Guide to the Alberta Wetland Rapid Evaluation Tool - Actual (ABWRET-A) for the Boreal and Foothills Natural Regions

July 2016

Title:	**Guide to the Alberta Wetland Rapid Evaluation Tool - Actual (ABWRET-A) for the Boreal and Foothills Natural Regions**
Number:	**AEP, Water Conservation, 2016, No. 2**
Program Name:	**Water Policy Branch**
Effective Date:	**July 4, 2016**
This document was updated on:	
ISBN No.	ISBN 978-1-4601-3042-1 (Print) ISBN 978-1-4601-3043-8 (PDF)
Disclaimer:	This publication is issued under the Open Government Licence – Alberta (http://open.alberta.ca/licence). Please note that the terms of this licence do not apply to any third-party materials included in this publication.

Purpose

To provide a manual with instructions and references for assessing the relative value of wetlands in the Boreal and Foothills Natural Regions of Alberta using the ABWRET-A rapid assessment method.

Policy Context

This directive supports the Alberta Wetland Policy and related wetland assessment tools.

Reference Documents

- Alberta Wetland Assessment and Impact Report Directive
- Alberta Wetland Mitigation Directive
- Alberta Wetland Identification and Delineation Directive
- Alberta Wetland Classification System

Enforcement / Compliance

All wetland applications where permanent wetland loss will occur must have completed an ABWRET-A assessment. Compliance with the wetland policy may require a retrospective ABWRET-A assessment.

Authors, Contributors and Field Staff

Adamus, Paul	Adamus Resource Assessment, Inc. (Author)
Creed, Irena	University of Western Ontario
Wilson, Matthew	Alberta Environment and Parks
Trites-Russell, Marsha	Alberta Environment and Parks
Xu, Chen	Alberta Environment and Parks
Churchill, Tom	Alberta Environment and Parks
Junor, Dave	Alberta Environment and Parks
Meilleur, Susan	Alberta Environment and Parks
Raven, Mary	Alberta Environment and Parks
Hebben, Thorsten	Alberta Environment and Parks
Olsen, Steve	Contractor
Barr, Michael	North American Waterfowl Management Plan

Citation

Government of Alberta. 2016. *Guide to the Alberta Wetland Rapid Evaluation Tool – Actual (ABWRET-A) for the Boreal and Foothills Natural Regions.* Water Policy Branch, Alberta Environment and Parks. Edmonton, Alberta.

Table of Contents

Figures and Tables

Executive Summary

ABWRET-A is a standardized method for rapidly assessing some of the important natural functions of all types of wetlands present in Alberta. The "A" stands for "actual", meaning it uses on-site observations and off-site spatial data to inform the regulatory relative value of a wetland. ABWRET-A consists of this manual and its appendices, three data forms (one of which is completed by Alberta Environment and Parks (AEP), the others by the Applicant), a GIS Tool and an Excel® spreadsheet containing the model formulas used to derive a wetland value.

ABWRET-A generates scores for a wetland's functions which then are used, with other inputs, to assign a wetland to a value category (A, B, C, or D) in a consistent and transparent manner. That category is intended to inform planning and regulatory decisions around wetland avoidance, minimization and replacement, and is used to determine the replacement ratios where that is required.

Standardized criteria for assigning wetlands to these value categories are based on both science and policy. Science enters into the criteria in the form of on-site observations by a wetland assessor (See Practice Standards for Wetland Practitioners), the use of existing spatial data that is compiled by AEP, and the use of models (logic-based formulas) to generate scores representing the relative levels of 15 wetland functions. Those models reflect studies published in scientific journals and the judgment of wetland scientists. Policy enters into the criteria at a later stage. The Government of Alberta (GoA) has specified that Alberta's wetlands will be assigned to categories (A, B, C, or D) based on the levels of their functions and local loss rates. ABWRET-A is designed to assist in that determination.

To assess a particular wetland, a wetland assessor performs a desktop review and then visits the wetland to delineate its limit according to procedures in the Alberta Wetland Identification and Delineation Guide. During the same or a subsequent visit, the assessor answers approximately 76 questions (depending on site characteristics) based on observations, and, if necessary and possible, on conversations with the person on whose property the wetland exists.

Completing the on-site part of ABWRET-A typically takes 1-3 hours, depending on wetland size, access, and the assessor’s prior experience applying the tool and familiarity with the area. Although most data form questions (indicators) are applied to estimate several wetland functions, users need only enter the data for each indicator in one place on the data form. In most cases, not all questions need to be answered because the data form allows many to be skipped if a wetland has specified characteristics.

The assessor or Applicant emails the completed field data form and the spatial file of digitized wetland limits to a regulatory ABWRET-A support technician at Alberta Environment and Parks (AEP), who enters the field data into the ABWRET-A spreadsheet calculator and uses the GIS tool to generate the off-site indicator scores, which are then combined with the field data in the ABWRET-A spreadsheet calculator. In its calculations, the spreadsheet accounts for differences among wetland types (classes) by ignoring responses to questions that are not relevant to the class of wetland being assessed, instead of scoring them “0.” After the spreadsheet calculates the function scores, an abundance modifier is applied and the policy-based rating criteria assigns the wetland to value category A, B, C, or D. Results are returned to the user.

ABWRET’s scoring is based on logic models programmed into the calculator spreadsheet which generates the function scores and value categories. Although this has the potential to create a “black box” wherein underlying assumptions and calculations are not transparent to the user, transparency has been assured by the open architecture of the Excel™ spreadsheet as well as by detailed explanations of the assumptions and mathematics of each scoring model (viewable both in the spreadsheet and Appendix C of this manual). The spreadsheet contains a rationale for use of each metric or indicator in every model, often with citation of supporting scientific literature. ABWRET-A is a refinement of the first wetland assessment method that was peer-reviewed and then used widely throughout the U.S. (Wetland Evaluation Technique, WET; Adamus 1983, Adamus et al. 1987) and a similar protocol (ORWAP) developed, peer-reviewed, and adopted for routine use by Oregon Department of State Lands with funding from the USEPA (Adamus et al. 2009). ABWRET-A also incorporates elements of the Hydrogeomorphic (HGM) Approach (Brinson 1993, Smith et al. 1995). Most components of ABWRET-A or its predecessors have been peer-reviewed by scientists in the various disciplines that its models cover. Repeatability of results among different users of ABWRET-A's predecessor (WESPAB) was independently tested in Alberta's Grasslands Region and found to be relatively high (mean confidence interval of ±0.76 around function scores on a 0-10 scale).

In 2015, ABWRET-A was developed and applied to 102 wetlands selected through a statistical procedure to encompass the range of variation mainly in Alberta's Boreal Region (the "Green Area"). Collecting such data was necessary to determine the range of function scores and then normalize the scores to a consistent 0-to-1 decimal scale, as necessary before the scores could be combined with other information required to assign a value category. Future refinement of ABWRET-A may include using the same or similar unbiased procedures to select additional calibration wetlands in other parts of the Green Area, as needed to enhance its specificity for those areas. That being said, until further notice, the ABWRET-A tool may be used to assess any wetland located in the Boreal and Foothills Natural Regions of Alberta.

1. Introduction

1.1. General Description

Directly measuring the natural functions of wetlands (Table 1) is expensive and may require years of data. Thus, a need has existed for a tool that can be applied rapidly by one person during a single visit to a wetland, which standardizes the data collected and the way it is interpreted, to indirectly yield relative estimates of a wide variety of important wetland functions.

Nature is complex, and varies enormously from place to place. As natural systems, wetlands are no exception. Thus, the use of one word or phrase describing a wetland's type (e.g., bog, swamp, fen) or a short list of its characteristics cannot meaningfully predict what a particular wetland does and how it may benefit people and ecosystems. The roles of dozens of factors and their interactions must be considered and addressed systematically.

Fortunately, there is a growing capacity to illustrate and encode some of nature's complexity in computer models. This, along with the commonplace availability of powerful personal computers that make those models quick and easy to use, has made some types of models simple to apply in the support of decisions and policies, while at the same time reassuring users and decision-makers that assumptions in these models are transparent.

ABWRET-A is a standardized method for rapidly assessing some of the important natural functions of all types of wetlands present in Alberta. The "A" stands for "actual", meaning it uses on-site observations and off-site spatial data to inform the regulatory relative value of a wetland. ABWRET-A consists of this manual and its appendices, three data forms (one of which is completed by AEP, the others by the applicant), and an Excel™ spreadsheet calculator containing models (formulas).

Table 1. Wetland functions and human uses scored by ABWRET-A in the Green Area of Alberta.

Function	Definition	Potential Benefits
HYDROLOGIC FUNCTIONS:		
Water Storage & Delay	The effectiveness for storing runoff or delaying the downslope movement of surface water for long or short periods.	Flood, drought resiliency, maintain ecology
Stream Flow Support	The effectiveness for contributing water to streams during the driest part of a growing season.	Support fish and other aquatic life, and human use
WATER QUALITY FUNCTIONS:		
Water Cooling	The effectiveness for maintaining or reducing temperature of downslope waters.	Support coldwater fish and other aquatic life
Sediment & Toxicant Retention & Stabilization	The effectiveness for intercepting and filtering suspended inorganic sediments thus allowing their deposition, as well as reducing energy of waves and currents, resisting excessive erosion, and stabilizing underlying sediments or soil.	Maintain quality of receiving waters. Protect shoreline structures from erosion.
Phosphorus Retention	The effectiveness for retaining phosphorus for long periods (>1 growing season)	Maintain quality of receiving waters.
Nitrate Removal & Retention	The effectiveness for retaining particulate nitrate and converting soluble nitrate and ammonium to nitrogen gas while generating little or no nitrous oxide (a potent greenhouse gas).	Maintain quality of receiving waters.
Organic Nutrient Export	The effectiveness for producing and subsequently exporting organic nutrients (mainly carbon), either particulate or dissolved.	Support food chains in receiving waters.
ECOLOGICAL (HABITAT) FUNCTIONS:		
Fish Habitat	The capacity to support an abundance and diversity of native fish (both resident and visiting species)	Support recreational and ecological values.
Invertebrate Habitat	The capacity to support or contribute to an abundance or diversity of invertebrate animals which spend all or part of their life cycle underwater or in moist soil. Includes dragonflies, midges, clams, snails, water beetles, shrimp, aquatic worms, and others.	Support salmon and other aquatic life. Maintain regional biodiversity.
Amphibian Habitat	The capacity to support or contribute to an abundance or diversity of native frogs, toads, and salamanders.	Maintain regional biodiversity.
Waterbird Feeding Habitat	The capacity to support or contribute to an abundance or diversity of waterbirds that migrate or winter but do not breed in the region.	Support hunting and maintain regional biodiversity.
Waterbird Nesting Habitat	The capacity to support or contribute to an abundance or diversity of waterbirds (waterfowl, waders and shorebirds) that nest in the region.	Maintain regional biodiversity.
Songbird, Raptor, & Mammal Habitat	The capacity to support or contribute to an abundance or diversity of native songbird, raptor, and mammal species and functional groups, especially those that are most dependent on wetlands or water.	Maintain regional biodiversity.
Native Plant & Pollinator Habitat	The capacity to support or contribute to a diversity of native, hydrophytic, vascular plant species, communities, and/or functional groups, as well as the pollinating insects linked to them.	Maintain regional biodiversity and food chains.
HUMAN USES[1]		
Fire Barrier	Capacity to resist ignition by wildfire, thus limiting wildfire spread.	Public safety and infrastructure protection.
Human Use & Recognition	Prior designation of the wetland as some type of special protected area. Also, the potential and actual use of a wetland for low-intensity recreation, education, or research.	Commercial and social benefits of recreation. Protection of public resources and assets.

[1] Human Use is conventionally considered a value, not a function, of wetlands, but for purposes of categorizing Alberta wetlands, the actual, current, and sustainable uses of wetlands are treated the same as functions.

ABWRET-A generates scores for a wetland's functions which then are used, with other inputs, to assign a wetland to a value category (A, B, C, or D) in a consistent and transparent manner. That category is intended to inform planning and regulatory decisions around wetland avoidance, minimization and replacement, as well as the replacement ratios where that is required. ABWRET-A can also be used with other tools (e.g., Rooney & Bayley 2012b, Wilson et al. 2013, Nwaishi et al. 2015) to help ensure that wetland replacement, when it is required, is genuine and addresses the loss of specific wetland functions, not just loss of wetland area.

Standardized criteria for assigning wetlands to these value categories are based on both science and policy. *Science* enters into the criteria in the form of on-site observations by a wetland assessor, the use of existing spatial data that is compiled by Alberta Environment and Parks (AEP), and the use of models (logic-based formulas) to generate scores representing the relative levels of 15 wetland functions (Table 1). Those models reflect studies published in scientific journals and the judgment of wetland scientists. *Policy* enters into the criteria at a later stage. Guidance for implementing Alberta's Wetlands Policy suggests that wetlands whose scores exceed the 90th percentile of the ABWRET-A calibration sites will be placed in category A, those in the 70th to 90th percentile will be category B, those in the 40th to 70th will be category C, and those below the 40th percentile of the calibration sites will be in category D. Also, in areas (defined as Relative Wetland Value Assessment Units, or RWVAUs) of high historical loss and low current abundance of wetlands, an "abundance factor" is applied whereby B's turn to A's, C's to B's, and D's to C's. Conversely, in areas of low historical loss and/or high wetland abundance, A's turn to B's, B's to C's, and C's to D's, The top and bottom 5% (5^{th} and 95^{th} percentiles) are unaffected by the abundance factor. In areas of moderate historical loss there is no change in relative value category. Scores generated by ABWRET-A reflect relative levels of wetland functions are used to help determine a specific wetland's percentile. Historical trends in wetland number and area are estimated separately and then factored into a wetland's category determination in a standardized manner (Figure 1).

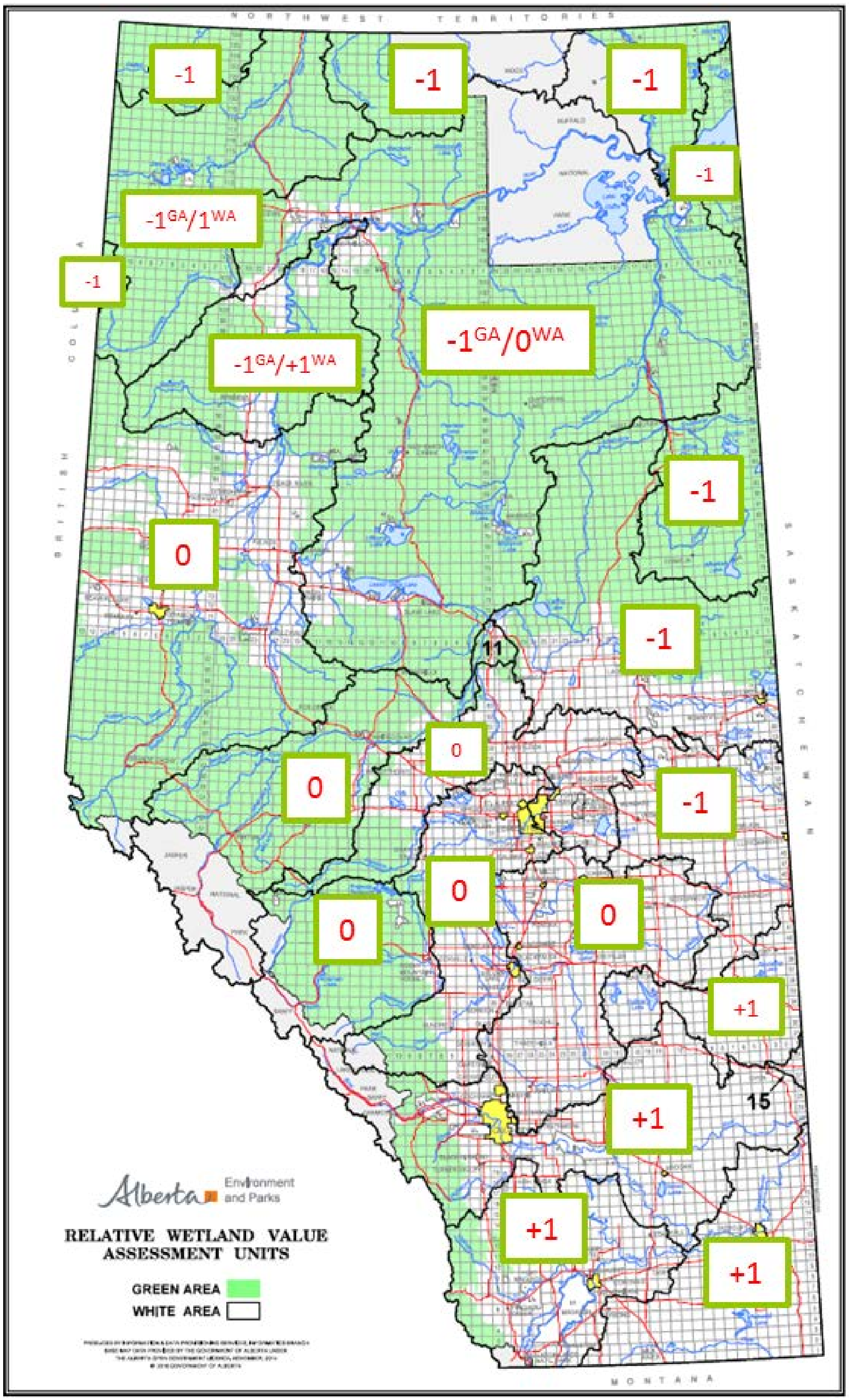


Figure 1. Map of regional abundance factors applied to ABWRET-A relative wetland value categories. The abundance factor for each Relative Wetland Value Assessment Unit (RWVAU) is applied after the relative function of a wetland is determined by ABWRET-A. WA = White Area. GA = Green Area.

As a standardized approach, ABWRET-A provides consistency and comparability when using wetland functions as a way to prioritize wetlands. It also can be used to assess the consequences of wetland alterations, in terms of the wetland functions that may be affected. ABWRET-A's assessment of a specific wetland function may not always be more accurate than ratings of that wetland made by someone who is a specialist on that function, particularly if such a person is experienced locally. Such expertise is seldom routinely available to wetland regulators for every function of concern.

ABWRET-A uses visual and GIS-based assessments of weighted ecological characteristics (indicators, or sometimes termed metrics) to generate the scores for the function of a wetland. The number of indicators that is applied to estimate a particular wetland function depends on which function is being assessed and not all indicators are assessed for every wetland. The indicators are combined in a spreadsheet using mathematical formulas (models) to generate the score for each wetland function. The models are logic-based rather than deterministic. Together they provide a profile of the processes a wetland performs and how well it performs them relative to other wetlands. ABWRET-A indicators and models attempt to incorporate the best and most recent scientific knowledge available on what determines the levels of functions provided by individual wetlands.

Each indicator has a suite of *conditions,* e.g., different wetland classes. Weighting has been pre-assigned to all conditions associated with each indicator. The weights can be viewed in column E of the individual worksheets (tabs at bottom) contained in the calculator spreadsheet.

For most models of wetland functions, the indicators were grouped by the underlying *processes* they inform. Indicator and process selection was based on the author's experience and review of much of the literature he compiled initially in an indexed bibliography of science relevant to functions of the Boreal and Foothills (Green Area) landscape. Further details about the development and regional calibration of ABWRET-A are provided in Appendix B. This manual addresses only the Green Area, and within that, focuses mainly on parts of the Boreal Forest and Foothills Natural Regions that are within the Green Area (Figure 2).

Before AEP developed ABWRET-A, over one hundred persons from government, non-profits, and industry were trained in a somewhat similar method specific to southern Alberta called WESPAB (Wetland Ecosystem Services Protocol for Alberta). That tool formed much of the basis for ABWRET-A as both were developed by the same primary author. The methods share many features. The field data forms are structured similarly, as is the spreadsheet calculator. Many of the indicators (questions) are the same, although choices for answers to some questions are worded differently. Thirteen of the 15 functions for which ABWRET-A calculates scores are ones also featured by WESPAB, although the formulas used to compute them differ somewhat. In contrast to WESPAB models of ecological benefits or ecosystem services, ABWRET-A only considers wetland functions in its models and scores.

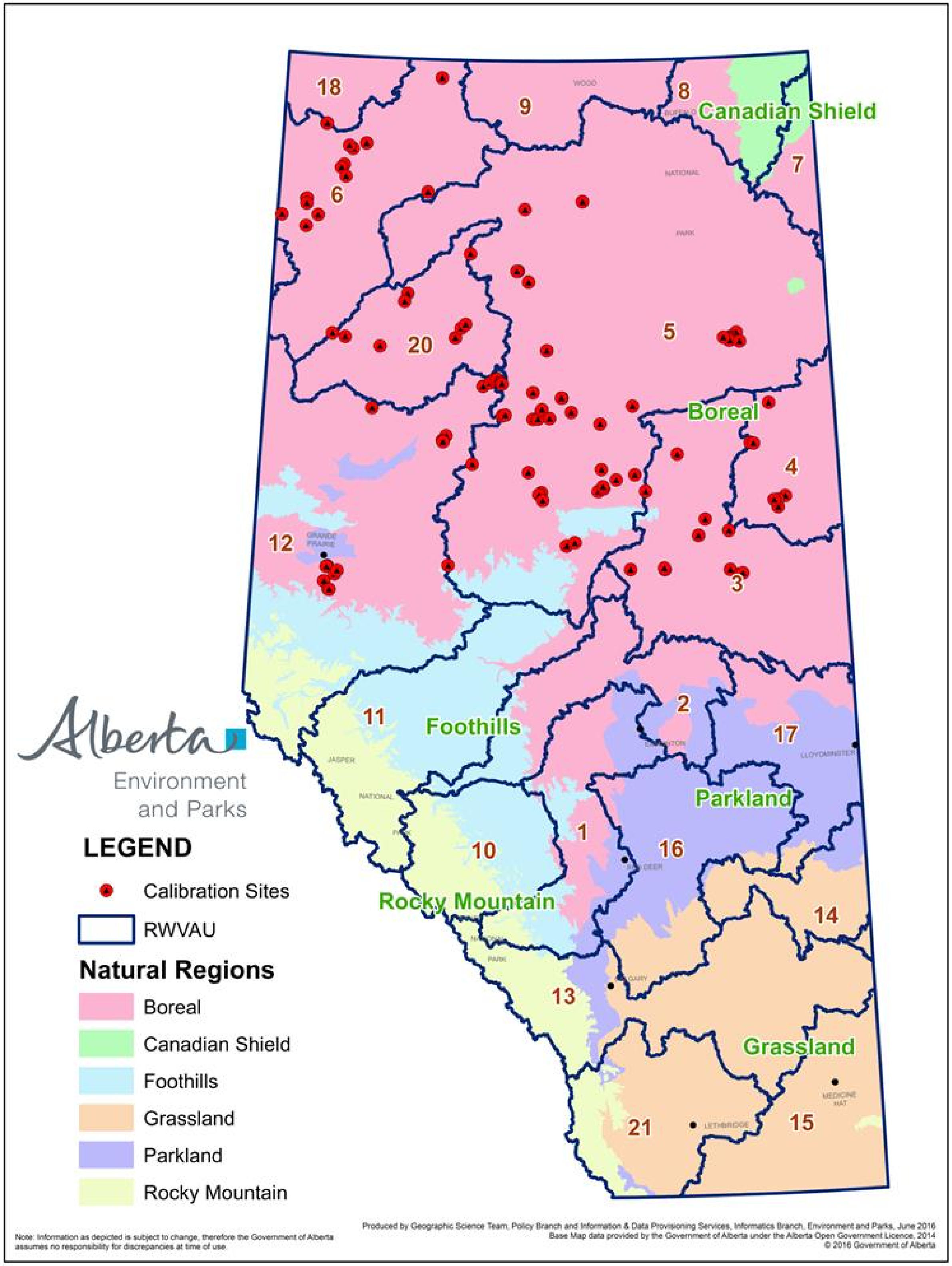


Figure 2. Natural Regions and RWVAUs where ABWRET-A was field-calibrated during 2015.

