies such as Ducks Unlimited to monitor permanence of restoration projects will inform the criteria used in the Wetlands C&R Protocol to monitor permanence.

VOTING – 47% Acceptable; 47% Acceptable with more work; 7% This option is a no-go

Conservation activity involves:

a.Termination of burning, clearing, and cultivating of the wetland margin

VOTING – 71% Acceptable; 21% Acceptable with more work; 7% This option is a no-go

b. Improvement of management of the wetland margin

VOTING – 40% Acceptable; 53% Acceptable with more work; 7% This option is a no-go

c. Improvement of management of the associated upland

VOTING – 60% Acceptable; 33% Acceptable with more work; 7% This option is a no-go

In the proposed Wetlands C&R Protocol, restoration will include activity to reverse wetland loss as a result of permanent impacts (Turner et al. 1987). Thus, restoration activity involves:

a) All activity prescribed for conservation

VOTING – 73% Acceptable; 20% Acceptable with more work; 7% This option is a no-go

b) Reversal of drainage and filling

VOTING – 100% Acceptable

The assessment of risk of reversal associated with the proposed Wetlands C&R Protocol, using a process like the Voluntary Carbon Standard guidance, should be completed using data from the restoration projects of agencies such as Ducks Unlimited Canada.

VOTING – 47% Acceptable; 47% Acceptable with more work; 7% This option is a no-go

The Prairie Pothole Region should comprise the leakage belt for the Wetlands Protocol.

VOTING – 47% Acceptable; 47% Acceptable with more work; 7% This option is a no-go

*Note: the above question and vote results were reported in draft workshop minutes but not in dedicated poll results report.

There is a high probability of leakage in the Prairie Pothole Region.

VOTING – 42% Agree; 58% Disagree