1.2. Limitations

ABWRET-A is not intended to answer all questions necessary for wetland approvals decisions. Users should understand the following important limitations:

1. ABWRET-A does not change any current procedures for determining land ownership, delineating wetland limits, classifying wetlands, or requirements for restoration and monitoring wetland projects
2. Users of ABWRET-A should be able to:
    - delineate a wetland limit according to the Alberta Wetland identification and Delineation Directive
    - recognize the most common wetland plants and invasive plants in this region,
    - determine soil texture broadly (fine, coarse, loamy, peat, or organic)
    - understand wetland hydrology and local climate
    - estimate wetland catchment (contributing area) from a topographic map
3. Some of the requested information may not be accurately determinable during a single visit to a wetland. Some wetland conditions vary dramatically from year to year and even within a growing season. Thus, the accuracy of results will be greater if users are familiar with the changes in wetland conditions that typically occur locally, or consult landowners or others who are familiar with local conditions and variability.
4. For the portion of ABWRET-A which incorporates existing digital data, it is understood that those data were originally created at a relatively coarse scale. Consequently, when those data are interpolated to the scale of an individual wetland, some of the data are likely to be inaccurate. Also, some of the conditions described by the spatial data, such as for land cover, may have changed since the layer was created or last updated. Nonetheless, it was decided that the advantages of judiciously using the existing spatial data, as just one component of each wetland's ABWRET-A scores, outweighed the disadvantages.
5. ABWRET-A's scores indicate a wetland's functional effectiveness relative to other wetlands in the Boreal and Foothills natural regions of the Green Area in Alberta. Intensive or long-term field measurements might subsequently determine that even the wetlands scored lowest by ABWRET-A are, in fact, performing a particular function at a very high absolute level, or some wetlands that score very high are found to barely provide the function (see Appendix B for more on model validation). Thus, the numeric estimates that ABWRET-A provides of wetland functions *are not actual measures* of those attributes, nor does ABWRET-A combine the data using deterministic models of ecosystem processes. Rather, the scores, like those of most rapid assessment methods (Hruby 1999), are estimates arrived at by using standardized criteria (models). The models systematically combine well-accepted indicators in a logically sophisticated manner that attempts to recognize context-specific, functionally contingent relationships among indicators, such as wetland type.

    There is an inherent conflict in attempting to develop a rapid assessment method based on science without over-simplifying complex natural systems to the point of disconnect. AEP is fully aware of this conflict and its implications. While it has been necessary for ABWRET-A to employ some untested assumptions, those assumptions are based on scientific principles and many were peer-reviewed.

6. As is true of all other rapid assessment methods, ABWRET-A's scoring models have not been validated in the sense of comparing their outputs with those from long-term direct measurement of wetland processes. That is the case because the time and cost of making the measurements necessary to fully determine model accuracy would be exorbitant. Nonetheless, the lack of validation is not, by itself, sufficient reason to avoid use of any standardized rapid method, because the only practical alternative—relying entirely on non-systematic judgments (best professional judgment)—is not demonstrably better overall. When properly applied, ABWRET-A's scoring models and their indicators are believed in most cases to adequately describe the relative effectiveness of a wetland for performing particular functions.

7. ABWRET-A converts raw scores to estimates of relative wetland function, and then normalizes these to the scores of other wetlands in the calibration data set developed by this project. However, if 90% of the wetlands in the data set had raw scores for the Fish Habitat function of 0 and among the remainder the maximum score was 0.4, after those raw scores are normalized (i.e., mathematically spread out into a scale of 0 to 1.0), a wetland with a score of 0.3 would have a normalized score of 0.9 (because 0.3 is close to the maximum score of 0.4 for this function in this data set). The high normalized score implies the wetland is functioning very well for Fish Habitat, when in fact the very low raw score of 0.3 (out of a theoretically possible score of 1.0) indicates it probably is not.

8. It is possible that two ABWRET-A users, viewing the same wetland, will interpret some indicator questions differently. Potentially, this could result in different scores for one or more of the wetland functions. This is true regardless of whether they use ABWRET-A, another tool, or their professional judgment. However, AEP independently tested the repeatability of ABWRET-A's similar predecessor and determined that the statistical confidence intervals around the scores, depending on the particular function, averaged ± 0.76 of the score mean on a scale of 0 to 10. For example, allowing for differing user perceptions of a wetland, a score of 6.00 could be interpreted as actually being between 5.24 (6.00 - 0.76) and 6.76 (6.00 + 0.76). Considering that ABWRET-A scores are then converted to four much-broader value categories (A, B, C, D), the user variability represented by these confidence intervals would seem to be of relatively little concern, despite the subjectivity inherent in some of the indicator questions. The relative narrowness of the score variance among users stems partly from the fact that some ABWRET-A indicators are intentionally redundant and/or positively correlated. Averaging these in the ABWRET-A models is expected to reduce the variance of function scores more often than increase it.

9. ABWRET-A may be augmented by data or interpretations of a subject professional (e.g., a fisheries biologist, plant ecologist, ornithologist, hydrologist, biogeochemist) when such expertise or finer-resolution data are available. ABWRET-A outputs, like those of other rapid methods, are not necessarily more accurate than judgments of a subject expert, partly because ABWRET-A's spreadsheet models lack the intuitiveness and integrative skills of an actual person knowledgeable of a particular function. Also, a model cannot anticipate every situation that may occur in nature. Nonetheless, ABWRET-A's scoring models provide a degree of standardization, balance, and comprehensiveness that seldom is obtainable from a single expert or limited set of measurements.

10. ABWRET-A's logic-based process for combining indicators has attempted to reflect currently-understood paradigms of wetland hydrology, biogeochemistry, and ecology. Still, the scientific understanding of wetlands is far less than optimal to support, as confidently as some might desire, the models ABWRET-A and other rapid methods use to score wetland functions.

11. ABWRET-A does not assess all natural functions that a wetland might support. Those which it addresses are ones ascribed to wetlands most commonly in this region, and which also are receptive to the following: estimation using indicators (metrics) that can be observed during a single visit to a wetland, analysis of existing spatial data, and manual interpretation of aerial images. Groundwater recharge, for example, is an important wetland function that is not scored because it has no reliable indicators that can be estimated rapidly in this region.
12. Science is constantly evolving as new studies refine, refute, or support what currently is known. It is incumbent that planning tools keep pace with new findings and their models be revised at regular intervals, perhaps every 5-10 years, to reflect that. This poses challenges to wetland approvals applicants and regulatory programs because necessary revisions to a method or expansion of the set of calibration wetlands used to normalize the scores can create a "moving target."
13. ABWRET-A does not assess the suitability of a wetland as habitat for any individual wildlife or plant species. Models of greater accuracy, using the same spreadsheet calculator and heuristic modeling framework that ABWRET-A uses, could easily be created for individual species, for more specific biological guilds (e.g., diving ducks vs. surface-feeding ducks instead of Waterbird Habitat) and functions (export of dissolved vs. particulate carbon instead of Organic Nutrient Export). However, as functions are split into finer categories, the amount of output information increases, perhaps gaining accuracy and specificity but losing simplicity in the interpretation and application of results.
14. In some wetlands, the scores that ABWRET-A's models generate may not be sufficiently sensitive to detect, in the short term, mild changes in some functions. For example, it is unknown whether ABWRET-A can meaningfully quantify small year-to-year changes in a slowly-recovering restored wetland, or minor changes in specific functions as potentially associated with limited "enhancement" activities such as weed control. Nonetheless, in such situations, ABWRET-A can use information about a project to predict at least the *direction* of change to all functions, as a result of some action. Quantifying the actual change will often require more intensive (not rapid) measurement protocols that are complementary.
15. ABWRET-A outputs are not intended to address the important question, "Is a proposed or previous wetland creation or enhancement project in a geomorphically appropriate location?" That is, is the wetland in a location where key processes can be expected to adaptively sustain the wetland and the particular functions which other wetlands of its type usually support, e.g., its "site potential?" Although ABWRET-A uses many landscape-scale indicators to estimate wetland functions, ABWRET-A is less practical for identifying the relative influence of multiple processes that support a single wetland.

2. Conceptual Basis

Fundamentally, the levels and types of functions that wetlands individually and collectively provide are determined by the processes and disturbances that affect the movement and other characteristics of water, soil/sediment, plants, and animals (Zedler & Kercher 2005). In particular, the frequency, duration, magnitude and timing of these processes and disturbances shape a given wetland's functions (Euliss et al. 2004, Smith et al. 2008). Climate, geology, topographic position, and land use strongly influence all of these processes. Well-functioning wetlands can reduce the need for humans to construct and maintain some types of expensive infrastructure at other locations that would otherwise be necessary to perform the same services, such as reducing regional flood damages or treating stormwater (Costanza et al. 1997, Finlayson et al. 2005, Feng et al. 2011, Gascoigne et al. 2011, van Kooten et al. 2011).

Despite popular perceptions, high-functioning wetlands are not always healthy and healthy wetlands are not always high-functioning. This is true for at least two reasons: (1) There exists no widely-accepted scientific definition of wetland "health" (or integrity, or ecological condition, or "intactness") or accepted protocols for measuring any of those concepts comprehensively, and (2) No single wetland, regardless of how intact, pristine, or biodiverse it may be, can provide all functions at a high level because many wetland functions operate naturally in opposing directions. Thus, it is inappropriate to describe a wetland as having "high function" or being "highly functional" without specifying the function or combination of functions to which one is referring and how they are being weighted. No research has yet confirmed that maintaining biodiversity alone will preserve all or perhaps even most wetland functions that are important at local, watershed, or province-wide scales. Although *generally* high levels of many wetland functions can often be expected to correlate positively with *generally* high levels of wetland health, a causal connection has never been proven and should not be assumed automatically. Any correlation will depend on how functions and health are measured, the types of stressors to which particular wetlands are being exposed, spatial variation of natural factors within the landscape, and other influences.

3. Procedures for Using ABWRET - Actual

3.1. General Procedures

1. Read the ABWRET-A manual, as well as review the illustrations in Appendix A and any definitions or other side notes in the right column of field data form F.
2. From the AEP website, download the most recent version of this manual, its appendices, and the ABWRET-A Field Form spreadsheet. Print a copy of the data forms from Appendix A of this manual for each wetland that will be assessed.
3. On an aerial image, delineate the preliminary limit of the wetland. You will later confirm or adjust this in the field in accordance with the Alberta Wetland Identification and Delineation Directive. If it will be impractical during your visit to view most of the wetland up close because it is so large, conditions are physically too hazardous, and/or property ownership status does not allow examination of a significant part, you may need to also draw a line around just the part you are likely to observe effectively. This is called the **assessment area (AA).** Part of its extent will likely be the same as the delineated wetland limit, but it comprises a subunit of the entire wetland. Read section 3.2 for guidance before drawing the AA.

4. **Major invasive plant species** and **exotic** plant species must be known before performing wetland assessment. Using a plant identification guide is expected if you are not very familiar with the region's flora. Online resources of invasive plant species are also available.

5. **Visit the wetland** during the growing season and do the following:

   a. Spend a minimum of 10 minutes walking towards the center of the AA unless safety concerns preclude that, in which case follow the safest nearby route that traverses wetland vegetation of the same class as the inaccessible portion. Then adjust your drawing of the AA extent to include the portion you walked or could adequately see, plus all directly adjoining (contiguous) surface water and all wetland that is of the same wetland class[2].

   b. Fill out a printed copy of Form F and Form S during your visit following instructions in Section 3.4. Also fill out the **Cover Page** form.

   c. When required by AEP, conduct surveys for plant and animal species at risk at an appropriate time of the season and using approved survey protocols if those are available.

   d. Check to be sure every question on both data forms was answered, except where the form directed you to skip one or more questions, and the data correctly entered.

   e. If AEP has provided you with measurements from any of the GIS layers they are querying to characterize and score your wetland, compare that information with what you see in the field, and report any discrepancies to AEP.

6. Email the data forms (F, S, and Cover Page) as well as digital files of the delineated wetland (as per the Alberta Wetland Identification and Delineation Directive) to a designated contact person at AEP with a request for determination of wetland value rating.

7. AEP will reply to that request and send back a spreadsheet of the determined wetland value category of each assessed wetland, along with scores for the wetland functions.

3.2. Drawing the Extent of a Wetland Assessment Area (AA)

Please see the Alberta Wetland Identification and Delineation Directive for information on how to identify and delineate the wetland limit. Whenever feasible, entire wetlands should be assessed. However, as explained above, it sometimes will be necessary to delimit just a portion of the wetland and assess it separately. This happens if it is impractical to view most of the wetland up close because it is so large, conditions are physically too hazardous, and/or property ownership status does not allow examination of a significant part.

The AA will be the same or smaller than the delineated wetland limit and will normally consist of vegetated wetland ***and*** **–** if that wetland vegetation is in a depression (basin) – all the **adjoining mudflat** within the depression as well as **water up to an estimated depth of 2 m at midsummer**. If the 2 m water depth contour cannot be estimated, the AA should extend into the open water a distance equal to the average width of the vegetated wetland. The AA should include as much of the area that will be impacted as possible, may include multiple wetland classes, and to the extent possible, should be representative of the hydrologic and vegetation characteristics of the larger wetland of which it is a part.

---

[2] wetland "class" as defined in the Alberta Wetland Classification System (AWCS):

http://aep.alberta.ca/water/programs-and-services/wetlands/documents/ClassificationSystem-Jun01-2015.pdf

The AA extent may need to be adjusted during the field component. Nonetheless, where you draw the limit of the AA can dramatically influence the resulting scores, so provide a map clearly showing the AA if different than the delineated wetland limit. The CoverPg worksheet requires you to estimate and describe the approximate percent of the mapped AA you were able to visit (taking into account both physical restrictions and private property restrictions) as well as the percentage of the entire wetland which the AA comprises.

There are at least three "special cases" in which more specific guidance is provided below for defining an appropriate AA extent:

- Fragmented wetlands
- Lake-fringe wetlands
- River-fringe and floodplain wetlands

Fragmented Wetlands

If a wetland that once was a contiguous whole is now divided or separated by a road or dike (Figure 2), assess the two units separately (two AA's) unless a functioning culvert, water control structure, or other opening connects them, and their water levels usually are simultaneously at about the same level. Extents of the AA should be based mainly on hydrologic connectivity. They normally should not be based solely on property lines, fence lines, mapped soil series, elevation zones, land use, or land use designations.

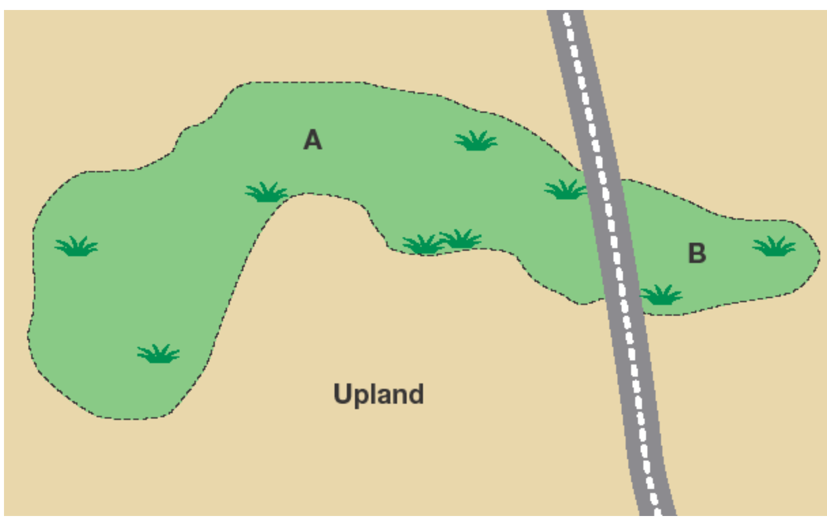


Figure 3. Dissected wetland. A wetland is crossed by a road or filled area. Separate the wetland into two AA's and assess separately if A and B have different water levels and circulation between them is significantly impeded. Otherwise, they can be evaluated as a single wetland.

Lake-fringe Wetlands

If a lake or reservoir (or any ponded water body) that adjoins a vegetated wetland is longer than 1 km, and its open water part is much wider than the width of the vegetated wetland along the shoreline, then the AA should be delimited to include the vegetated wetland plus only the portion of adjoining open water that is believed to be shallower than 2 m during annual low water. If that cannot be estimated, extend the AA outward into the lake a distance equal to about the average width of the wetland that is along its shoreline (measured perpendicular to the shore).

If distinct units of vegetated wetland are located discontinuously along the shoreline, any two adjoining units separated by non-wetland can be combined if the distance separating them, measured parallel to shore, is less than the length of the larger of the two vegetated wetlands, measured parallel to shore.

River-fringe Wetlands

If a stream, ditch, or other flowing-water channel intersects a vegetated wetland, the AA should normally include that feature if the feature is narrower than the maximum width of the vegetated wetland, as measured perpendicular to shore along one side of the stream, ditch, or channel. If the adjoining stream or river is wider, the AA should consist of the vegetated wetland plus the portion of the open water in the stream or river that is shallower than 2 m at annual low water. If that cannot be estimated, extend the AA outward into the channel a distance equal to about the average width of the wetland that is along its shoreline (width measured perpendicular to the shore). If the wetland is within an area that floods at least once every two years from river overflow, the AA should include all the contiguous overflow area (floodplain) that exists between the wetland and the channel.

If distinct units of vegetated wetland are located discontinuously along a river shoreline, any two adjoining units separated by non-wetland can be combined if the distance separating them, measured parallel to flow, is less than the length of the larger of the two vegetated wetlands, measured parallel to flow.

3.3. Estimating the Catchment Area (CA)

Estimating the approximate extent of the AA's catchment (CA, also called the "contributing area," Figure 4) is necessary in order to answer a few of the questions on Form S. The CA includes all areas uphill from the AA until a ridge or topographic rise is reached, often many kilometers away, beyond which water would travel in a direction that would not take it to the AA. The water does not need to travel on the land surface; it may reach the AA slowly as shallow subsurface seepage[3]. The lowest point of a CA is the lowest point in the AA. The CA's highest point will be along a ridgeline or topographic rim or mound located in the uplands. Although it is possible that roads, tile drains, and other diversions that run perpendicular to the slope may interfere with movement of runoff or groundwater into a wetland (at least seasonally), it is virtually impossible to determine their relative influence without detailed maps and hydrologic modeling. Therefore, in most cases draw the CA as it would exist without existing infrastructure, i.e., based solely on natural topography as depicted in the topographic map. The only exception is where maps, aerial images, or field inspections show artificial ditches or drains that obviously intercept and divert a substantial part of the runoff before it reaches the wetland, or where a runoff-blocking berm, dike, or elevated road adjoins all of a wetland's uphill perimeter.

The CA may include other wetlands and ponds, even those without outlets, if they're at a higher elevation. Normally, the limit of a CA will *cross a stream at only one point*— at the CA's and AA's outlet, if it has one. Include bordering perennial waters at the same elevation (such as a pond, lake, and river). Especially in urban areas and areas of flat terrain, the CA can be somewhat subjective and estimation in the field may be preferable. However, for ABWRET-A's purposes a high degree of precision is not needed.

Although the amount of runoff received by an AA may vary annually as wetlands farther upslope connect or disconnect in response to varying precipitation, the size of the CA you draw will remain constant because it is based on topography rather than on presence of surface connections.

[3] There are often situations where subsurface flow (especially deep groundwater), that potentially feeds a wetland, ignores such topographic divides. However, due to the limitations imposed by rapid assessment, no attempt should be made to account for that process.

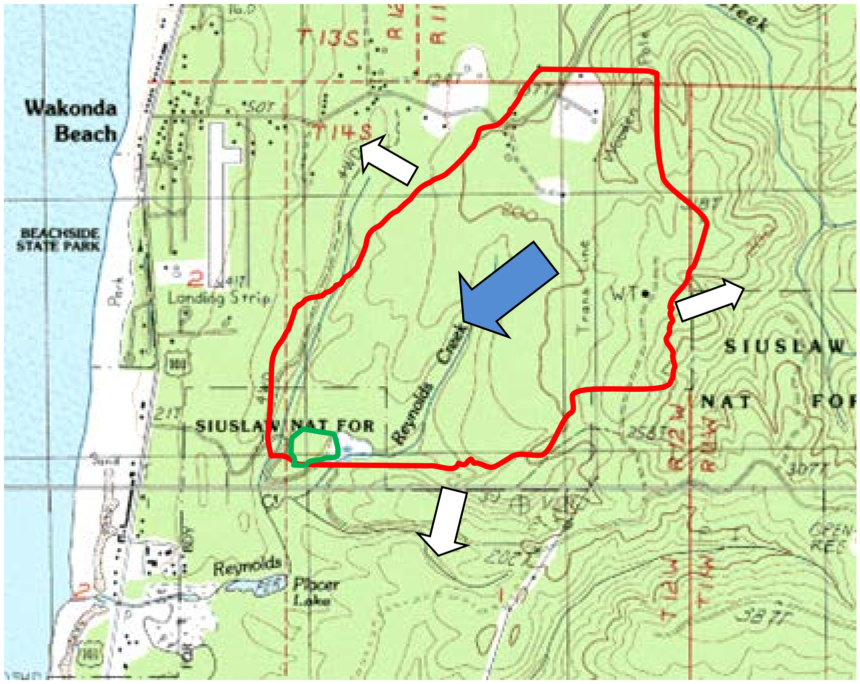


Figure 4. Approximating a wetland's catchment (CA).

In Figure 4 above, the wetland (Green) is fed by its catchment (Red). The dark arrow denotes flow of water downgradient within the CA. The light arrows denote the likely path of water away from the CA and into adjoining drainages, as interpreted from the topography. Note that the CA limit crosses a stream at only one point, that being the outlet of the wetland.

3.4. Instructions for Field Component

The field component involves visiting as much of the AA as possible and filling out the two field forms (F and S). The field component will generally require between one and two hours to complete (large or complex sites may take longer). If circumstances allow, visit the AA during both the wettest and driest times of the growing season. If you cannot, you must rely more on the aerial imagery, maps, other office information, and discussions with the landowner and other knowledgeable sources.

3.4.1. Items to Take to the Field

Take the following with you into the field:

- Blank data forms F and S
- Aerial image that includes the entire wetland and its extent
- Detailed map of wetland, if any available
- Plant identification guides
- List of invasive species (Alberta Native Plant Council or *Alberta Weed Act*)
- List of species at risk in your area (ACIMS - Alberta Conservation Information Management System)
- An electronic instrument that measures pH and either conductivity or TDS (total dissolved solids)

- Shovel or trowel for soil texture determination
- Handheld GPS, or a smartphone or camera that geo-tags the photographs you take
- Clip board, pencil, other items you'd normally take in the field

3.4.2. Conduct Field Assessment

Step 1. Review the questions on the F and S forms to refresh your memory of what to observe during the field visit. Be sure to read all the notes in the Explanations column (E) of form F.

Step 2. Plan your visit beforehand to visit as wide a range as possible of the hydrologic vegetation, and disturbance conditions within the AA (these may be evident on the aerial imagery before your visit if the AA is large). Determine the soil texture and measure the pH and conductivity (or TDS) of surface water if possible. After spending a minimum of 10 minutes walking in the predominant wetland class, you may begin filling out forms F and S.

Step 3. Generally note the extent of invasive and exotic plant cover within the AA and along its upland edge. If you have the skills to survey plant or animal species at risk and the timing of your visit is appropriate, search for these as time allows, following any established survey protocols.

Step 4. If you have access to the entire wetland, look for inlets and outlets, even ones that may flow only for a few days each year (as evidenced by flood marks or culverts that may be dry at the time of visit).

Step 5. Fill out forms F and S, paying attention to all the explanatory notes and definitions in the last column. As you answer the questions dealing with "percent of the area," pay particular attention to the spatial context (area) which the question is addressing. Is it the entire wetland or just the vegetated part? Or just the part covered by emergent or by woody vegetation?

Step 6. Determine the soil texture category nearest the ground surface after removing dead leaves and other loose non-soil materials. You will be asked to categorize the soil simply as *Organic*, *Clayey*, *Loamy*, *Peat*, or *Coarse*. Use the *Soil Composition by Feel* diagnostics flow chart in Appendix A.

Step 7. Look uphill of the wetland to see if any artificial feature that adjoins the wetland unmistakably diverts most of the surface runoff away from it (e.g., high berm) during normal runoff events. If such is found, reconsider some of the form S questions.

Step 8. If possible, talk with the landowner or other knowledgeable sources to determine the following, at a minimum:

- if the wetland and/or its bordering waters have gone completely dry during most recent years (if this is not obvious during your visit)
- how extensively the wetland floods during the peak of snowmelt or whenever it is wettest during most recent years
- annual duration of surface-water connection with streams and other wetlands

Local government offices may also be sources of useful information that will improve the accuracy of your assessment. An online search of the name of a nearby feature can sometimes be productive. Use the guidance and direction given in the Alberta Wetland Identification and Delineation Directive to investigate changes in water levels from multiple images taken at different seasons and years.

Potentially Confusing Terms as Used in ABWRET-A

Memorizing the following hierarchies and their terms may help you apply ABWRET-A with greater accuracy. Definitions of these terms are found in column E of the data forms.

Water:
- Ground water
- *vs.*
- Surface water
  - Ponded *vs.* Flowing
  - Open *vs.* Vegetated

Vegetation:
- Woody (trees, shrubs)
- *vs.*
- Non-woody
  - Moss
  - Herbaceous
    - Emergent *vs.* Floating-leaved *vs.* Submerged *vs.* Other
    - Forbs *vs.* Graminoids

3.5. Reviewing the Output

Before accepting the scores and rating provided by AEP, think carefully about those results. From your knowledge of wetland functions, do they make sense for this wetland? If not, review the worksheet for that function as well as Appendix C (Modeling Descriptions) to see how the score was generated. If you disagree with the results, write a few sentences explaining your reasoning and submit them to AEP in a cover letter or email along with the wetland assessment data. Review the caveats given in the Limitations section (section 1.2). Remember, ABWRET-A is just one tool intended to help the decision-making process, and other important tools are your common sense and professional experience with a particular function, wetland type, or species.

If you believe some of the scores which ABWRET-A generated do not match your understanding of a particular wetland function or other attribute, first examine the summary of your responses that pertain to that by clicking on the worksheet with that attribute's code (e.g., NR for Nitrate Removal). If you want to reconsider one of your responses (perhaps because you weren't able to see part of the AA, or view it during a preferred time of year), change the 0 or 1 you entered on form F or S. Then resubmit your forms to AEP for re-calculation.

4. References

ABMI. 2007 (and revised). Wetland survey methods. Alberta Biodiversity Monitoring Institute, Edmonton, AB.

ABMI. 2009. Manual for estimating species and habitat intactness at the regional scale. Version 2010-03-01. Alberta Biodiversity Monitoring Institute, Edmonton, AB.

ABMI. 2010. Manual for reporting human footprint. Version 2010-05-18. Alberta Biodiversity Monitoring Institute, Edmonton, AB.

Acreman, M. C., R. J. Harding, C. Lloyd, N. P. McNamara, J. O. Mountford, D. J. Mould, B. V. Purse, M. S. Heard, C. J. Stratford, and S. J. Dury. 2011. Trade-off in ecosystem services of the Somerset Levels and Moors wetlands. Hydrological Sciences Journal 56:1543-1565.

Adamus, P. R. 1983. A Method for Wetland Functional Assessment. Vol. II. Methodology. Report No. FHWA-IP-82-24. Federal Highway Administration, Washington, D.C.

Adamus, P. R., E. J. Clairain, Jr., R. D. Smith, and R. E. Young. 1987. Wetland Evaluation Technique (WET) Volume II: Methodology. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Adamus, P.R., E.J. Clairain, Jr., D.R. Smith, and R.E. Young. 1992. Wetland Evaluation Technique (WET). Volume I: Literature review and evaluation rationale. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Adamus P.R., J. Morlan, and K. Verble. 2009. Oregon Rapid Wetland Assessment Protocol (ORWAP): Calculator spreadsheet, databases, and data forms. Oregon Dept. of State Lands, Salem, OR.

Adamus, P., J. Morlan, and K. Verble. 2010. Wetland Ecosystem Services Protocol for the United States (WESPUS). Beta test version 1.0. Online: http://people.oregonstate.edu/~adamusp/WESP/

Alberta Natural Regions Committee. 2006. Natural regions and subregions of Alberta. Compiled by D.J. Downing and W.W. Pettapiece. Publication Number T/852. Government of Alberta, Edmonton, AB.

Boyd, J. and L. Wainger. 2003. Measuring ecosystem service benefits: The use of landscape analysis to evaluate environmental trades and compensation. Discussion Paper 02-63. Resources for the Future, Washington, DC.

Brinson, M. M. 1993. A hydrogeomorphic classification of wetlands. Technical Report WRP-DE-11. Environmental Research Laboratory, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Costanza, R., R. d'Arge, R. d. Groot, S. Farberk, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Suttonkk, and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. Nature 387(6630):253-260.

Euliss, N. H., J.W. LaBaugh, L.H. Fredrickson, D.M. Mushet, M.K. Laubhan, G.A. Swanson, T.C. Winter, D.O. Rosenberry, and R.D. Nelson. 2004. The wetland continuum: a conceptual framework for interpreting biological studies. Wetlands 24(2): 448-458.

Fiera (Fiera Biological Consulting Ltd.). 2010. Aquatic Environmentally Significant Areas in Alberta. Report prepared for Alberta Environment, Edmonton, Alberta. Fiera Biological Consulting Report Number 9030-2.

Finlayson, C. M., R. D'Cruz, and N. Davidson. 2005. Ecosystems and Human Well-being: Wetlands and Water: Synthesis. World Resources Institute, Washington, DC.

Forrest, A. 2010. Created stormwater wetlands as wetland compensation and a floristic quality approach to wetland condition assessment in Central Alberta. Master's Thesis. University of Alberta, Edmonton, AB.

Guntenspergen, G. R., S. A. Peterson, S. G. Leibowitz, and L. M. Cowardin. 2002. Indicators of wetland condition for the Prairie Pothole Region of the United States. Environmental Monitoring and Assessment 78:229-252.

Hruby, T. 1999. Assessments of wetland functions: what they are and what they are not. Environmental Management 23:75-85.uby 1999

Jenks, G. F. 1967. The data model concept in statistical mapping. International Yearbook of Cartography 7: 186–190.

Raab, D. and S. E. Bayley. 2012. A vegetation-based Index of Biotic Integrity to assess marsh reclamation success in the Alberta oil sands, Canada. Ecological Indicators 15:43-51.

Rooney, R. C. and S. E. Bayley. 2012a. Community congruence of plants, invertebrates and birds in natural and constructed shallow open-water wetlands: Do we need to monitor multiple assemblages? Ecological Indicators 20:42-50.

Rooney, R. C. and S. E. Bayley. 2012b. Development and testing of an index of biotic integrity based on submersed and floating vegetation and its application to assess reclamation wetlands in Alberta's oil sands area, Canada. Environmental Monitoring and Assessment 184(2):749-761.

Rooney, R. C., S. E. Bayley, I. F. Creed, and M. J. Wilson. 2012c. The accuracy of land cover-based wetland assessments is influenced by landscape extent. Landscape Ecology 27:1321-1335.

Russi, D., P. ten Brink, A. Farmer, T. Badura, D. Coates, J. Förster, R. Kumar, and N. Davidson. 2013. The economics of ecosystems and biodiversity for water and wetlands. IEEP, London and Brussels; Ramsar Secretariat, Gland, Switzerland.

Smith, R.D., A. Ammann, C. Bartoldus, and M.M. Brinson. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. Tech. Rept. WRP-DE-9, Waterways Exp. Stn., US Army Corps of Engineers, Vicksburg, MS.

Smith, L.M., N.H. Euliss, D.A. Wilcox, and M.M. Brinson. 2008. Application of a geomorphic and temporal perspective to wetland management in North America. Wetlands 28:563-77.

Wilson, M. J. and S. E. Bayley. 2012. Use of single versus multiple biotic communities as indicators of biological integrity in northern prairie wetlands. Ecological Indicators 20:187-195.

Wray, H.E. and S.E. Bayley. 2006. A review of indicators of wetland health and function in Alberta’s prairie, aspen parkland, and boreal dry mixedwood regions. University of Alberta and Alberta Environment, Edmonton, AB.

Zedler, J. and S. Kercher. 2005. Wetland resources: Status, trends, ecosystem services, and restorability. Annual Review of Environment and Resources 30:39-74.

Appendix A. Data Forms, Illustrations, Reference Tables

For each wetland you are assessing, print one copy of A.1 (the Cover Page, and forms F and S) and fill out the form in the field. Print one copy of the other sections for general reference.

A.1 ABWRET-A Cover Page and Data Forms F and S

Cover Page. Documentation of Wetland Assessment Using ABWRET-A for the Boreal and Foothills Natural Regions of Alberta. (Version 1.0 July 2016)		
1	Wetland Identifier:	
2	Name of Assessor:	
3	Name of Company:	
4	Date(s) of Field Assessment:	
5	Legal Land Description(s) of site:	
6	Approximate size of the Assessment Area (AA, in hectares)	
7	AA as percent of entire **wetland** (approx.)	
8	What percent (approx.) of the **AA** were you able to visit?	
9	How many wetlands have you assessed previously using this tool (approx.)?	
10	Have you received formal training in ABWRET-A (Yes or No)	
11	Is this assessment done for the purpose of submitting a regulatory application? (Yes or No)	
12	Is this assessment related to a compliance incident? (Yes or No)	
13	Is this assessment related to a research project, training course, or any other purpose other than a regulatory requirement? (Yes or No). Please specify.	
14	Comments :	

Wetland Identifier:	Legal Land Description:
Name of Assessor:	Long/Lat (Decimal Degrees):
Date:	
AA size:	

Data Form F. ABWRET-A. version 1.0 for the Boreal and Foothills Natural Regions of Alberta

DIRECTIONS: Walk for no less than 10 minutes from the wetland edge towards its core, in the part of the AA that is proposed for alteration. If no alteration is proposed, walk in a portion that appears to be most representative of the wetland overall. Walk only where it is safe and legal to do so. Conduct this assessment only after reading the accompanying Manual and the Explanations column of the data form. In the Data column, unless indicated otherwise, change the 0 (false) to a 1 (true) for the best choice, or mark "1" for multiple choices where allowed and so indicated. Answer these questions primarily based on your onsite observations and interpretations. Answering some questions accurately may require conferring with the landowner or other knowledgeable persons, and/or reviewing aerial imagery. Report only the conditions believed to prevail during the majority of the past 5 years, unless requested otherwise.

#	Indicator	Condition Choices	Data	Explanations, Definitions
F1	Wetland Type-Predominant	Follow the key below and mark the ONE row that best describes MOST of the AA:		[FH, INV, NR, OE, PH, SBM, SFS, WB, WC].
		A. Moss and/or lichen cover more than 25% of the ground. Substrate is mostly undecomposed peat. Choose between A1 and A2 and mark the choice with a 1 in their adjoining column. Otherwise go to B below.		
		A1. Surface water is usually absent or, if present, pH is typically <4.5 and conductivity is <100 uS/cm (about 64 ppm TDS). Often dominated by ericaceous shrubs (e.g., Labrador tea, lingonberry), sometimes with pitcher plant, sundew. Sedge cover usually sparse or absent. Trees, if present, are mainly limited to black spruce. Wetland surface is never sloping, except sometimes from wetland center towards outer edges (convex), and surrounding landscape is flat. Inlet and outlet channels are usually absent.	0	
		A2. Not A1. Surface water, if present, has pH typically >4.5 and conductivity is >100 uS/cm. Sedges and/or cottongrass often dominate the ground cover, while ericaceous shrubs and black spruce may also be present. Sometimes at toe of slope or edge of water body. An exit channel is usually present. Wetter than A1, often with many small persistent pools.	0	

		B. Moss and/or lichen cover **less than** 25% of the ground. Soil is mineral or decomposed organic (muck). Choose between B1 and B2 and mark the choice with a 1 in their adjoining column:		
		B1. Trees and shrubs taller than 1 m comprise **more than** 25% of the vegetated cover. Surface water is mostly absent or inundates the vegetation only seasonally (e.g., snowmelt pools or floodplain). Often in riparian settings, abandoned beaver flowages.	0	
		B2. Not B1. Tree & tall shrubs taller than 1 m comprise **less than** 25% of the vegetated cover. Vegetation is mostly herbaceous, e.g., cattail, bulrush, burreed, pond lily, horsetail. Often in depressions (potholes, created ponds), or along lakes and rivers, or where fill has blocked water movement causing prolonged flooding of wetlands formerly covered by moss. Surface water often fluctuates widely among seasons and years.	0	
F2	Wetland Type - Subordinate	If the AA is smaller than 1 ha, mark all **other** types that occupy more than 1% of the vegetated AA. If the AA is larger than 1 ha, mark all other types which adjoin directly (are contiguous with) the AA and occupy more than 1 ha, as visible from the AA or as interpreted from aerial imagery. Do not mark again the type marked in F1.		The 1 hectare and 1% thresholds represent the minimum cumulative area of that type within the vegetated AA, i.e., add up the multiple patches. [INV, PH, SBM, WC]
		A1	0	
		A2	0	
		B1	0	
		B2	0	
		no types other than the predominant one in F1 meet the stated conditions.	0	
F3	Woody Cover by Height	Following **EACH** row below, indicate with a number code the percentage of the living vegetation in the AA occupied by that feature (5 if >75%, 4 if 50-75%, 3 if 25-50%, 2 if 5-25%, 1 if <5%, 0 if none). If the AA has no trees or shrubs, **SKIP to F8** (N Fixers).		Note that this question asks you to answer the question using the coding system, differentiating from the usually binary system. Do not count trees or shrubs if they merely hang into the wetland. They must be rooted in soils that are saturated for several weeks of the growing season. The "vegetated part" should not include floating-leaved or submersed aquatics. [NR, PH, SBM WB, WS]
		coniferous trees (including tamarack) taller than 3 m	0	
		deciduous trees taller than 3 m	0	
		coniferous or ericaceous shrubs or trees 1-3 m tall not directly below the canopy of trees >3 m (e.g., conifer saplings, many ericaceous shrubs)	0	
		deciduous shrubs or trees 1-3 m tall not directly below the canopy of trees >3 m (e.g., deciduous saplings)	0	
		coniferous or ericaceous shrubs or trees <1 m tall not directly below the canopy of taller vegetation (e.g., conifer seedlings, many ericaceous shrubs); >3 m	0	
		deciduous shrubs or trees <1 m tall (e.g., deciduous seedlings)	0	

F4	Woody Diameter Classes	Mark all the diameter classes of woody plants within the AA, but **only IF** they comprise **>5% of the woody canopy** or subcanopy within the AA. Do not count trees that adjoin but are not within the AA.		If large-diameter trees overhang (shade) small-diameter ones, visualise a "subcanopy" at the average height of the smaller-dbh trees, to serve as a basis for the minimum 5% canopy requirement in this question. The trees and shrubs need not be wetland species. Diameters are the d.b.h., the diameter of the tree measured at 4.5 ft above the ground. [AM, PH, SBM, WB]
		coniferous, 1-9 cm diameter and >1 m tall	0	
		broad-leaved deciduous, 1-9 cm diameter and >1 m tall	0	
		coniferous, 10-19 cm diameter	0	
		broad-leaved deciduous, 10-19 cm diameter	0	
		coniferous, 20-40 cm diameter	0	
		broad-leaved deciduous, 20-40 cm diameter	0	
		coniferous, >40 cm diameter	0	
		broad-leaved deciduous, >40 cm diameter	0	
F5	Interspersion of Tall and Short Vegetation	Follow the key below and mark the ONE row that best describes MOST of the AA:		In larger forested wetlands, patchiness is best interpreted from aerial imagery. Images that show "coarse-grained" forests indicate presence of multiple age classes and/or numerous small openings, whereas those that show "fine-grained" forests suggest more even-aged, even-sized forest with little interspersion. [AM, INV, PH, SBM]
		A. Neither the vegetation taller than 1m nor the vegetation shorter than that comprise >70% of the vegetated part of the AA. They each comprise 30-70%. If false, go to B below. Otherwise choose between A1 and A2 and mark the choice with a 1 in the adjoining column:		
		A1. The two height classes are mostly scattered and intermixed throughout the AA.	0	
		A2. Not A1. The two height classes are mostly in separate zones or bands, or in proportionately large clumps.	0	
		B. Either the vegetation taller than 1m or the vegetation shorter than 1m **comprise** >70% of the vegetated part of the AA. One size class might even be totally absent. Choose between B1 and B2 and mark the choice with a 1 in the adjoining column:		
		B1. The less prevalent height class is mostly scattered and intermixed within the prevalent one.	0	
		B2. Not B1. The less prevalent height class is mostly located apart from the prevalent one, in separate zones or clumps, or is completely absent	0	
F6	Downed Wood	If trees taller than 3 m comprise <5% of the vegetative cover, **SKIP to F10** (Sphagnum Moss Extent). Otherwise, answer this: The number of downed wood pieces **longer than 2 m** and with diameter >5 cm, and **not persistently submerged**, is:		Exclude temporary "burn piles." [AM, INV, PH, SBM]
		Several (>5 if AA is >5 hectares, less for smaller AAs)	0	
		Few or none that meet these criteria.	0	
F7	Dominance of Most Abundant Shrub Species	If shrubs shorter than 3 m comprise <5% of the vegetative cover, proceed to next question. Otherwise, determine which two native shrub species (<3 m tall) comprise the greatest portion of the native shrub cover. Then choose one of the following:		[PH, SBM]
		those species together comprise **>** 50% of the areal cover of native shrub species.	0	
		those species together do **not** comprise **>** 50% of the areal cover of native shrub species.	0	

F8	N Fixers	The percent of the AA's vegetated cover that is nitrogen-fixing plants (e.g., alder, baltic (wire) rush, sweetgale, lupine, clover, other legumes) is:		Do not include N-fixing algae or lichens. Select only the first true statement. [INV, OE, PH]
		<1% or none	0	
		1-25% of the shrub plus ground cover, in the AA or along its water edge (whichever has more).	0	
		25-50% of the shrub plus ground cover, in the AA or along its water edge (whichever has more).	0	
		50-75% of the shrub plus ground cover, in the AA or along its water edge (whichever has more).	0	
		>75% of the shrub plus ground cover, in the AA or along its water edge (whichever has more).	0	
F9	Large Snags (Dead Standing Trees)	The number of large snags (**diameter >20 cm**) in the AA plus adjoining upland area within 10 m of the wetland edge is:		Snags are standing trees at least 2 m tall that often (not always) lack bark and foliage. [PH, SBM, WB]
		Few or none that meet these criteria.	0	
		Several (>5/hectare) and a pond, lake, or slow-flowing water wider than 10 m is within 1 km.	0	
		Several (>5/hectare) but above not true.	0	
F10	Sphagnum Moss Extent	The cover of **Sphagnum** moss (or any moss that forms a dense cushion many centimeters thick), including the moss obscured by taller sedges and other plants rooted in it, is:		Exclude moss growing on trees or rocks. [INV, OE, PH]
		<5% of the ground cover, or none	0	
		5-25% of the ground cover	0	
		25-50% of the ground cover	0	
		50-95% of the ground cover	0	
		>95% of the ground cover	0	
F11	% Bare Ground & Thatch	Consider the parts of the AA that lack surface water at the driest time of the growing season. Viewed **from directly above the ground layer**, the predominant condition in those areas at that time is:		Thatch is dead plant material (stems, leaves) resting on the ground surface. Bare ground that is present under a tree or shrub canopy should be counted. Wetlands with mineral soils and that are heavily shaded or are dominated by annual plant species tend to have more extensive areas that are bare during the early growing season. [NR, OE, PR, SR]
		Little or no (<5%) bare ground is visible between erect stems or under canopy anywhere in the vegetated AA. Ground is extensively blanketed by dense thatch, moss, lichens, graminoids with great stem densities, or plants with ground-hugging foliage.	0	
		Slightly bare ground (5-20% bare between plants) is visible in places, but those areas comprise less than 5% of the unflooded parts of the AA.	0	
		Much bare ground (20-50% bare between plants) is visible in places, and those areas comprise **more than** 5% of the unflooded parts of the AA.	0	
		Other conditions	0	
		Not applicable. Surface water (open or obscured by emergent plants) covers all of the AA all the time.	0	

F12	Ground Irregularity	Consider the parts of the AA that lack surface water at some time of the year. The number of hummocks, small pits, raised mounds, upturned trees, animal burrows, gullies, natural levees, microdepressions, and other areas of peat or mineral soil that are raised or depressed >10 cm compared to most of the area immediately surrounding them is:		If parts of the AA are flat but others are highly irregular, base your answer on which condition predominates in the parts of the AA that lack persistent water. [AM, INV, NR, PH, POL, PR, SBM, SR, WS]
		Few or none (minimal microtopography; <1% of the land has such features, or entire site is always water-covered).	0	
		Intermediate	0	
		Several (extensive micro-topography)	0	
F13	Upland Inclusions	Within the AA, inclusions of upland that individually are >100 sq.m. are:		Inclusions are slightly elevated "islands" or "pockets" dominated by upland vegetation and soils. Do not count as inclusions the elevated roots of trees or logs unless supported by a mound of soil meeting the size threshold. Upland inclusions may sometimes be created by fill. [AM, NR, SBM]
		Few or none	0	
		Intermediate (1 - 10% of vegetated part of the AA).	0	
		Many (e.g., wetland-upland "mosaic", >10% of the vegetated AA).	0	
F14	Soil Texture	In parts of the AA that lack persistent water, the texture of soil in the uppermost layer is mostly: [To determine this, use a trowel to check in at least 3 widely spaced locations, and use the soil texture key in Appendix A of the Manual]		Do not include duff (loose organic surface material, e.g., dead plant leaves and stems). If texture varies greatly, base your answer on which texture predominates in the parts of the AA that lack persistent water. [NR, OE, PH, PR, SFS, WS]
		Loamy: includes loam, sandy loam	0	
		Fines: includes silt, glacial flour, clay, clay loam, silty clay, silty clay loam, sandy clay, sandy clay loam.	0	
		Peat, present to 40 cm depth or greater.	0	
		Peat, but becomes mineral before reaching 40 cm depth	0	
		Organic or organic muck, but becomes mineral before reaching 40 cm depth.	0	
		Coarse: includes sand, loamy sand, gravel, cobble, stones, boulders, fluvents, fluvaquents, riverwash.	0	
F15	Shorebird Feeding Habitats	During any 2 consecutive weeks of the growing season, the extent of mudflats, bare unshaded saturated areas not covered by thatch, and unshaded waters shallower than 6 cm is: [include also any area that immediately adjoins the AA]		This addresses needs of many migratory sandpipers, plovers, and related species, but not Wilson's snipe. [WB]
		none, or <100 sq. m within the AA.	0	
		100-1000 sq. m within the AA.	0	
		1000 – 10,000 sq. m within the AA.	0	
		>10,000 sq. m within the AA.	0	

F16	Herbaceous - Percent of Vegetated Wetland	In aerial ("ducks eye") view, the maximum annual cover of herbaceous vegetation (excluding moss) that is not under shrubs or trees is:		[POL, WB]
		<5% of the vegetated part of the AA or <0.01 hectare (whichever is less). Mark "1" here and **SKIP to F20** (Invasive Plant Cover).	0	
		5-25% of the vegetated AA.	0	
		25-50% of the vegetated AA.	0	
		50-95% of the vegetated AA.	0	
		>95% of the vegetated AA.	0	
F17	Forb Cover	The areal cover of **forbs** reaches an annual maximum of:		**Forbs** do **not** include grasses, sedges, cattail, or other graminoids. Although technically a forb, include horsetail (Equisetum) as a graminoid, not a forb. Do not include non-wetland forb species, or floating-leaved aquatic plants. Areal cover (percentage of an area) is not the same as aerial cover (viewed from the air). [POL]
		<5% of the vegetated AA	0	
		5-25% of the vegetated AA	0	
		25-50% of the vegetated AA	0	
		50-95% of the vegetated AA	0	
		>95% of the vegetated AA. **SKIP to F20** (Invasive Plant Cover).	0	
F18	Sedge Cover	Sedges (*Carex* spp.) and/or cottongrass (*Eriophorum* spp.) occupy:		[PH]
		<0.01 hectare and <1% of the herbaceous cover (excluding mosses)	0	
		1-30% of the herbaceous cover	0	
		30-60% of the herbaceous cover	0	
		60-90% of the herbaceous cover	0	
		>90% of the herbaceous cover	0	
F19	Dominance of Most Abundant Herbaceous Species	Determine which two native herbaceous (forb and graminoid) species comprise the greatest portion of the herbaceous cover that is unshaded by a woody canopy. Then choose one of the following:		[INV, PH, POL]
		those species together comprise **> 50%** of the areal cover of **native** herbaceous plants at any time during the year.	0	
		those species together do **not** comprise > 50% of the areal cover of native herbaceous plants at any time during the year.	0	

F20	Invasive Plant Cover	In this region, the more frequent invasive graminoids include smooth brome, several bluegrasses, quackgrass, timothy, alfalfa, reed canarygrass, red fescue, spreading bentgrass. The more frequent invasive forbs include most thistles and sow-thistles, most clovers, sweetclover, black medick, dandelion, great plantain, hemp-nettle, lamb's-quarters, shepherd's-purse, curly dock, pennycress, wallflower, hawksbeard, tansy, some chickweeds, sticky-willy bedstraw, stickseed, tall buttercup. Select the condition that represents **whichever cover of invasives is greater** -- percent herbaceous that is invasive, or percent woody that is invasive:		Listing the species you find is encouraged but optional. [PH, POL]
		invasive species appear to be **absent** in the AA, or are present only in trace amount (a few individuals)	0	
		Invasive species are present in more than trace amounts, but comprise <5% of herbaceous cover (or woody cover, if the invasives are woody).	0	
		Invasive species comprise 5-20% of the herb cover (or woody cover, if the invasives are woody).	0	
		Invasive species comprise 20-50% of the herb cover (or woody cover, if the invasives are woody).	0	
		Invasive species comprise >50% of the herb cover (or woody cover, if the invasives are woody).	0	
F21	Weed Source Along Edge	Along the wetland-upland edge, the percent of the upland edge (within 3 m of wetland) that is occupied by plant species that are considered invasive (see above) is:		If the AA has no upland edge, or upland edge is <10% of AA's perimeter, then answer for the portion of the upland closest to the wetland. Listing the species you find is encouraged but optional. See PlantList worksheet for full list of invasives. [PH]
		none of the upland edge (invasives apparently absent)	0	
		some (but <5%) of the upland edge	0	
		5-50% of the upland edge	0	
		most (>50%) of the upland edge	0	
F22	% Never With Surface Water	The percentage of the AA that never contains surface water during an average year (that is, except perhaps for a few hours after snowmelt or rainstorms), but which is still a wetland, is:		This is the cumulative area of the AA lacking surface water. [AM, FH, INV, NR, PH, PR, SBM, WB, WC]
		<0.01 hectare (about 10 m on a side) **and** <1% of the AA never has surface water. In other words, all or nearly all of the AA is covered by water permanently or at least seasonally.	0	
		1-25% of the AA never contains surface water.	0	
		25-50% of the AA never contains surface water.	0	
		50-99% of the AA never contains surface water.	0	
		>99% of the AA never contains surface water, except perhaps for water flowing in channels and/or in pools that occupy <1% of the AA. **SKIP to F48** (Channel Connection & Outflow Duration).	0	
F23	% with **Persistent** Surface Water	The percentage of the AA that has **surface** water (either ponded or flowing, either open or obscured by vegetation) during **all** of the growing season during most years is:		This is the cumulative area that has surface water. If you are unable to determine the condition at the driest time of year, asking the land owner or neighbors about it will be particularly important. Indicators of persistence may include fish, some dragonfly species, beaver, and muskrat. [FH, INV, NR, PH, PR, SBM, WB]
		<0.01 hectare and <1% of the AA. **SKIP to F27** (% Flooded Only Seasonally).	0	
		1-5% of the AA	0	
		5-25% of the AA	0	
		25-50% of the AA	0	
		50-95% of the AA	0	
		>95% of the AA	0	

F24	% of Summertime Water That Is Shaded	At mid-day during the warmest time of year, the area of surface water within the AA that is shaded by vegetation and other features that are within the AA is:		Do not include shade from floating-leaved plants or moss. [FH, OE, WC]
		<5% of the water is shaded, or no surface water is present then.	0	
		5-25% of the water is shaded	0	
		25-50% of the water is shaded	0	
		50-75% of the water is shaded	0	
		>75% of the water is shaded	0	
F25	Fringe Wetland	Open water that adjoins the vegetated wetland in a lake, stream, or river during annual low water condition is much wider than the vegetated wetland. Enter "1" if true, "0" if false.	0	[FH, HU]
F26	Lacustrine Wetland	The AA borders a body of ponded open water whose size -- not counting the vegetated AA -- exceeds 8 hectares (about 300 x 300 m) during most of the growing season. Enter "1" if true, "0" if false.	0	[FH, HU, PR, WB]
F27	% Flooded Only Seasonally	The percentage of the AA that is covered by unfrozen surface water only during the wettest time of the year is:		Flood marks (algal mats, adventitious roots, debris lines, ice scour, etc.) are often evident when not fully inundated. Along some rivers, the extent of this zone can be estimated by multiplying by 2 the bankful height and visualizing where that would intercept the land along the river. Width may vary depending on ice jams. [INV, NR, OE, SR, WB, WS]
		None, or <0.01 hectare and <1% of the AA.	0	
		1-25%	0	
		25-50%	0	
		50-95%	0	
		>95%	0	
F28	Annual Water Fluctuation Range	The annual fluctuation in surface water level within most of the parts of the AA that contain surface water is:		Look for flood marks (see above). Because the annual range of water levels is difficult to estimate without multiple visits, consider asking the land owner or neighbors about it. [AM, INV, NR, OE, PH, PR, SR, WB, WS]
		<10 cm change (stable or nearly so)	0	
		10 cm - 50 cm change	0	
		0.5 - 1 m change	0	
		1-2 m change	0	
		>2 m change	0	
Does the AA comprise an entire wetland that is smaller than 0.01 hectare? If so, enter "1" in column D and SKIP TO F45 (Beaver).			0	

F29	Predominant Depth Class	During most of the time when water is present, its depth in **most** of the area is: [*Note: This is not asking for the maximum depth.*] If a ponded body of open water that adjoins the AA is larger than 8 ha, include its waters in this estimate, but only those waters within a distance from the AA that is equal to the vegetated AA's width]		This describes the spatial median depth that occurs during most of that time, even if inundation is only seasonal or temporary. If inundation in most but not all of the wetland is brief, the answer will be based on the depth of the most persistently inundated part of the wetland. [FH, INV,` PH, PR, SFS, SR, WC]
		<10 cm deep (but >0)	0	
		10 - 50 cm deep	0	
		0.5 - 1 m deep	0	
		1 - 2 m deep	0	
		>2 m deep. True for many fringe wetlands.	0	
F30	Depth Classes - Evenness of Proportions	Within the area described above, and during most of the time when surface water is present, it usually is comprised of: (select one):		Estimate these proportions by considering the gradient and microtopography of the site. See diagram in the manual. [FH, INV, WB]
		One depth class covering >90% of the AA's inundated area (use the classes in the question above).	0	
		One depth class covering 51-90% of the AA's inundated area.	0	
		Multiple depth classes and none occupy more than 50% of the AA.	0	
F31	% of Water Ponded vs. Flowing	The percentage of the AA's surface water that is **ponded** (stagnant, or flows so slowly that fine sediment is not held in suspension) **during most of the time it is present** during the growing season, and which is either open or shaded by emergent vegetation, is:		Nearly all wetlands with surface water have some ponded water. [AM, FH, NR, OE, SR, WB, WC, WS]
		None, or <0.01 hectare and <1% of the AA. Nearly all water is flowing. Enter "1" and **SKIP to F43** (pH measurement).	0	
		1-5% of the water. The rest is flowing.	0	
		5-30% of the water	0	
		30-70% of the water	0	
		70-99% of the water	0	
		>99% of the water. Little or no visibly flowing water **within** the AA.	0	
F32	Ponded Open Water - Minimum Size	During most of the growing season, the largest patch of **open** water that is **ponded** and is in or bordering the AA is **>0.01 hectare** (about 10 m by 10 m) **and mostly deeper than 0.5 m.** If true enter "1" and continue, If false, enter "0" and **SKIP to F41** (Floating Algae & Duckweed).	0	Open water is not obscured by vegetation in aerial ("duck's eye") view. It includes vegetation floating on the water surface or entirely submersed beneath it. It may be flowing or ponded.
F33	% of Ponded Water That Is Open	In ducks-eye aerial view, the percentage of the ponded water that is **open** (lacking emergent vegetation during most of the growing season, and unhidden by a forest or shrub canopy) is:		Open water may have floating aquatic vegetation provided that it does not usually extend above the water surface. [AM, FH, HU, INV, NR, OE, PH, PR, SBM, SR, WB, WC, WS]
		None, or <1% of the AA and largest pool occupies <0.01 hectares. Enter "1" and **SKIP to F41** (Floating Algae & Duckweed).	0	
		1-4% of the ponded water. Enter "1" and **SKIP to F41.**	0	
		5-30% of the ponded water.	0	
		30-70% of the ponded water.	0	
		70-99% of the ponded water.	0	
		100% of the ponded water.	0	

F34	Predominant Width of Vegetated Zone within Wetland	At the time during the growing season when the AA's water level is lowest, the average width of vegetated area **in the AA** that separates adjoining uplands from open water within the AA is:		"Vegetated area" does not include submersed or floating-leaved plants, i.e., aquatic bed. Width may include wooded riparian areas if they have wetland soil or plant indicators. For most sites larger than 10 hectares and with persistent water, measure the width using aerial imagery rather than estimate in the field. Free apps are available for estimating distance through the camera lens of most smartphones. [AM, NR, OE, PH, PR, SBM, SR, WB, WS]
		<1 m	0	
		1 - 9 m	0	
		10 - 29 m	0	
		30 - 49 m	0	
		50 - 100 m	0	
		> 100 m	0	
F35	Flat Shoreline Extent	During most of the part of the growing season when water is present, the percentage of the AA's water edge length that is **nearly flat** (a slope less than about 5% measured within 5 m landward) is:		If several pools are present within the AA, estimate the percent of their collective shorelines that has such a gentle slope. See diagram in the manual. [SR, WB]
		<1%	0	
		1-25%	0	
		25-50%	0	
		50-75%	0	
		>75%	0	
F36	Robust Emergents	During most of the part of the growing season when water is present, the percentage of the AA's water edge length that is occupied by a band (>1m wide) or small islands of robust emergents (cattail, tall bulrush, buckbean), is:		The "water edge" should include the circumference of any patches of robust emergents that are surrounded by water.
		None, or <0.01 hectare and <1% of the AA. **SKIP to F38** (Open Water – Minimum Depth).	0	
		1-25%	0	
		25-50%	0	
		50-75%	0	
		>75%	0	
F37	Interspersion of Robust Emergents & Open Water	During most of the part of the growing season when water is present, the spatial **pattern** of robust herbaceous vegetation (e.g., cattail, tall bulrush, buckbean) is **mostly**:		[AM, FH, INV, NR, OE, PH, PR, SBM, SR, WB]
		Scattered. More than 30% of such vegetation forms small islands or corridors surrounded by water.	0	
		Intermediate	0	
		Clumped. More than 70% of such vegetation is in bands along the wetland perimeter or is clumped at one or a few sides of the surface water area.	0	
F38	Open Water - Minimum Depth	During most of the growing season, the deepest patch of surface water (flowing or ponded) in or directly adjacent to the AA is **mostly deeper than 0.5 m**. If true enter "1" and continue, If false, enter "0" and **SKIP to F41** (Floating Algae and Duckweed).	0	

F39	Non-vegetated Aquatic Cover	During most of the growing season and in waters deeper than 0.5 m, the cover for fish, aquatic invertebrates, and/or amphibians that is provided NOT by living vegetation, but by **accumulations of dead wood and undercut banks** is:		Consider only the wood that is at or above the water surface, because estimates of underwater wood based only on observations from terrestrial viewing points are unreliable. [AM, FH, INV]
		Little or none	0	
		Intermediate	0	
		Extensive	0	
F40	Isolated Island	The AA contains (or is part of) an island or beaver lodge within a lake, pond, or river, and is isolated from the shore by water depths >2 m on all sides during an average June. The island may be solid, or it may be a floating vegetation mat that is sufficiently large and dense to support a waterbird nest.	0	[WB]
F41	Floating Algae & Duckweed	At some time of the year, mats of algae and/or duckweed cover >50% of the AA's otherwise-unshaded water surface, or blanket >50% of the underwater substrate. If true, enter "1" in next column. If untrue or unlikely, enter "0".	0	[HU, PR]
F42	Fish	Fish from connected waters can access at least part of the AA during one or more days annually, or are otherwise known to be present in the AA at least temporarily. If true, enter "1" in next column. If untrue or unlikely, enter "0".	0	[AM, FH, INV, WB]
F43	pH Measurement	The pH in most of the AA's surface water:		Do not dig holes or make depressions in peat in order to provide water for this measurement. pH of <4.5 usually indicates bog. pH of >5.5 often indicates marsh or swamp, but also some fens. Fens can be classified as poor fens (pH<5.5), moderate-rich fens (pH 5.5 - 7), and rich fens (pH>7.0). [AM, FH, INV, OE, WB]
		was not measured because no surface water could be found during this visit. Enter "1" in column to the right.	0	
		was not measured, and surface water is tea-colored. Enter "1" in column to the right,	0	
		was not measured but surface water is NOT tea-colored. Enter "1" in column to the right.	0	
		was measured, and is: [*enter the reading in the column to the right*]:		
F44	TDS and/or Conductivity	The Total Dissolved Solids (TDS) and/or conductivity in most of the AA's surface water:		If possible, avoid measuring this near roads. Do not dig holes or make depressions in peat in order to provide water for this measurement. Conductance of <100 µS/cm usually indicates bog or poor fen. 100-250 µS/cm indicates moderate-rich fen, >250 µS/cm indicates rich fen.
		was not measured because no surface water could be found during this visit. Enter "1" in column to the right.	0	
		was not measured, and plants that indicate saline conditions are absent or in trace amounts. Enter "1" in column to the right.	0	
		was not measured, but plants that indicate saline conditions are present. Enter "1" in column to the right.	0	
		TDS is: [*enter the reading **in ppm** or mg/L in the column to the right if measured, or answer next row*]:		
		Conductivity is [*enter the reading **in µS/cm** in the column to the right*]:		

F45	Beaver Probability	Use of the AA by beaver during the past 5 years is (select most applicable ONE):		[AM, FH, PH, SBM, WB]
		evident from direct observation or presence of gnawed limbs, dams, tracks, dens, lodges, or extensive stands of water-killed trees (snags).	0	
		likely based on known occurrence in the region and proximity to suitable habitat, which may include: (a) a persistent freshwater wetland, pond, or lake, or a perennial low or mid-gradient (<10%) channel, and (b) a corridor or multiple stands of hardwood trees and shrubs in vegetated areas near surface water.	0	
		unlikely because site characteristics above are deficient, and/or this is a settled area or other area where beaver are routinely removed. But beaver occur in this part of the region (i.e., within 25 km).	0	
F46	Tributary Inflow	At least once annually, surface water from a tributary channel that is >100 m long moves into the AA. Or, surface water from a larger permanent water body that directly adjoins the AA spills into the AA. If false (no input), enter 0 and **SKIP to F48** (Channel Connection & Outflow Duration). Otherwise, enter 1 and continue.	0	[PH]
F47	Through Flow Pattern	During its travel through the AA at the time of peak annual flow, water arriving in channels: [select only the ONE encountered by **most** of the incoming water]		[FH, INV, NR, OE, PR, SR, WS]
		Does not bump into plant stems as it travels through the AA. Nearly all the water continues to travel in unvegetated (often incised) channels that have minimal contact with wetland vegetation, or through a zone of open water such as an instream pond or lake.	0	
		bumps into **herbaceous** vegetation but mostly remains in fairly straight channels.	0	
		bumps into **herbaceous** vegetation and mostly spreads throughout, or is in widely meandering, multi-branched, or braided channels.	0	
		bumps into **tree trunks and/or shrub stems** but mostly remains in fairly straight channels.	0	
		bumps into tree trunks and/or shrub stems and follows a fairly **indirect** path from entrance to exit (meandering, multi-branched, or braided)	0	
F48	Channel Connection & Outflow Duration	The **most persistent** surface water connection (outlet channel or pipe, ditch, or overbank water exchange) between the AA and the closest larger water body located downslope is: [Note: If the AA represents only part of a wetland, answer this according to whichever is the least permanent surface connection: the one between the AA and the rest of the wetland, or the surface connection between the wetland and a mapped stream or lake located within 200 m downslope from the wetland]		A channel is an observably incised landform that transports surface water in a downhill direction during some part of a normal year. A larger difference in elevation between the wetland-upland edge and the bottom of the wetland outlet (if any) indicates shorter outflow duration. The frequencies given are only approximate and are for a "normal" year. The connection need not occur during the growing season. [FH, NR, OE, PR, SFS, SR, WC, WS]
		persistent (>9 months/year, including times when frozen)	0	
		seasonal (14 days to 9 months/year, not necessarily consecutive, including times when frozen)	0	
		temporary (<14 days, not necessarily consecutive, but must be unfrozen)	0	
		none -- but maps show a stream or other water body that is downslope from the AA and within a distance that is less than the AA's length. If so, mark "1" here and **SKIP TO F50** (Groundwater).	0	
		no surface water flows out of the wetland except possibly during extreme events (< once per 10 years). Or, water flows only into a wetland, ditch, or lake that lacks an outlet. If so, mark "1" here and **SKIP TO F50** (Groundwater).	0	

F49	Outflow Confinement	During major runoff events, in the places where surface water exits the AA or connected waters nearby, it:		"Major runoff events" would include biennial high water caused by storms and/or rapid snowmelt. [NR, OE, PR SR, WS]
		mostly passes through a pipe, culvert, narrowly breached dike, berm, beaver dam, or other partial obstruction (other than natural topography) that does not appear to drain the wetland artificially during most of the growing season.	0	
		leaves through natural exits (channels or diffuse outflow), not mainly through artificial or temporary features.	0	
		Is exported more quickly than usual due to ditches or pipes within the AA (or connected to its outlet or within 10 m of the AA's edge) which drain the wetland artificially, or water is pumped out of the AA.	0	
F50	Groundwater: Strength of Evidence	Select the first applicable choice.		Adhere to these criteria strictly -- do not use personal judgment based on fen conditions or other evidence. Consult topographic maps to detect breaks in slope described here. [AM, FH, INV, NR, PH, SFS, WC, WS]
		Springs are known to be present within the AA, or if groundwater levels have been monitored, that has demonstrated that groundwater primarily discharges to the wetland for longer periods during the year than periods when the wetland recharges the groundwater.	0	
		If surface water is present, its pH (Q44) is >5.5 AND one or more of the following are true: (a) the upper end of the AA is located very close to the base of (but mostly not ON) a natural slope much steeper (usually >15%) than that within the AA and longer than 100 m, OR (b) rust deposits ("iron floc"), colored precipitates, or a dispersible natural oil sheen is prevalent in the AA, OR (c) AA is located at a geologic fault.	0	
		Neither of above is true, although some groundwater may discharge to or flow through the AA. Or groundwater influx is unknown.	0	
F51	Internal Gradient	The gradient along most of the flow path within the AA is:		This is not the same as the shoreline slope. It is the elevational difference between the AA's inlet and outlet, divided by the flow-distance between them and converted to percent. If available, use a clinometer to measure this. Free apps for measuring gradient (clinometers) can be downloaded to smartphones. [AM, NR, OE, PR, SR, WB, WS]
		<2%, or, no slope is ever apparent (i.e., flat). Or, the wetland is in a depression or pond with no inlet and no outlet.	0	
		2-5%	0	
		6-10%	0	
		>10%	0	
F52	Percent of Buffer with Perennial Vegetation	Extending 30 m on all sides from the AA's edge, the percentage that contains water or perennial vegetation taller than 10 cm during most of the growing season is:		**Perennial vegetation** is vegetation that persists from year to year, e.g., not crops that are completely harvested at some point each year. It may or may not include invasive species. [AM, INV, PH, SBM, WB]
		<5%	0	
		5 to 30%	0	
		30 to 60%	0	
		60 to 90%	0	
		>90%. SKIP to F54 (Cliffs).	0	

F53	Type of Cover in Buffer	Within 30 m upslope of the wetland-upland edge, the upland land cover that is NOT unmanaged vegetation or water is mostly (mark ONE):		[AM, INV, NR, PH, SBM, WB]
		impervious surface, e.g., paved road, parking lot, building, exposed rock.	0	
		bare or nearly bare pervious surface or managed vegetation, e.g., lawn, annual crops, mostly-unvegetated clearcut, landslide, unpaved road, drill pad, dike.	0	
F54	Cliffs, Steep Banks, or Salt Lick	In the AA or within 100 m, there is a known salt lick, or elevated terrestrial features such as cliffs, talus slopes, stream banks, or excavated pits (but not riprap) that extend at least 2 m nearly vertically, are unvegetated, and potentially contain crevices or other substrate suitable for nesting or den areas. Enter 1 (yes) or 0 (no).	0	[POL, SBM]
F55	New or Expanded Wetland	Part or all of the AA resulted from human actions that persistently expanded a naturally occurring wetland or created a wetland where there previously was none (e.g., by excavation, impoundment):		Do not include wetlands created by beaver dams except for the part where former uplands were flooded. Determine this using historical aerial photography, old maps, soil maps, or permit files as available [NR, OE, PH]
		No	0	
		yes, and created or expanded 20 - 100 years ago	0	
		yes, and created or expanded 3-20 years ago	0	
		yes, and created or expanded within last 3 years	0	
		yes, but time of origin unknown	0	
		unknown if new or expanded within 20 years or not	0	
F56	Burn History	More than 1% of the AA's previously vegetated area:		[Fire]
		burned within past 5 years	0	
		burned 6-10 years ago	0	
		burned 11-30 years ago	0	
		burned >30 years ago, or no evidence of a burn and no data.	0	
F57	Visibility	From the best vantage point on public roads, public parking lots, public buildings, or well-defined public trails that intersect, adjoin, or are within 100 m of the wetland, **some part** of the AA is (select best case):		[HU]
		easily visible	0	
		somewhat visible	0	
		barely or not visible	0	
F58	Ownership	Most of the AA is (select one):		[HU]
		Publicly owned **conservation** lands that exclude new timber harvest, roads, mineral extraction, and intensive summer recreation (e.g., off-road vehicles).	0	
		Publicly owned **resource use** lands (that allow activities such as timber harvest, mining, or intensive recreation), or unknown.	0	
		Private owner who allows public access.	0	
		Private owner who does not allow access, or access permission unknown.	0	

F59	Non-consumptive Uses - Actual or Potential	Assuming access permission was granted, select ALL statements that are true of the AA as it currently exists:		[HU]
		For an average person, walking is physically possible in (not just near) >5% of the AA during most of the growing season, e.g., free of deep water and dense shrub thickets.	0	
		Maintained roads, parking areas, or foot-trails are within 10 m of the AA, or the AA can be accessed part of the year by boats arriving via contiguous waters.	0	
		Within or near the AA, there is an interpretive center, trails with interpretive signs or brochures, and/or regular guided interpretive tours.	0	
		The AA contains or adjoins a **public** boat dock or ramp, or is within 1 km of a campground, picnic area, or day park.	0	
F60	Unvisited Core Area	The percentage of the AA almost never visited by humans during an average growing season probably comprises: [Note: Only include the part actually walked or driven (not simply viewed from) with a vehicle or boat. Do not include visitors on trails outside of the AA unless more than half the wetland is visible from the trails and they are within 30 m of the wetland edge. In that case include only the area occupied by the trail]		Include visits by foot, canoe, kayak, or ATV. Judge this based on proximity to population centers, roads, trails, accessibility of the wetland to the public, wetland size, usual water depth, other physical hindrances, and physical evidence of human visitation. Exclude visits that are not likely to continue and/or that are not an annual occurrence, e.g., by construction or monitoring crews. [AM, PH, HU, SBM, WB]
		<5% and no inhabited building is within 100 m of the AA	0	
		<5% and an inhabited building is within 100 m of the AA	0	
		5-50% and no inhabited building is within 100 m of the AA	0	
		5-50% and an inhabited building is within 100 m of the AA	0	
		50-95%, with or without inhabited building nearby.	0	
		>95% of the AA with or without inhabited building nearby.	0	
F61	Frequently Visited Area	The percentage of the AA visited by humans almost daily for several weeks during an average growing season probably comprises: [*Note: Do not include visitors on trails outside of the AA unless more than half the wetland is visible from the trails and they are within 30 m of the wetland edge. In that case, imagine the percentage of the AA that would be covered by the trail if it were placed within the AA.*]		Include visits by foot, canoe, kayak, or any non-motorized mode. Exclude visits that are not likely to continue and/or that are not an annual occurrence, e.g., by construction or monitoring crews. [AM, PH, HU, SBM, WB]
		<5%. If F62 was answered ">95%", SKIP to F64 (Consumptive Uses).	0	
		5-50%	0	
		50-95%	0	
		>95% of the AA	0	
F62	BMP - Soils	Boardwalks, paved trails, fences or other infrastructure and/or well-enforced regulations appear to effectively deter visitors from walking on soils within nearly all of the AA when they are unfrozen. Enter "1" if true.	0	[PH, HU]
F63	BMP - Wildlife Protection	Fences, observation blinds, platforms, paved trails, exclusion periods, and/or well-enforced prohibitions on motorized boats, off-leash pets, and off road vehicles appear to effectively exclude or divert visitors and their pets from the AA at critical times in order to minimize disturbance of wildlife (except during hunting seasons). Enter "1" if true.	0	[WB]

F64	Consumptive Uses (Provisioning Services)	Recent evidence was found within the AA of the following potentially-sustainable consumptive uses. Select all that apply.		"Low impact" means adherence to Best Management Practices. Evidence of these consumptive uses may consist of direct observation, or presence of physical evidence (e.g., recently cut stumps, fishing lures, shell cases), or might be obtained from communication with the land owner or manager. [HU]
		Low-impact commercial timber harvest (e.g., selective thinning)	0	
		Extraction of surface water without noticeably affecting surface water area, depth, or persistence.	0	
		Grazing by livestock	0	
		Harvesting of native plants, native hay, or mushrooms (observed or known, **not** assumed)	0	
		Hunting (observed or known, not assumed)	0	
		Furbearer trapping (observed or known, not assumed)	0	
		Fishing (observed or known, not assumed)	0	
		No evidence of any of the above	0	
F65	Domestic Wells	The closest wells or water bodies that currently provide drinking water are:		If unknown, assume this is true if there is an inhabited structure within the specified distance and the neighborhood is known to not be connected to a municipal drinking water system (e.g., is outside a densely settled area). [HU]
		Within 0-100 m of the AA	0	
		100-500 m away	0	
		>500 m away, or no information	0	
F66	Distance to Tailings Pond	The distance between the AA and the nearest industrial (e.g., tailings) pond in which waterbirds could land and be exposed to contaminants is:		[WB]
		Within 0-100 m of the AA	0	
		100-500 m away	0	
		>500 m away, or no information	0	
F67	Prior Investment in the Wetland	Mark ALL of the following that apply to this AA:		[HU]
		Regulatory Investment: The AA is all or part of a mitigation or replacement site used explicitly to offset impacts elsewhere.	0	
		Non-regulatory Investment: The AA is part of or contiguous to a wetland on which public or private organizational funds were spent to preserve, create, restore, enhance, the wetland (excluding wetland replacement wetlands).	0	
		Sustained Scientific Use: Plants, animals, soils, or water in the AA have been monitored for >2 years, unrelated to any regulatory requirements, and data are available to the public. Or the AA is part of an area that has been designated by an agency or institution as a benchmark, reference, or status-trends monitoring area.	0	
		None of the above, or no information for any.	0	

F68	Plants or Animals of Conservation Concern	If required, survey the AA for plant or animal species at risk in Alberta (see list in RarePlants or RareAnimals worksheet tabs), especially if the data review conducted during the office phase of this assessment indicated their past presence in the general vicinity. Do so at appropriate times of the year. If you do detect these species or have reliable knowledge of their recent (within ~5 years) occurrence within the AA, indicate that below.		Includes species at risk or that may be at risk. Species status can be searched for in your area using ACIMS (Alberta Conservation Information Management System) for plants, FWMIS (Fish and Wildlife Management Information System) for wildlife, or using the general status search on the Fish and Wildlife website for the Province. [FR, AM, WB, SBM, PH]
		One or more plant species at risk was detected within the AA.	0	
		One or more fish species at risk was detected within the AA.	0	
		One or more amphibian species at risk was detected within the AA.	0	
		One or more waterbird species at risk was detected within the AA.	0	
		One or more songbird or mammal species at risk was detected within the AA.	0	
		None of the above, or no data.	0	
F69	Wetland as a % of Its Contributing Area (Catchment)	Estimate the approximate boundaries of the wetland's catchment (CA) from a topographic map. Then adjust those boundaries if necessary based on your field observations of the surrounding terrain, and/or by using procedures described in the ABWRET Manual. Divide the area of the wetland (not just the AA) by the approximate area of its catchment, **excluding** the area of the wetland itself. When doing the calculation, if ponded water adjoins the wetland, include that in the wetland's area. The result is:		
		<1%, or catchment size unknown due to stormwater pipes that collect water from an indeterminate area.	0	
		1-10%	0	
		10-100%	0	
		>100% (wetland is larger than its catchment (e.g., wetland is isolated by dikes with no input channels, is fed entirely by groundwater, or is a raised bog).	0	

Wetland Identifier		Legal Land Description:			
Name of Assessor:		Long/Lat (Decimal Degrees):			
Date:					
AA size:					

Data Form S (Stressors). ABWRET-A version 1.0 for the Boreal and Foothills Natural Regions of Alberta.

					Data
S1	Aberrant Hydrologic Regime				
	In the last column, place a check mark next to any item in the AA or its CA (contributing area) that is likely to have caused the ***timing, depth, or volume*** *of this AA's surface or subsurface water to fall outside the natural range of hydrologic conditions that is usual for this AA's wetland class.*				
	stormwater from impervious surfaces that drains directly to the wetland				
	water subsidies from wastewater effluent, septic system leakage, snow storage areas, or irrigation				
	regular removal of surface or groundwater for irrigation or other consumptive use				
	flow regulation in tributaries or water level regulation in adjoining water body, or other control structure at water entry points that regulates inflow to the wetland				
	a dam, dike, levee, weir, berm, or fill -- within or downgradient from the wetland -- that interferes with surface or subsurface flow in/out of the AA (e.g., road fill, wellpads, pipelines)				
	excavation within the wetland, e.g., dugout, artificial pond, dead-end ditch				
	artificial drains or ditches in or near the wetland				
	accelerated downcutting or channelization of an adjacent or internal channel (incised below the historical water table level)				
	logging within the wetland				
	subsidence or compaction of the wetland's substrate as a result of machinery, livestock, fire, drainage, or off road vehicles				
	straightening, ditching, dredging, and/or lining of tributary channels				
	If any items were checked above, then for each row of the table below, you may assign points. However, if you believe the checked items had ***no measurable effect*** *on the timing, depth, or volume in any part of the AA, then leave the "0's" for the scores in the following rows. To estimate effects, contrast the current condition with the condition if the checked items never occurred or were no longer present.*				
		Severe (3 pts)	Medium (2 points)	Mild (1 point)	
	Spatial extent of the change within the AA	>95% of wetland	5-95% of wetland	<5% of wetland	0
	When the change began	>3 yrs ago	3-9 yrs ago	10-100 yrs ago	0
	Score the following 2 rows only if the altered inputs began within past 10 years, and only for the part of the wetland that experiences those.				
	Input timing now vs. previously	shift of weeks, or became very flashy or controlled	intermediate	shift of hours or minutes, or became mildly flashy or controlled	0
	Water level increase or decrease	>30 cm	15-30 cm	<15 cm	0

S2	**Accelerated Inputs of Contaminants and/or Salts**				
	In the last column, place a check mark next to any item -- occurring in either the wetland or its CA -- that is likely to have accelerated the inputs of contaminants or salts to the AA.				
	stormwater or wastewater effluent (including failing septic systems), landfills, industrial facilities				
	road salt				
	metals & chemical wastes from mining, shooting ranges, snow storage areas, oil/ gas extraction, other sources				
	oil or chemical spills (not just chronic inputs) from nearby roads				
	artificial drainage or erosion of contaminated or saline soils				
	pesticides, as applied to lawns, croplands, roadsides, or other areas in the CA				
	If any items were checked above, then for each row of the table below, you may assign points. However, if you believe the checked items did not cumulatively expose the AA to significantly higher levels of contaminants and/or salts, then leave the "0's" for the scores in the following rows. To estimate effects, contrast the current condition with the condition if the checked items never occurred or were no longer present.				
		Severe (3 points)	Medium (2 points)	Mild (1 point)	
	Usual toxicity of most toxic contaminants	industrial effluent, metals mine, or AA is cropped (& sprayed) annually	crops in catchment but not in AA, fossil fuel extraction or pipeline, power station	mildly impacting (e.g., residential/ commercial)	0
	Frequency & duration of input	frequent and year-round	frequent but mostly seasonal	infrequent & during high runoff events mainly	0
	AA proximity to main sources (actual or potential)	0 - 15 m	15-100 m or in groundwater	in more distant part of contributing area	0

S3	**Accelerated Inputs of Nutrients**				
	In the last column, place a check mark next to any item -- occurring in either the wetland or its CA -- that is likely to have accelerated the inputs of nutrients to the wetland.				
	stormwater or wastewater effluent (including failing septic systems), landfills				
	fertilizers applied to lawns, ag lands, or other areas in the CA				
	livestock, dogs				
	artificial drainage of upslope lands				
	If any items were checked above, then for each row of the table below, you may assign points. However, if you believe the checked items did not cumulatively expose the AA to significantly more nutrients, then leave the "0's" for the scores in the following rows. To estimate effects, contrast the current condition with the condition if the checked items never occurred or were no longer present.				
		Severe (3 points)	Medium (2 points)	Mild (1 point)	
	Type of loading	high density of unmaintained septic, confined feedlot operation	moderate density septic, cropland, secondary wastewater treatment plant	livestock, pets, low density residential	0
	Frequency & duration of input	frequent and year-round	frequent but mostly seasonal	infrequent & during high runoff events mainly	0
	AA proximity to main sources (actual or potential)	0 - 15 m	15-100 m	in more distant part of contributing area	0

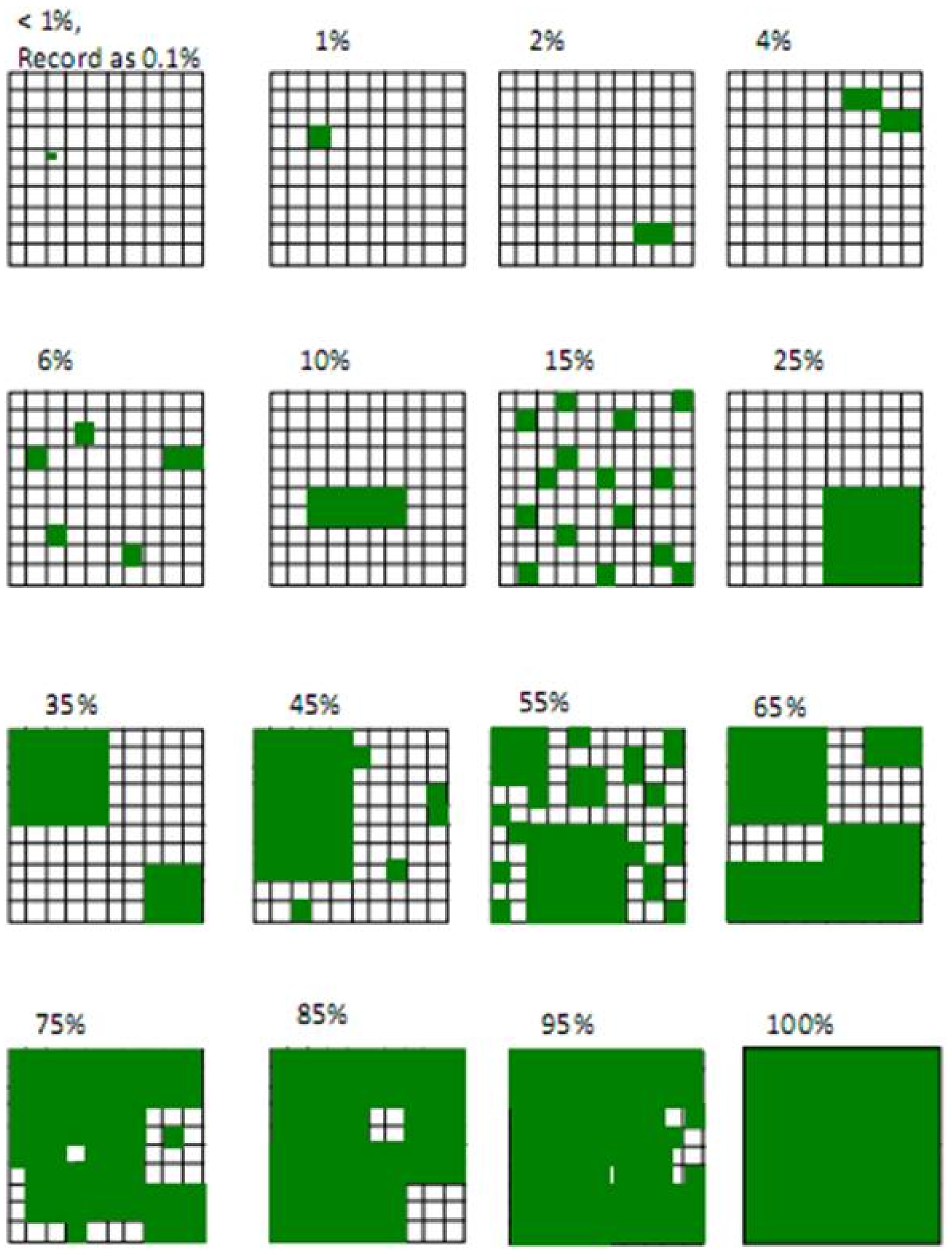
S4	**Excessive Sediment Loading *from Contributing Area***				
	In the last column, place a check mark next to any item present in the CA that is likely to have elevated the load of waterborne or windborne sediment reaching the wetland from its CA.				
	erosion from plowed fields, fill, timber harvest, dirt roads, vegetation clearing, fires				
	erosion from construction, in-channel machinery in the CA				
	erosion from off-road vehicles in the CA				
	erosion from livestock or foot traffic in the CA				
	stormwater or wastewater effluent				
	sediment from road sanding, gravel mining, other mining, oil/ gas extraction				
	accelerated channel downcutting or headcutting of tributaries due to altered land use				
	other human-related disturbances within the CA				
	If any items were checked above, then for each row of the table below, you may assign points (3, 2, or 1 as shown in header) in the last column. However, if you believe the checked items did not cumulatively add significantly more sediment or suspended solids to the AA, then leave the "0's" for the scores in the following rows. To estimate effects, contrast the current condition with the condition if the checked items never occurred or were no longer present.				
		Severe (3 points)	Medium (2 points)	Mild (1 point)	
	Erosion in CA	extensive evidence, high intensity*	potentially (based on high-intensity* land use) or scattered evidence	potentially (based on low-intensity* land use) with little or no direct evidence	0
	Recentness of significant soil disturbance in the CA	current & ongoing	1-12 months ago	>1 yr ago	0
	Duration of sediment inputs to the wetland	frequent and year-round	frequent but mostly seasonal	infrequent & during high runoff events mainly	0
	AA proximity to actual or potential sources	0 - 15 m, or farther but on steep erodible slopes	15-100 m	in more distant part of contributing area	0
	* **high**-intensity= extensive off-road vehicle use, plowing, grading, excavation, erosion with or without veg removal; **low**-intensity= veg removal only with little or no apparent erosion or disturbance of soil or sediment				

S5	**Soil or Sediment Alteration *Within the Assessment Area***				
	In the last column, place a check mark next to any item present in the wetland that is likely to have compacted, eroded, or otherwise altered the wetland's soil. If the AA is a created or restored wetland or pond, exclude those actions.				
	compaction from machinery, off-road vehicles, mountain bikes, or livestock, especially during wetter periods				
	leveling or other grading not to the natural contour				
	tillage, plowing (but excluding disking for enhancement of native plants)				
	fill or riprap, excluding small amounts of upland soils containing organic amendments (compost, etc.) or small amounts of topsoil imported from another wetland				
	excavation				
	ditch cleaning or dredging in or adjacent to the wetland				
	boat traffic in or adjacent to the wetland and sufficient to cause shore erosion or stir bottom sediments				
	artificial water level or flow manipulations sufficient to cause erosion or stir bottom sediments				
	If any items were checked above, then for each row of the table below, you may assign points. However, if you believe the checked items did not measurably alter the soil structure and/or topography, then leave the "0's" for the scores in the following rows. To estimate effects, contrast the current condition with the condition if the checked items never occurred or were no longer present.				
		Severe (3 points)	Medium (2 points)	Mild (1 point)	
	Spatial extent of altered soil	>95% of wetland or >95% of its upland edge (if any)	5-95% of wetland or 5-95% of its upland edge (if any)	<5% of wetland and <5% of its upland edge (if any)	0
	Recentness of significant soil alteration in wetland	current & ongoing	1-12 months ago	>1 yr ago	0
	Duration	long-lasting, minimal veg recovery	long-lasting but mostly revegetated	short-term, revegetated, not intense	0
	Timing of soil alteration	frequent and year-round	frequent but mostly seasonal	infrequent & mainly during scattered or one-time events	0

A.2 Explanatory Illustrations

These are keyed to questions on Form F which preceded.

Question F16 (Herbaceous – Percent of Vegetated Wetland) and others. Visually estimating percentage of a cover type (or hydrologic zones) within a polygon (from USEPA 2011). *Imagine the wetland as a square. "Squeeze together" all the patches of a type into one corner. Then estimate that as a percent of the wetland.*

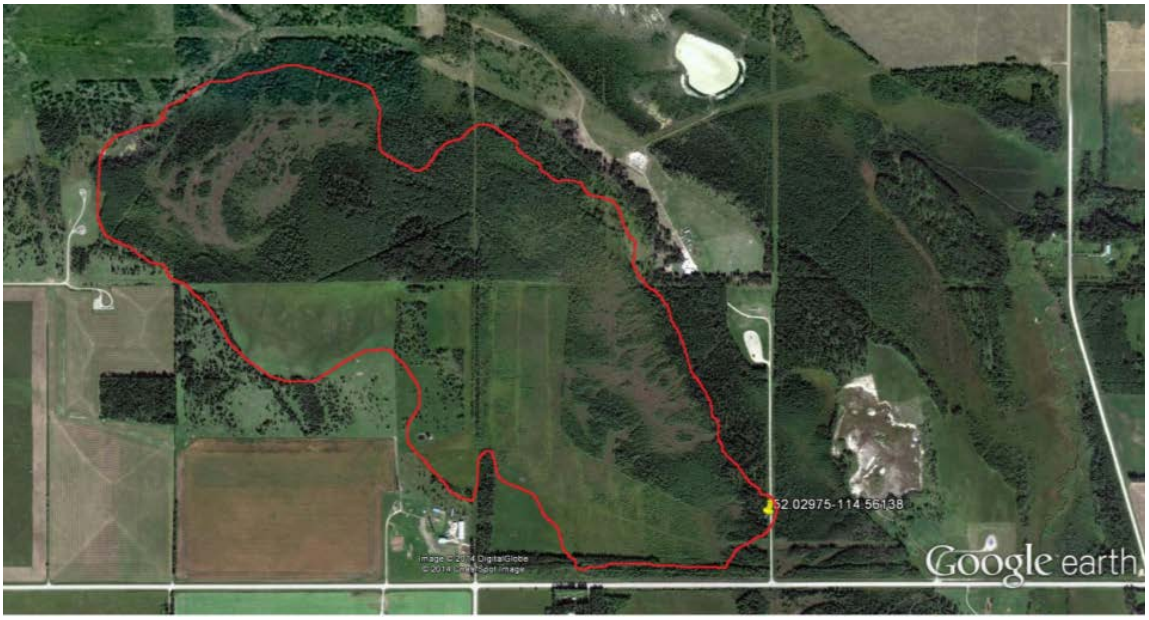


Question F5 (Interspersion Tall and Short Vegetation).

The red-outlined wetland below has >30% tall woody vegetation intermixed with shorter herbaceous vegetation, which is lighter green in colour and has flatter visual texture.

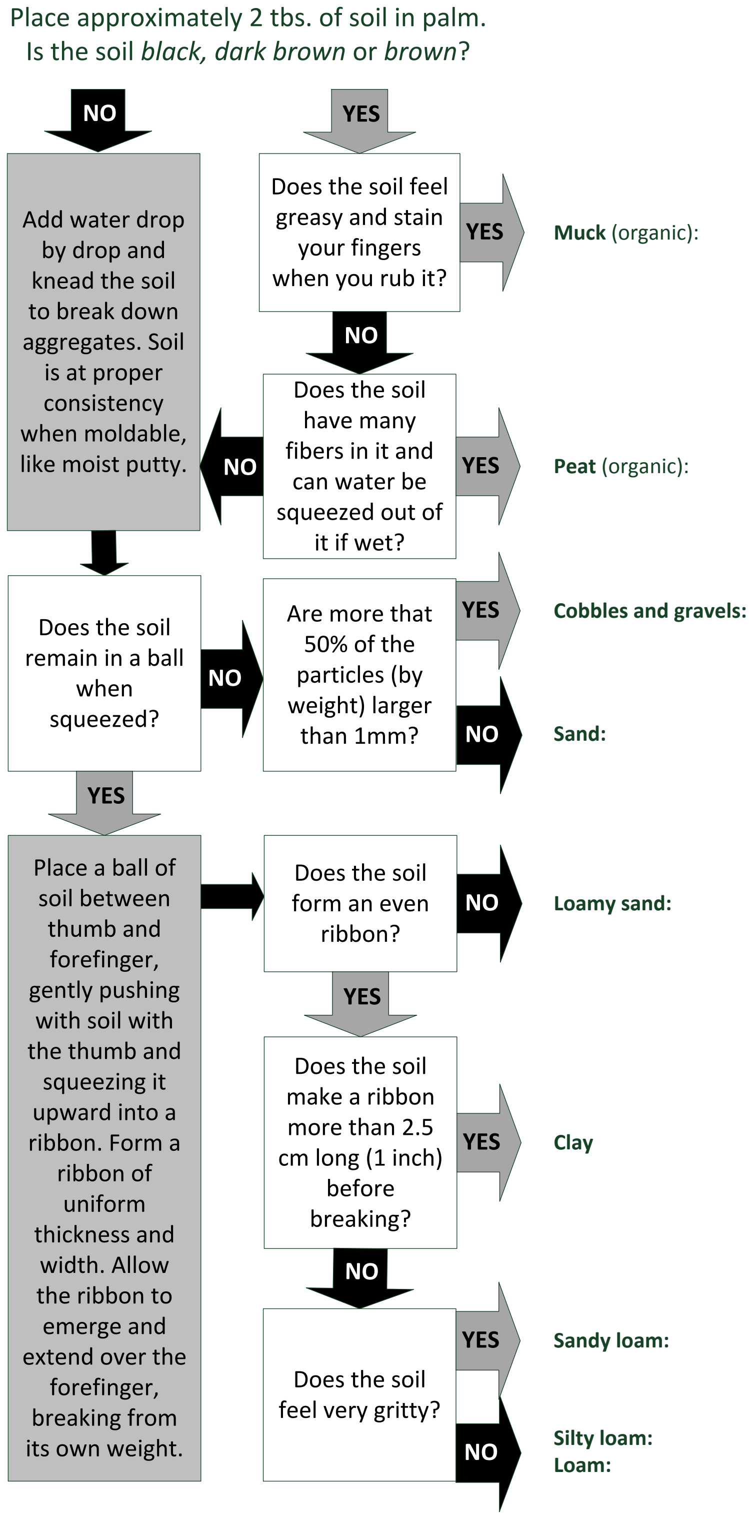
The red-outlined wetland below is almost 100% tall woody vegetation with few or no gaps of shorter herbaceous vegetation. The presence of deepwater ponds within the wetland should be ignored in this question.

The red-outlined wetland has about an equal mix of taller woody (darker-shaded) and shorter herbaceous vegetation, but they are not well-interspersed. Most of the tall woody vegetation is in one patch and likewise with the shorter herbaceous.



In the wetland below, neither tall woody vegetation nor short herbaceous vegetation comprise >70% of the wetland, and they are well interspersed.

Question F15. *The procedure in the diagram below should be used to help diagnose the soil texture. However, you need only determine if the soil is Loam (including Sandy Loam, Silty Loam), Coarse (including Loamy Sand, Sand, Cobbles & Gravels), Organic (Peat or Muck), or Fines (Clay).*

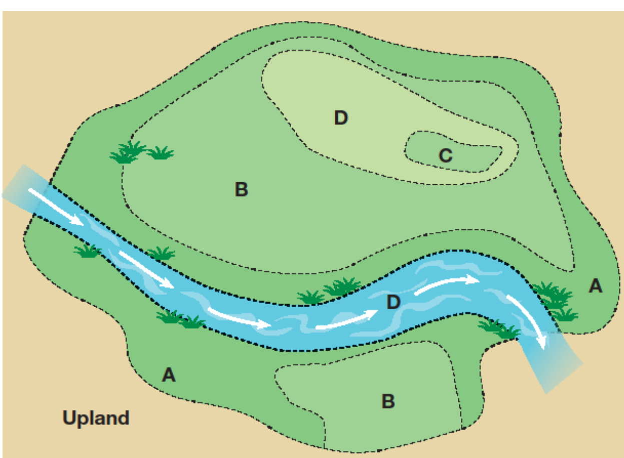


Flow Chart for Identifying Soil Texrture (from: Washington Dept. of Ecology 2004)

F19. Sedge Cover. *Sedges usually have sharp edges (but so do some other grasslike plants). Note the large brownish or greenish fruit, usually located partway up the stem or near the tip.*

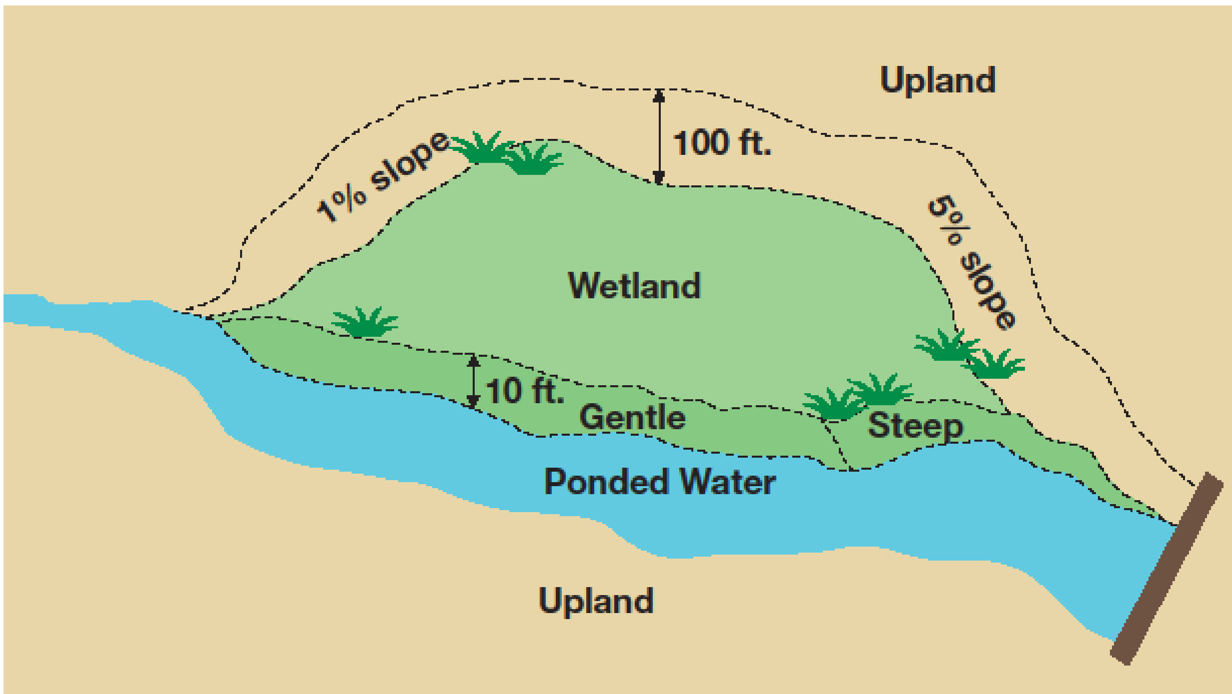
F30	Depth Class – Evenness of Proportions	Within the area described above, and during most of the time when surface water is present, it usually is comprised of: (select one):
		One depth class that comprises >90% of the AA's inundated area (use the classes in the question above).
		One depth class that comprises 51-90% of the AA's inundated area.
		Multiple depth classes and none occupy more than 50% of the AA.

In this diagram, assuming all the vegetation (green) is inundated; the two areas in depth class B together comprise more than 50% of the wetland, so the second choice is correct. Numeric ranges that define the depth classes are given in question F30. Wetland size, shape, surrounding topography, and vegetation should be used to estimate the depth classes that possibly are present.



F35	Flat Shoreline Extent	During most of the part of the growing season when water is present, the percentage of the AA's water edge length that is **nearly flat** (a slope less than about 5% measured within 5 m landward) is:
		<1% of the shoreline length (true for many excavated ponds).
		1-25% of the shoreline length
		25-50% of the shoreline length
		50-75% of the shoreline length
		>75% of the shoreline length
		not applicable because no open water patch occupies >0.1 hectare of the AA during an average June.

*In this diagram, **50-75%** of the area within 3 m (10 ft.) of surface water (in this case ponded water) is classified as having a gentle (less than 2%) slope.*



A.3 Plant Species Tentatively Identified as Indicative of Wetlands in Alberta or Adjoining Parts of the United States

In last column, "IF DOM" means indicative of wetland conditions only if a dominant part of the vegetation in an area. AEP= Alberta Environment and Parks. B=bog, F= fen, M= marsh, S= swamp.

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Tree	*Abies balsamea*	Balsam Fir		US	IF DOM
Tree	*Acer glabrum*	Rocky Mountain Maple		US	IF DOM
Tree	*Acer negundo*	Ash-leaf Maple		US	IF DOM
Tree	*Betula neoalaskana*	Alaska birch	S	AEP	IF DOM
Tree	*Betula papyrifera*	white birch	S	AEP	IF DOM
Tree	*Fraxinus pennsylvanica*	Green Ash		US	IF DOM
Tree	*Larix laricina*	tamarack	F, S	AEP	
Tree	*Picea engelmannii*	Engelmann's Spruce		US	IF DOM
Tree	*Picea mariana*	black spruce	B, F, S	AEP	
Tree	*Picea pungens*	Blue Spruce		US	IF DOM
Tree	*Pinus contorta*	Lodgepole pine		US	IF DOM
Tree	*Populus angustifolia*	narrow-leaf cottonwood	S	AEP	
Tree	*Populus balsamifera*	balsam poplar	S	AEP	
Tree	*Populus deltoides*	plains cottonwood	S	AEP	IF DOM
Tree	*Populus tremuloides*	Quaking Aspen		US	IF DOM
Shrub	*Alnus incana* ssp. tenuifolia	river alder	S	AEP	
Shrub	*Alnus viridis*	green alder	S	AEP	IF DOM
Shrub	*Andromeda polifolia*	bog rosemary	B, F, S	AEP	
Shrub	*Arctostaphylos rubra*	Red Fruit Bearberry		US	IF DOM
Shrub	*Betula glandulosa*	bog birch	F	AEP	
Shrub	*Betula occidentalis*	water birch	F, S	AEP	
Shrub	*Betula pumila*	dwarf birch	B, F, S	AEP	
Shrub	*Chamaedaphne calyculata*	leatherleaf	B, F	AEP	
Shrub	*Cornus sericea*	red-osier dogwood	S	AEP	
Shrub	*Crataegus douglasii*	Black Hawthorn		US	IF DOM
Shrub	*Elaeagnus commutata*	silverberry	S	AEP	NO
Shrub	*Empetrum nigrum*	crowberry	B, F	AEP	IF DOM
Shrub	*Gaultheria hispidula*	creeping snowberry	B, F, S	AEP	
Shrub	*Kalmia microphylla*	mountain laurel	B, F	AEP	IF DOM
Shrub	*Kalmia polifolia*	northern laurel	B, F, S	AEP	
Shrub	*Ledum groenlandicum*	Rusty Labrador-Tea		US	YES
Shrub	*Ledum palustre*	Marsh Labrador Tea		US	YES
Shrub	*Linnaea borealis*	twinflower	B, F, S	AEP	NO

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Shrub	*Lonicera caerulea*	fly honeysuckle	B, F, S	AEP	IF DOM
Shrub	*Lonicera dioica*	twining honeysuckle	S	AEP	
Shrub	*Lonicera involucrata*	bracted honeysuckle	F, S	AEP	IF DOM
Shrub	*Myrica gale*	sweet gale	F, S	AEP	
Shrub	*Oplopanax horridus*	Devil's club		US	IF DOM
Shrub	*Prunus virginiana*	choke cherry	S	AEP	NO
Shrub	*Rhamnus alnifolia*	alder-leaved buckthorn	F, S	AEP	
Shrub	*Rhododendron albiflorum*	Cascade Azalea		US	YES
Shrub	*Rhododendron groenlandicum*	common Labrador tea	B, F, S	AEP	IF DOM
Shrub	*Rhododendron tomentosum*	northern Labrador tea	B	AEP	
Shrub	*Ribes americanum*	wild black currant	S	AEP	
Shrub	*Ribes glandulosum*	skunk currant	S	AEP	
Shrub	*Ribes hirtellum*	Hairy-Stem Gooseberry		US	IF DOM
Shrub	*Ribes hudsonianum*	northern black currant	F, S	AEP	
Shrub	*Ribes inerme*	White-Stem Gooseberry		US	YES
Shrub	*Ribes lacustre*	bristly black currant	F, S	AEP	
Shrub	*Ribes triste*	wild red currant	F, S	AEP	
Shrub	*Rubus idaeus*	wild red raspberry	B, F, S	AEP	NO
Shrub	*Salix amygdaloides*	Peach-Leaf Willow		US	YES
Shrub	*Salix arbusculoides*	shrubby willow	F, S	AEP	
Shrub	*Salix athabascensis*	Athabasca Willow		US	YES
Shrub	*Salix barclayi*	Barclay's Willow		US	YES
Shrub	*Salix bebbiana*	beaked willow	F, S	AEP	
Shrub	*Salix boothii*			US	YES
Shrub	*Salix brachycarpa*			US	YES
Shrub	*Salix candida*	hoary willow	F, S	AEP	
Shrub	*Salix commutata*	Undergreen Willow		US	YES
Shrub	*Salix discolour*	pussy willow	F, S	AEP	
Shrub	*Salix drummondiana*	Drummond's Willow		US	YES
Shrub	*Salix exigua*	sandbar willow	F, S	AEP	
Shrub	*Salix famelica*			US	YES
Shrub	*Salix farriae*	Farr's Willow		US	YES
Shrub	*Salix glauca*	smooth willow	F, S	AEP	
Shrub	*Salix interior*			US	YES
Shrub	*Salix lasiandra*			US	YES
Shrub	*Salix lucida*	shiny willow	F, S	AEP	
Shrub	*Salix lutea*	Yellow Willow		US	YES
Shrub	*Salix maccalliana*	velvet-fruited willow	F, S	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Shrub	*Salix melanopsis*	Dusky Willow		US	YES
Shrub	*Salix myrtillifolia*	Blueberry Willow		US	YES
Shrub	*Salix pedicellaris*	bog willow	F, S	AEP	
Shrub	*Salix petiolaris*	basket willow	F	AEP	
Shrub	*Salix planifolia*	flat-leaved willow	F, S	AEP	
Shrub	*Salix prolixa*	Mackenzie's Willow		US	YES
Shrub	*Salix pseudomonticola*	False Mountain Willow		US	YES
Shrub	*Salix pseudomyrsinites*	Firmleaf Willow		US	YES
Shrub	*Salix pyrifolia*	balsam willow	F, S	AEP	
Shrub	*Salix scouleriana*	Scouler willow	F, S	AEP	IF DOM
Shrub	*Salix serissima*	autumn willow	F	AEP	
Shrub	*Salix sitchensis*	Sitka Willow		US	YES
Shrub	*Sambucus racemosa*	red elderberry	S	AEP	NO
Shrub	*Sarcobatus vermiculatus*	greasewood	M	AEP	IF DOM
Shrub	*Sorbus sitchensis*	Sitka Mountain-Ash		US	IF DOM
Shrub	*Spiraea alba*	narrow-leaved meadowsweet	F, S	AEP	
Shrub	*Tamarix aphylla*	Athel Tamarisk		US	YES
Shrub	*Tamarix chinensis*	Five-Stamen Tamarisk		US	YES
Shrub	*Tamarix gallica*	French Tamarisk		US	YES
Shrub	*Tamarix parviflora*	Small-Flower Tamarisk		US	YES
Shrub	*Vaccinium caespitosum*	Dwarf Blueberry		US	IF DOM
Shrub	*Vaccinium myrtilloides*	Velvet-Leaf Blueberry		US	YES
Shrub	*Vaccinium oxycoccos*	small bog cranberry	B, F, S	AEP	
Shrub	*Vaccinium uliginosum*	Alpine Blueberry		US	IF DOM
Shrub	*Vaccinium vitis-idaea*	bog cranberry	B, F, M, S	AEP	IF DOM
Shrub	*Viburnum edule*	low-bush cranberry	S	AEP	
Shrub	*Viburnum opulus* var. americanum	high bush-cranberry	F, S	AEP	IF DOM
Moss/Liverwort	*Amblystegium serpens*	moss	F, S	AEP	
Moss/Liverwort	*Aneura pinguis*	liverwort	F, S	AEP	
Moss/Liverwort	*Anomodon minor*	moss	F	AEP	
Moss/Liverwort	*Aulacomnium palustre*	tufted moss	B, F, S	AEP	
Moss/Liverwort	*Blepharostoma trichophyllum*	liverwort	F, S	AEP	
Moss/Liverwort	*Brachythecium campestre*	moss	B, F	AEP	
Moss/Liverwort	*Brachythecium mildeanum*	moss	F	AEP	
Moss/Liverwort	*Brachythecium turgidum*	moss	B, F, S	AEP	
Moss/Liverwort	*Bryum pseudotriquetrum*	moss	B, F, S	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Moss/Liverwort	*Calliergon cordifolium*	moss	F	AEP	
Moss/Liverwort	*Calliergon giganteum*	giant calliergon moss	F	AEP	
Moss/Liverwort	*Calliergon richardsonii*	brown moss	F, S	AEP	
Moss/Liverwort	*Calliergon stramineum*	brown moss	F, S	AEP	
Moss/Liverwort	*Calliergon trifarium*	moss	F	AEP	
Moss/Liverwort	*Calliergonella cuspidata*	moss	F	AEP	
Moss/Liverwort	*Calypogeia sphagnicola*	liverwort	F, S	AEP	
Moss/Liverwort	*Campylium chrysophyllum*	moss	F, S	AEP	
Moss/Liverwort	*Campylium polygamum*	moss	F	AEP	
Moss/Liverwort	*Campylium stellatum*	yellow starry fen moss	F	AEP	
Moss/Liverwort	*Cephalozia connivens*	liverwort	B, F, S	AEP	
Moss/Liverwort	*Cephalozia lunulifolia*	liverwort	F	AEP	
Moss/Liverwort	*Cephalozia pleniceps*	liverwort	F	AEP	
Moss/Liverwort	*Ceratodon purpureus*	purple horn-toothed moss	F, S	AEP	
Moss/Liverwort	*Cinclidium stygium*	moss	B, F, S	AEP	
Moss/Liverwort	*Climacium dendroides*	moss	F, S	AEP	
Moss/Liverwort	*Dicranum fragilifolium*	cushion moss	B, F	AEP	
Moss/Liverwort	*Distichium capillaceum*	moss	S	AEP	
Moss/Liverwort	*Distichium inclinatum*	inclined-fruited didymodon	F, S	AEP	
Moss/Liverwort	*Drepanocladus aduncus*	aduncus brown moss	F, M, S	AEP	
Moss/Liverwort	*Drepanocladus sendtneri*	brown moss	F	AEP	
Moss/Liverwort	*Eurhynchium pulchellum*	moss	B	AEP	
Moss/Liverwort	*Geocalyx graveolens*	liverwort	F, S	AEP	
Moss/Liverwort	*Hamatocaulis lapponicus*	hamatocaulis moss	F	AEP	
Moss/Liverwort	*Hamatocaulis vernicosus*	hamatocaulis brown moss	F	AEP	
Moss/Liverwort	*Helodium blandowii*	Blandow's feathermoss	B, F, S	AEP	
Moss/Liverwort	*Hylocomium splendens*	stair-step moss	B, F, S	AEP	
Moss/Liverwort	*Hypnum lindbergii*	moss	B, F	AEP	
Moss/Liverwort	*Hypnum pallescens*	moss	B, F, S	AEP	
Moss/Liverwort	*Hypnum pratense*	moss	F, S	AEP	
Moss/Liverwort	*Isopterygium pulchellum*	moss	B, S	AEP	
Moss/Liverwort	*Jamesoniella autumnalis*	liverwort	B, F, S	AEP	
Moss/Liverwort	*Lepidozia reptans*	liverwort	B, F, S	AEP	
Moss/Liverwort	*Leptobryum pyriforme*	moss	B, F, S	AEP	
Moss/Liverwort	*Leptodictyum riparium*	streamside leptodictyum moss	F, S	AEP	
Moss/Liverwort	*Limprichtia revolvens*	limprichtia brown moss	F	AEP	
Moss/Liverwort	*Lophocolea heterophylla*	liverwort	F, S	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Moss/Liverwort	*Lophocolea minor*	liverwort	F	AEP	
Moss/Liverwort	*Lophozia grandiretis*	liverwort	B	AEP	
Moss/Liverwort	*Lophozia guttulata*	liverwort	B, F	AEP	
Moss/Liverwort	*Lophozia rutheana*	liverwort	B, F	AEP	
Moss/Liverwort	*Lophozia ventricosa*	liverwort	B, F	AEP	
Moss/Liverwort	*Marchantia polymorpha*	green tongue liverwort	B, F, M, S	AEP	
Moss/Liverwort	*Meesia triquetra*	three-angled thread-moss	F, S	AEP	
Moss/Liverwort	*Meesia uliginosa*	moss	F, S	AEP	
Moss/Liverwort	*Moerckia hibernica*	liverwort	B, F	AEP	
Moss/Liverwort	*Mylia anomala*	liverwort	B, F, S	AEP	
Moss/Liverwort	*Myurella julacea*	moss	F, S	AEP	
Moss/Liverwort	*Oncophorus wahlenbergii*	mountain curved-back moss	F, S	AEP	
Moss/Liverwort	*Orthotrichum speciosum*	moss	F, S	AEP	
Moss/Liverwort	*Paludella squarrosa*	moss	F	AEP	
Moss/Liverwort	*Pellia endiviifolia*	liverwort	S	AEP	
Moss/Liverwort	*Plagiochila asplenioides*	liverwort	B, F, S	AEP	
Moss/Liverwort	*Plagiochila porelloides*	liverwort	F	AEP	
Moss/Liverwort	*Plagiomnium cuspidatum*	moss	F, S	AEP	
Moss/Liverwort	*Plagiomnium ellipticum*	moss	B, F, S	AEP	
Moss/Liverwort	*Plagiomnium medium*	moss	B, F, S	AEP	
Moss/Liverwort	*Pleurozium schreberi*	Schreber's moss	B, F, S	AEP	
Moss/Liverwort	*Pohlia nutans*	copper wire moss	B, F, S	AEP	
Moss/Liverwort	*Polytrichum commune*	common hair-cap	B, F, S	AEP	
Moss/Liverwort	*Polytrichum strictum*	slender haircap-moss	B, F, S	AEP	
Moss/Liverwort	*Porella platyphylla*	liverwort	S, B	AEP	
Moss/Liverwort	*Pseudobryum cinclidioides*	moss	B, F, S	AEP	
Moss/Liverwort	*Ptilidium ciliare*	liverwort	B, F, S	AEP	
Moss/Liverwort	*Ptilidium pulcherrimum*	liverwort	B, F, S	AEP	
Moss/Liverwort	*Ptilium crista-castrensis*	knight's plume moss	B, F, S	AEP	
Moss/Liverwort	*Pylaisiella polyantha*	moss	F, S	AEP	
Moss/Liverwort	*Radula complanata*	liverwort	F, M, S	AEP	
Moss/Liverwort	*Rhizomnium gracile*	fringed bog moss	F, S	AEP	
Moss/Liverwort	*Rhizomnium pseudopunctatum*	moss	B, F, S	AEP	
Moss/Liverwort	*Rhytidiadelphus triquetrus*	red-stemmed pipecleaner moss	F, S	AEP	
Moss/Liverwort	*Riccardia multifida*	liverwort	S	AEP	
Moss/Liverwort	*Riccia fluitans*	crystalwort	M, W	AEP	
Moss/Liverwort	*Ricciocarpos natans*	purple-fringed	F, M, W	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
		heartwort			
Moss/Liverwort	*Sanionia uncinata* var. uncinata	hook moss	F	AEP	
Moss/Liverwort	*Scapania paludosa*	liverwort	B	AEP	
Moss/Liverwort	*Scorpidium scorpioides*	scorpidium moss	F	AEP	
Moss/Liverwort	*Scorpidium turgescens*	moss	F	AEP	
Moss/Liverwort	*Sphagnum angustifolium*	poor-fen sphagnum; peat moss	B, F, S	AEP	
Moss/Liverwort	*Sphagnum balticum*	balticum peat moss	B, F	AEP	
Moss/Liverwort	*Sphagnum capillifolium*	acute-leaved peat moss	B, F, S	AEP	
Moss/Liverwort	*Sphagnum centrale*	peat moss	B, F	AEP	
Moss/Liverwort	*Sphagnum contortum*	twisted bog moss	B, F	AEP	
Moss/Liverwort	*Sphagnum fallax*	peat moss	B, F	AEP	
Moss/Liverwort	*Sphagnum fimbriatum*	shore-growing peat moss	B, F	AEP	
Moss/Liverwort	*Sphagnum fuscum*	rusty peat moss	B, F, S	AEP	
Moss/Liverwort	*Sphagnum girgensohnii*	Girgensohn's moss	B, F, S	AEP	
Moss/Liverwort	*Sphagnum jensenii*	pendant branch peat moss	B, F	AEP	
Moss/Liverwort	*Sphagnum lindbergii*	Lindberg's bog moss	B, F	AEP	
Moss/Liverwort	*Sphagnum magellanicum*	midway peat moss	B, F	AEP	
Moss/Liverwort	*Sphagnum majus*	peat moss	F	AEP	
Moss/Liverwort	*Sphagnum obtusum*	blunt-leaved peat moss	B, F	AEP	
Moss/Liverwort	*Sphagnum riparium*	shore-growing peat moss	F	AEP	
Moss/Liverwort	*Sphagnum russowii*	wide-tongued peat moss	F	AEP	
Moss/Liverwort	*Sphagnum squarrosum*	squarrose peat moss	F, S	AEP	
Moss/Liverwort	*Sphagnum subsecundum*	twisted bog moss	B, F	AEP	
Moss/Liverwort	*Sphagnum teres*	thin-leaved peat moss	F	AEP	
Moss/Liverwort	*Sphagnum warnstorfii*	Warnstorf's sphagnum	F, S	AEP	
Moss/Liverwort	*Splachnum ampullaceum*	flagon-fruited splachnum	B	AEP	
Moss/Liverwort	*Splachnum rubrum*	red collar moss	B	AEP	
Moss/Liverwort	*Splachnum sphaericum*	globe-fruited splachnum	B	AEP	
Moss/Liverwort	*Splachnum vasculosum*	large-fruited splachnum	B	AEP	
Moss/Liverwort	*Tetraphis pellucida*	moss	B, F, S	AEP	
Moss/Liverwort	*Tetraplodon angustatus*	narrow-leaved splachnum	B, F, S	AEP	
Moss/Liverwort	*Thuidium recognitum*	moss	B, F, S	AEP	
Moss/Liverwort	*Tomentypnum falcifolium*	golden moss	B, F	AEP	
Moss/Liverwort	*Tomentypnum nitens*	golden moss	F	AEP	
Moss/Liverwort	*Warnstorfia exannulata*	Brown moss	B, F, S	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Moss/Liverwort	*Warnstorfia fluitans*	warnstorfia peat moss	B, F, S	AEP	
Moss/Liverwort	*Warnstorfiia tundrae*	moss	F	AEP	
Graminoid	*Achnatherum nelsonii*	Nelson's Rice Grass		US	IF DOM
Graminoid	*Acorus americanus*	sweet flag	M	AEP	
Graminoid	*Agropyron cristatum*	Crested Wheatgrass		US	IF DOM
Graminoid	*Agropyron fragile*	Siberian Wheatgrass		US	IF DOM
Graminoid	*Agrostis exarata*	Spiked Bent		US	YES
Graminoid	*Agrostis scabra*	rough hair grass	F, M, S	AEP	IF DOM
Graminoid	*Agrostis stolonifera*	redtop	M, S	AEP	
Graminoid	*Alopecurus aequalis*	short-awned foxtail	M	AEP	
Graminoid	*Alopecurus arundinaceus*	Creeping Meadow-Foxtail		US	YES
Graminoid	*Alopecurus carolinianus*	Tufted Meadow-Foxtail		US	YES
Graminoid	*Alopecurus geniculatus*	Marsh Meadow-Foxtail		US	YES
Graminoid	*Alopecurus pratensis*	meadow foxtail	M, S	AEP	
Graminoid	*Amphiscirpus nevadensis*	Nevada bulrush	M	AEP	
Graminoid	*Anthoxanthum hirtum*			US	YES
Graminoid	*Beckmannia syzigachne*	sloughgrass	M	AEP	
Graminoid	*Bolboschoenus maritimus* ssp. paludosus	prairie bulrush	M	AEP	
Graminoid	*Bromus ciliatus*	fringed brome	F, M, S	AEP	IF DOM
Graminoid	*Bromus inermis*	smooth brome	M	AEP	NO
Graminoid	*Bromus latiglumis*	Early-Leaf Brome		US	YES
Graminoid	*Butomus umbellatus*	Flowering-Rush		US	YES
Graminoid	*Calamagrostis canadensis*	bluejoint	F, M, S	AEP	
Graminoid	*Calamagrostis stricta* ssp. inexpansa	northern reed grass	F, M, S	AEP	
Graminoid	*Carex albonigra*	Black-and-White-Scale Sedge		US	IF DOM
Graminoid	*Carex aperta*	Columbian Sedge		US	YES
Graminoid	*Carex aquatilis*	water sedge	F, M, S	AEP	
Graminoid	*Carex arcta*	Northern Cluster Sedge		US	YES
Graminoid	*Carex atherodes*	awned sedge	F, M	AEP	
Graminoid	*Carex athrostachya*	Slender-Beak Sedge		US	YES
Graminoid	*Carex atratiformis*			US	YES
Graminoid	*Carex atrosquama*			US	IF DOM
Graminoid	*Carex aurea*	golden sedge	B, F, M, S	AEP	
Graminoid	*Carex bebbii*	Bebb’s sedge	F, M, S	AEP	
Graminoid	*Carex brevior*	slender-beaked sedge	B, F, M	AEP	IF DOM
Graminoid	*Carex brunnescens*	brownish sedge	B, F, M, S	AEP	IF DOM
Graminoid	*Carex buxbaumii*	brown sedge	F, M	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Graminoid	*Carex canescens*	hoary sedge	B, F, M, S	AEP	
Graminoid	*Carex capillaris*	hairlike sedge	B, F, M, S	AEP	
Graminoid	*Carex capitata*	Capitate Sedge		US	YES
Graminoid	*Carex chordorrhiza*	prostrate sedge	B, F, M, S	AEP	
Graminoid	*Carex concinna*			US	IF DOM
Graminoid	*Carex crawei*	Crawe's Sedge		US	YES
Graminoid	*Carex crawfordii*	Crawford's sedge	M	AEP	
Graminoid	*Carex deweyana*	two-stamened sedge	F, M, S	AEP	NO
Graminoid	*Carex diandra*	soft-leaf sedge	B, F, S	AEP	
Graminoid	*Carex disperma*	Dewey's sedge	S	AEP	
Graminoid	*Carex douglasii*	Douglas' Sedge		US	YES
Graminoid	*Carex echinata*	Star Sedge		US	YES
Graminoid	*Carex flava*	Yellow-Green Sedge		US	YES
Graminoid	*Carex garberi*	Elk Sedge		US	YES
Graminoid	*Carex gynocrates*	northern bog sedge	B, F, M, S	AEP	
Graminoid	*Carex heleonastes*	Hudson Bay sedge	B, F, M, S	AEP	
Graminoid	*Carex heteroneura*	Different-Nerve Sedge		US	YES
Graminoid	*Carex hystericina*	Porcupine Sedge		US	YES
Graminoid	*Carex illota*	Small-Head Sedge		US	YES
Graminoid	*Carex incurviformis*	Coastal-Sand Sedge		US	IF DOM
Graminoid	*Carex infirminervia*	Weak-Nerved Sedge		US	IF DOM
Graminoid	*Carex interior*	inland sedge	F, M, S	AEP	
Graminoid	*Carex lachenalii*	Arctic Hare-Foot Sedge		US	YES
Graminoid	*Carex lacustris*	lakeshore sedge	F, M, S	AEP	
Graminoid	*Carex lasiocarpa*	hairy-fruited sedge	B, F, M, S	AEP	
Graminoid	*Carex lenticularis*	Lakeshore Sedge		US	YES
Graminoid	*Carex leptalea*	bristle-stalked sedge	B, F, S	AEP	
Graminoid	*Carex limosa*	mud sedge	F, M, S	AEP	
Graminoid	*Carex livida*	livid sedge	B, M, F	AEP	
Graminoid	*Carex loliacea*	rye-grass sedge	M	AEP	
Graminoid	*Carex macloviana*	Falkland Island Sedge		US	YES
Graminoid	*Carex magellanica* ssp. irrigua	bog sedge	B, F, M	AEP	
Graminoid	*Carex maritima*			US	IF DOM
Graminoid	*Carex media*			US	YES
Graminoid	*Carex mertensii*	Mertens' Sedge		US	IF DOM
Graminoid	*Carex microglochin*	False Uncinia Sedge		US	YES
Graminoid	*Carex microptera*	Small-Wing Sedge		US	IF DOM
Graminoid	*Carex nebrascensis*	Nebraska Sedge		US	YES
Graminoid	*Carex nigricans*	Black Alpine Sedge		US	YES

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Graminoid	*Carex norvegica*	Norway Sedge		US	YES
Graminoid	*Carex oligosperma*	few-fruited sedge	B, M, F	AEP	
Graminoid	*Carex pachystachya*	Thick-Head Sedge		US	IF DOM
Graminoid	*Carex parryana*			US	YES
Graminoid	*Carex pauciflora*	few-flowered sedge	B, F, M, S	AEP	
Graminoid	*Carex peckii*	Peck's Sedge		US	YES
Graminoid	*Carex pedunculata*	Long-Stalk Sedge		US	YES
Graminoid	*Carex pellita*	woolly sedge	M	AEP	
Graminoid	*Carex podocarpa*	Short-Stalk Sedge		US	IF DOM
Graminoid	*Carex praegracilis*	graceful sedge	F, M	AEP	
Graminoid	*Carex prairea*	prairie sedge	F, M, S	AEP	
Graminoid	*Carex praticola*	meadow sedge	M, S	AEP	IF DOM
Graminoid	*Carex pseudocyperus*	cyperus-like sedge	B, F	AEP	
Graminoid	*Carex raymondii*	Raymond's Sedge		US	YES
Graminoid	*Carex retrorsa*	turned sedge	F, M	AEP	
Graminoid	*Carex richardsonii*	Richardson's Sedge		US	IF DOM
Graminoid	*Carex rostrata*	beaked sedge	F, S	AEP	
Graminoid	*Carex sartwellii*	Sartwell sedge	M	AEP	
Graminoid	*Carex saxatilis*	rocky-ground sedge	M	AEP	
Graminoid	*Carex scoparia*	Pointed Broom Sedge		US	YES
Graminoid	*Carex scopulorum*	Holm's Rocky Mountain Sedge		US	YES
Graminoid	*Carex siccata*	Dry-Spike Sedge		US	YES
Graminoid	*Carex simulata*	Analogue Sedge		US	YES
Graminoid	*Carex spectabilis*	Northwestern Showy Sedge		US	YES
Graminoid	*Carex stipata*	awl-fruited sedge	M, S	AEP	
Graminoid	*Carex sychnocephala*	long-beaked sedge	M	AEP	
Graminoid	*Carex tenera*	broad-fruited sedge	B, F, M, S	AEP	
Graminoid	*Carex tenuiflora*	thin-flowered sedge	B, M, S	AEP	
Graminoid	*Carex torreyi*	Torrey's sedge	M	AEP	IF DOM
Graminoid	*Carex trisperma*	three-seeded sedge	B, F, M, S	AEP	
Graminoid	*Carex utriculata*	small bottle sedge	B, F, M	AEP	
Graminoid	*Carex vaginata*	sheathed sedge	B, F, M, S	AEP	
Graminoid	*Carex vesicaria*	Lesser Bladder Sedge		US	YES
Graminoid	*Carex viridula*	green sedge	M	AEP	
Graminoid	*Carex vulpinoidea*	fox sedge	M	AEP	
Graminoid	*Carex xerantica*	Whitescale Sedge		US	YES
Graminoid	*Catabrosa aquatica*	brook grass	M	AEP	
Graminoid	*Cinna latifolia*	drooping wood-reed	S	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Graminoid	*Cyperus esculentus*	Yellow Nutsedge		US	YES
Graminoid	*Cyperus squarrosus*	Awned Flat Sedge		US	YES
Graminoid	*Danthonia californica*			US	IF DOM
Graminoid	*Danthonia intermedia*	Timber Wild Oat Grass		US	IF DOM
Graminoid	*Deschampsia cespitosa*	tufted hairgrass	B, F, M	AEP	
Graminoid	*Deschampsia elongata*	Slender Hair Grass		US	IF DOM
Graminoid	*Dichanthelium acuminatum*	hot-springs millet	M	AEP	IF DOM
Graminoid	*Distichlis spicata* ssp. stricta	Inland saltgrass	M	AEP	
Graminoid	*Draba albertina*	Slender Whitlow-Grass		US	IF DOM
Graminoid	*Draba aurea*	Golden Whitlow-Grass		US	IF DOM
Graminoid	*Echinochloa crus-galli*			US	IF DOM
Graminoid	*Echinochloa muricata*			US	YES
Graminoid	*Elymus canadensis*	Canada wild rye	M	AEP	IF DOM
Graminoid	*Elymus repens*	quackgrass	M	AEP	NO
Graminoid	*Elymus trachycaulus*	slender wheatgrass	M	AEP	NO
Graminoid	*Elymus virginicus*	Virginia Wild Rye		US	IF DOM
Graminoid	*Eriophorum angustifolium*	narrowleaf cottongrass	B, F, M, S	AEP	
Graminoid	*Eriophorum brachyantherum*	close-sheathed cotton grass	M	AEP	
Graminoid	*Eriophorum chamissonis*	russet cotton grass	B, F, M, S	AEP	
Graminoid	*Eriophorum gracile*	slender cottongrass	F, M, S	AEP	
Graminoid	*Eriophorum scheuchzeri*	one-spike cottongrass	B, F, M, S	AEP	
Graminoid	*Eriophorum vaginatum*	sheathed cottongrass	B, F, S	AEP	
Graminoid	*Eriophorum viridicarinatum*	Tassel Cotton-Grass		US	YES
Graminoid	*Festuca rubra*	Red Fescue		US	IF DOM
Graminoid	*Glyceria borealis*	northern manna grass	M	AEP	
Graminoid	*Glyceria elata*	Tall Manna Grass		US	YES
Graminoid	*Glyceria grandis*	common tall mannagrass	M	AEP	
Graminoid	*Glyceria pulchella*	graceful manna grass	M	AEP	
Graminoid	*Glyceria striata*	fowl manna grass	F, M, S	AEP	
Graminoid	*Holcus lanatus*			US	IF DOM
Graminoid	*Hordeum jubatum*	foxtail barley	M	AEP	
Graminoid	*Iris pseudacorus*			US	YES
Graminoid	*Juncus albescens*	Northern White Rush		US	YES
Graminoid	*Juncus alpinoarticulatus*	alpine rush	M	AEP	
Graminoid	*Juncus arcticus*	Wire Rush; Baltic or Arctic Rush		US	YES

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Graminoid	*Juncus balticus*	wire rush	M	AEP	
Graminoid	*Juncus brevicaudatus*	short-tailed rush	M	AEP	
Graminoid	*Juncus bufonius*	toad rush	M	AEP	
Graminoid	*Juncus castaneus*	Chestnut Rush		US	YES
Graminoid	*Juncus compressus*	Round-Fruit Rush		US	YES
Graminoid	*Juncus confusus*	Colorado Rush		US	YES
Graminoid	*Juncus drummondii*	Drummond's Rush		US	YES
Graminoid	*Juncus dudleyi*	Dudley's Rush		US	YES
Graminoid	*Juncus effusus*			US	YES
Graminoid	*Juncus ensifolius*	Dagger-Leaf Rush		US	YES
Graminoid	*Juncus filiformis*	Thread Rush		US	YES
Graminoid	*Juncus interior*			US	IF DOM
Graminoid	*Juncus longistylis*	long-styled rush	M	AEP	
Graminoid	*Juncus mertensianus*	Mertens' Rush		US	YES
Graminoid	*Juncus nevadensis*	Sierran Rush		US	YES
Graminoid	*Juncus nodosus*	knotted rush	M	AEP	
Graminoid	*Juncus stygius*	Moor Rush		US	YES
Graminoid	*Juncus tenuis*	slender rush	M	AEP	IF DOM
Graminoid	*Juncus torreyi*	Torrey's rush	M	AEP	
Graminoid	*Juncus triglumis*			US	YES
Graminoid	*Juncus vaseyi*	big-head rush	M	AEP	
Graminoid	*Kobresia myosuroides*	Pacific Bog Sedge		US	IF DOM
Graminoid	*Kobresia simpliciuscula*	Simple Bog Sedge		US	YES
Graminoid	*Leymus cinereus*	basin wildrye		US	IF DOM
Graminoid	*Lolium perenne*			US	IF DOM
Graminoid	*Luzula acuminata*	Hairy Wood-Rush		US	IF DOM
Graminoid	*Luzula multiflora*	Common Wood-Rush		US	IF DOM
Graminoid	*Luzula parviflora*			US	IF DOM
Graminoid	*Muhlenbergia asperifolia*	scratch grass	M	AEP	
Graminoid	*Muhlenbergia glomerata*	bog muhly	B, F, M, S	AEP	
Graminoid	*Oryzopsis asperifolia*	Roughleaf Ricegrass		US	IF DOM
Graminoid	*Oryzopsis pungens*	Northern Ricegrass		US	IF DOM
Graminoid	*Panicum capillare*	witch grass	M	AEP	IF DOM
Graminoid	*Parnassia fimbriata*	Fringed Grass-of-Parnassus		US	YES
Graminoid	*Parnassia kotzebuei*	Kotzebue's Grass-of-Parnassus		US	YES
Graminoid	*Parnassia parviflora*			US	YES
Graminoid	*Phalaris arundinacea*	reed canary grass	M	AEP	
Graminoid	*Phalaris canariensis*	canary grass	M	AEP	NO

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Graminoid	*Phleum alpinum*			US	IF DOM
Graminoid	*Phleum pratense*	timothy	M	AEP	NO
Graminoid	*Phragmites australis*	reed	M, S	AEP	
Graminoid	*Poa abbreviata*	Northern Blue Grass		US	IF DOM
Graminoid	*Poa alpina*			US	IF DOM
Graminoid	*Poa arctica*	Arctic Blue Grass		US	YES
Graminoid	*Poa arida*	Prairie Blue Grass		US	IF DOM
Graminoid	*Poa interior*			US	IF DOM
Graminoid	*Poa leptocoma*	Marsh Blue Grass		US	YES
Graminoid	*Poa nemoralis*	inland bluegrass		US	IF DOM
Graminoid	*Poa palustris*	fowl bluegrass	F, M, S	AEP	
Graminoid	*Poa pratensis*	Kentucky bluegrass	M	AEP	NO
Graminoid	*Poa stenantha*	Narrow-Flower Blue Grass		US	IF DOM
Graminoid	*Polypogon monspeliensis*	Annual Rabbit's-Foot Grass		US	YES
Graminoid	*Puccinellia distans*	slender salt-meadow grass	M	AEP	
Graminoid	*Puccinellia nuttalliana*	Nuttall's salt-meadow grass	M	AEP	
Graminoid	*Rhynchospora alba*	White Beak Sedge		US	YES
Graminoid	*Rhynchospora capillacea*	slender beak-rush	M	AEP	
Graminoid	*Schizachne purpurascens*	purple oat grass	S	AEP	NO
Graminoid	*Schoenoplectus acutus* var. acutus	great bulrush	M	AEP	
Graminoid	*Schoenoplectus americanus*			US	YES
Graminoid	*Schoenoplectus heterochaetus*	slender bulrush	M	AEP	
Graminoid	*Schoenoplectus maritimus*	cosmopolitan bulrush		US	YES
Graminoid	*Schoenoplectus pungens* var. pungens	three-square rush	M	AEP	
Graminoid	*Schoenoplectus tabernaemontani*	Soft-Stem Club-Rush		US	YES
Graminoid	*Schoeoplectus tabernaemontani*	common great bulrush	M	AEP	
Graminoid	*Scirpus cyperinus*	wool-grass	M	AEP	
Graminoid	*Scirpus hudsonianus*			US	YES
Graminoid	*Scirpus microcarpus*	small-fruited bulrush	M	AEP	
Graminoid	*Scirpus nevadensis*	Nevada Bulrush		US	YES
Graminoid	*Scirpus pallidus*	Pale Bulrush		US	YES
Graminoid	*Scolochloa festucacea*	spangletop	M	AEP	
Graminoid	*Sisyrinchium*	Northern Blue-Eyed-		US	IF DOM

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
	septentrionale	Grass			
Graminoid	*Sparganium americanum*	American Burr-Reed		US	YES
Graminoid	*Sparganium angustifolium*	narrow-leaved bur-reed	F, M, W	AEP	
Graminoid	*Sparganium emersum*			US	YES
Graminoid	*Sparganium eurycarpum*	giant burreed	M	AEP	
Graminoid	*Sparganium fluctuans*	Floating Burr-Reed		US	YES
Graminoid	*Sparganium glomeratum*	Clustered Burr-Reed		US	YES
Graminoid	*Sparganium natans*	slender bur-reed	M	AEP	
Graminoid	*Sparganium natans*	small bur-reed		US	YES
Graminoid	*Spartina gracilis*	alkali cordgrass	M	AEP	
Graminoid	*Spartina pectinata*	prairie cord grass	M	AEP	
Graminoid	*Sphenopholis intermedia*	Slender Wedgescale		US	IF DOM
Graminoid	*Sphenopholis obtusata*	Prairie Wedgescale		US	IF DOM
Graminoid	*Torreyochloa pallida*	Pale False Manna Grass		US	YES
Graminoid	*Trichophorum aespitosum*	Hudson Bay bulrush	F, M	AEP	
Graminoid	*Trichophorum alpinum*	tufted bulrush	B, F, M	AEP	
Graminoid	*Trichophorum clintonii*	Clinton's bulrush	M	AEP	
Graminoid	*Trichophorum pumilum*	Rolland's Leafless-Bulrush		US	YES
Graminoid	*Typha latifolia*	common cattail	F, M	AEP	
Graminoid	*Zizania palustris*	wild rice	M, W	AEP	
Forb/Fern	*Achillea millefolium*	common yarrow	M, S	AEP	NO
Forb/Fern	*Achillea sibirica*	Siberian Yarrow		US	IF DOM
Forb/Fern	*Aconitum delphiniifolium*	Larkspurleaf Monkshood		US	IF DOM
Forb/Fern	*Actaea rubra*	red and white baneberry	S	AEP	NO
Forb/Fern	*Adiantum aleuticum*	Aleutian Maidenhair		US	IF DOM
Forb/Fern	*Adoxa moschatellina*	moschatel	S	AEP	IF DOM
Forb/Fern	*Agastache foeniculum*	Blue Giant Hyssop		US	IF DOM
Forb/Fern	*Agoseris glauca*	yellow false dandelion	M	AEP	NO
Forb/Fern	*Agrimonia striata*	agrimony	M	AEP	NO
Forb/Fern	*Alisma gramineum*	narrow-leaved water-plantain	M	AEP	
Forb/Fern	*Alisma plantago-aquatica*	broad-leaved water-plantain	M	AEP	
Forb/Fern	*Alisma triviale*	broad-leaved water-plantain	M	AEP	
Forb/Fern	*Allium schoenoprasum*	wild chives	M	AEP	
Forb/Fern	*Almutaster pauciflorus*	few-flower aster	M, W	AEP	
Forb/Fern	*Amaranthus blitoides*			US	YES
Forb/Fern	*Amaranthus californicus*	California Amaranth		US	YES

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Amaranthus retroflexus*	red-root pigweed	M	AEP	NO
Forb/Fern	*Ambrosia psilostachya*	perennial ragweed	M	AEP	
Forb/Fern	*Ambrosia trifida*			US	IF DOM
Forb/Fern	*Amerorchis rotundifolia*	Roundleaf Orchid		US	YES
Forb/Fern	*Androsace occidentalis*	western fairy candelabra	M	AEP	
Forb/Fern	*Anemone canadensis*	Canada anemone	M, S	AEP	
Forb/Fern	*Anemone parviflora*			US	YES
Forb/Fern	*Anemone quinquefolia*	wood anemone	S	AEP	IF DOM
Forb/Fern	*Anemone richardsonii*			US	IF DOM
Forb/Fern	*Angelica genuflexa*	Kneeling Angelica		US	IF DOM
Forb/Fern	*Antennaria pulcherrima*			US	IF DOM
Forb/Fern	*Apocynum cannabinum*	Indian hemp	M	AEP	IF DOM
Forb/Fern	*Aralia nudicaulis*	wild sarsaparilla	F, S	AEP	NO
Forb/Fern	*Arnica chamissonis*	leafy arnica	F, M, W	AEP	
Forb/Fern	*Arnica latifolia*	Daffodil Leopardbane		US	IF DOM
Forb/Fern	*Arnica longifolia*	Spear-Leaf Leopardbane		US	YES
Forb/Fern	*Arnica mollis*	Cordilleran Leopardbane		US	IF DOM
Forb/Fern	*Artemisia biennis*	biennial sagewort	M	AEP	NO
Forb/Fern	*Artemisia campestris*	Field Sagewort		US	IF DOM
Forb/Fern	*Artemisia ludoviciana*	prairie sagewort	M	AEP	NO
Forb/Fern	*Artemisia norvegica*	Boreal Sagebrush		US	YES
Forb/Fern	*Asclepias ovalifolia*	Oval-Leaf Milkweed		US	IF DOM
Forb/Fern	*Asclepias speciosa*	Showy Milkweed		US	IF DOM
Forb/Fern	*Astragalus agrestis*	purple milkvetch		US	IF DOM
Forb/Fern	*Astragalus alpinus*	alpine milk vetch	M	AEP	IF DOM
Forb/Fern	*Astragalus americanus*	American milk vetch	M, S	AEP	IF DOM
Forb/Fern	*Astragalus australis*	Indian Milkvetch		US	IF DOM
Forb/Fern	*Astragalus bisulcatus*	Twogrooved Milkvetch		US	IF DOM
Forb/Fern	*Astragalus bodinii*	Bodin's Milk-Vetch		US	IF DOM
Forb/Fern	*Astragalus canadensis*	Canadian milk vetch	M	AEP	IF DOM
Forb/Fern	*Astragalus cicer*	Chickpea Milkvetch		US	IF DOM
Forb/Fern	*Astragalus crassicarpus*	Groundplum Milkvetch		US	IF DOM
Forb/Fern	*Astragalus drummondii*	Drummond's Milkvetch		US	IF DOM
Forb/Fern	*Astragalus miser*	Timber Milkvetch		US	IF DOM
Forb/Fern	*Astragalus missouriensis*	Missouri Milkvetch		US	IF DOM
Forb/Fern	*Astragalus pectinatus*	Narrowleaf Milkvetch		US	IF DOM
Forb/Fern	*Astragalus robbinsii*	Robbins' Milk-Vetch		US	IF DOM
Forb/Fern	*Athyrium americanum*	American Alpine Lady Fern		US	IF DOM
Forb/Fern	*Athyrium filix-femina*	Subarctic Lady Fern		US	IF DOM

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Atriplex argentea*	silver saltbrush	M, W	AEP	IF DOM
Forb/Fern	*Atriplex hortensis*	Garden Orache		US	IF DOM
Forb/Fern	*Atriplex micrantha*	saltbush	M	AEP	
Forb/Fern	*Atriplex nuttallii*	Nuttall's Saltbush		US	IF DOM
Forb/Fern	*Atriplex powellii*	Powell's saltbush	M	AEP	
Forb/Fern	*Atriplex prostrata*	prostrate saltbush	M	AEP	
Forb/Fern	*Atriplex subspicata*	spearscale saltbush	M, W	AEP	
Forb/Fern	*Atriplex truncata*	saltbush	M, W	AEP	IF DOM
Forb/Fern	*Bacopa rotundifolia*	water hyssop	M	AEP	
Forb/Fern	*Barbarea orthoceras*	American winter cress	M	AEP	
Forb/Fern	*Barbarea vulgaris*			US	IF DOM
Forb/Fern	*Bassia hyssopifolia*	Five-Horn Smotherweed		US	YES
Forb/Fern	*Bassia scoparia*	Burningbush		US	IF DOM
Forb/Fern	*Bidens cernua*	nodding beggarticks	M, F, S	AEP	
Forb/Fern	*Bidens frondosa*	common beggarticks	M	AEP	
Forb/Fern	*Bidens tripartita*	Three-Lobe Beggarticks		US	YES
Forb/Fern	*Bistorta vivipara*	alpine bistort	M	AEP	
Forb/Fern	*Botrychium ascendens*	Triangle-Lobe Moonwort		US	IF DOM
Forb/Fern	*Botrychium lanceolatum*	Lance-Leaf Moonwort		US	YES
Forb/Fern	*Botrychium lunaria*	Common Moonwort		US	IF DOM
Forb/Fern	*Botrychium simplex*	Least Moonwort		US	IF DOM
Forb/Fern	*Botrychium virginianum*	Rattlesnake Fern		US	IF DOM
Forb/Fern	*Botrypus virginianus*			US	IF DOM
Forb/Fern	*Brasenia schreberi*	watershield	F, M, W	AEP	
Forb/Fern	*Calla palustris*	water arum	F, M, S	AEP	
Forb/Fern	*Callitriche hermaphroditica*	northern water-starwort	M, W	AEP	
Forb/Fern	*Callitriche palustris*	vernal water-starwort	F, M	AEP	
Forb/Fern	*Caltha leptosepala*	White Marsh-Marigold		US	YES
Forb/Fern	*Caltha natans*	floating marsh-marigold	F, M, W	AEP	
Forb/Fern	*Caltha palustris*	marsh marigold	F, M, S	AEP	
Forb/Fern	*Calypso bulbosa*	Fairy-Slipper Orchid		US	YES
Forb/Fern	*Campanula aparinoides*	Marsh Bellflower		US	YES
Forb/Fern	*Campanula rotundifolia*	Bluebell-of-Scotland		US	IF DOM
Forb/Fern	*Canadanthus modestus*	large northern aster	F, M	AEP	
Forb/Fern	*Capsella bursa-pastoris*	shepherd's purse	M	AEP	NO
Forb/Fern	*Cardamine oligosperma*	Little Western Bittercress		US	IF DOM
Forb/Fern	*Cardamine parviflora*	Sand Bittercress		US	YES
Forb/Fern	*Cardamine pensylvanica*	bittercress	M, S	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Cardamine pratensis*	meadow bitter cress	M	AEP	
Forb/Fern	*Cardaria pubescens*	Globe-Pod Hoarycress		US	IF DOM
Forb/Fern	*Castilleja miniata*			US	YES
Forb/Fern	*Castilleja occidentalis*	Pale-Yellow Indian-Paintbrush		US	IF DOM
Forb/Fern	*Castilleja raupii*	purple paintbrush	M	AEP	IF DOM
Forb/Fern	*Castilleja rhexiifolia*	Rosy Indian-Paintbrush		US	IF DOM
Forb/Fern	*Cerastium arvense*	field mouse-ear chickweed	M	AEP	NO
Forb/Fern	*Cerastium beeringianum*	Bering Sea Mouse-Ear Chickweed		US	IF DOM
Forb/Fern	*Cerastium brachypodum*	Nodding Mouse-Ear Chickweed		US	IF DOM
Forb/Fern	*Cerastium nutans*	Nodding Mouse-Ear Chickweed		US	IF DOM
Forb/Fern	*Chamerion angustifolium* ssp. angustifolium	common fireweed	F, M, S	AEP	IF DOM
Forb/Fern	*Chamerion latifolium*	broad-leaved fireweed	M, F	AEP	
Forb/Fern	*Chenopodium album*	lamb's quarters	M	AEP	NO
Forb/Fern	*Chenopodium capitatum*	strawberry blite	M	AEP	IF DOM
Forb/Fern	*Chenopodium glaucum* var. salinum	oak-leaved goosefoot	F, M. S	AEP	IF DOM
Forb/Fern	*Chenopodium pratericola*	Desert Goosefoot		US	IF DOM
Forb/Fern	*Chenopodium rubrum*	red goosefoot	M	AEP	
Forb/Fern	*Chenopodium simplex*	Mapleleaf Goosefoot		US	IF DOM
Forb/Fern	*Chrysosplenium iowense*	golden saxifrage	F, M	AEP	
Forb/Fern	*Chrysosplenium tetrandrum*	green saxifrage	F, M	AEP	
Forb/Fern	*Cicuta bulbifera*	bulb-bearing water-hemlock	F, M, S	AEP	
Forb/Fern	*Cicuta douglasii*			US	YES
Forb/Fern	*Cicuta maculata*	water-hemlock	F, M, S	AEP	
Forb/Fern	*Cicuta virosa*	narrow-leaved water-hemlock	M	AEP	
Forb/Fern	*Circaea alpina*	small enchanter's nightshade	S	AEP	
Forb/Fern	*Cirsium arvense*	creeping thistle	M, S	AEP	NO
Forb/Fern	*Cirsium drummondii*	Dwarf Thistle		US	IF DOM
Forb/Fern	*Cirsium flodmanii*	Flodman's Thistle		US	IF DOM
Forb/Fern	*Cirsium scariosum*	Meadow Thistle		US	IF DOM
Forb/Fern	*Claytonia lanceolata*	Lance-Leaf Springbeauty		US	YES
Forb/Fern	*Clematis ligusticifolia*			US	IF DOM
Forb/Fern	*Coeloglossum viride*	bracted bog orchid	M	AEP	IF DOM
Forb/Fern	*Comarum palustre*	marsh cinquefoil	B, F, M, S	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Conium maculatum*	poison hemlock	M	AEP	
Forb/Fern	*Conyza canadensis*	horseweed	M	AEP	
Forb/Fern	*Coptis trifolia*	goldthread	M, S	AEP	
Forb/Fern	*Corallorhiza trifida*	pale coralroot	F, S	AEP	IF DOM
Forb/Fern	*Corallorrhiza trifida*	yellow coralroot		US	IF DOM
Forb/Fern	*Coreopsis tinctoria*	Golden Tickseed		US	IF DOM
Forb/Fern	*Cornus canadensis*	bunchberry	S	AEP	IF DOM
Forb/Fern	*Corydalis aurea*	golden corydalis	M	AEP	IF DOM
Forb/Fern	*Crepis runcinata*	scapose hawk's-beard	M	AEP	IF DOM
Forb/Fern	*Crepis tectorum*	annual hawk's-beard	M	AEP	
Forb/Fern	*Cyclachaena xanthifolia*	false ragweed	F, M, W	AEP	
Forb/Fern	*Cypripedium acaule*	stemless lady's-slipper	B, S	AEP	
Forb/Fern	*Cypripedium parviflorum*	yellow lady's-slipper	M	AEP	
Forb/Fern	*Cypripedium passerinum*			US	YES
Forb/Fern	*Dasiphora fruticosa*	shrubby cinquefoil		US	IF DOM
Forb/Fern	*Delphinium glaucum*	tall larkspur	M, S	AEP	
Forb/Fern	*Descurainia sophia*	flixweed	M	AEP	
Forb/Fern	*Diphasiastrum complanatum*	groundcedar		US	IF DOM
Forb/Fern	*Dodecatheon pulchellum*	Dark-Throat Shootingstar		US	YES
Forb/Fern	*Dracocephalum parviflorum*	American dragonhead	M	AEP	NO
Forb/Fern	*Drosera anglica*	great sundew	B, F	AEP	
Forb/Fern	*Drosera linearis*	slender-leaved sundew	B, F, S	AEP	
Forb/Fern	*Drosera rotundifolia*	round-leaved sundew	B, F, S	AEP	
Forb/Fern	*Dryas drummondii*	Drummond's Mountain-Avens		US	IF DOM
Forb/Fern	*Dryopteris carthusiana*	narrow spinulose shield fern	S	AEP	
Forb/Fern	*Dryopteris cristata*	crested shield fern	S	AEP	
Forb/Fern	*Dryopteris expansa*			US	YES
Forb/Fern	*Echinocystis lobata*	Wild Cucumber		US	IF DOM
Forb/Fern	*Elatine triandra*	waterwort	M	AEP	
Forb/Fern	*Eleocharis acicularis*	needle spikerush	M	AEP	
Forb/Fern	*Eleocharis elliptica*	Elliptic Spike-Rush		US	YES
Forb/Fern	*Eleocharis engelmannii*	Engelmann's spike-rush	M	AEP	
Forb/Fern	*Eleocharis erythropoda*	Bald Spikerush		US	YES
Forb/Fern	*Eleocharis macrostachya*	Pale Spikerush		US	YES
Forb/Fern	*Eleocharis nitida*	Quill Spikerush		US	YES
Forb/Fern	*Eleocharis palustris*	creeping spike-rush	M	AEP	
Forb/Fern	*Eleocharis quinqueflora*	few-flowered spike-rush	M	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Eleocharis tenuis*	slender spike-rush	F	AEP	
Forb/Fern	*Eleocharis uniglumis*	Onescale Spikerush		US	YES
Forb/Fern	*Ellisia nyctelea*	waterpod	M	AEP	
Forb/Fern	*Elodea bifoliata*	two-leaved waterweed	F, M	AEP	
Forb/Fern	*Elodea canadensis*	Canada waterweed	M, W	AEP	
Forb/Fern	*Elodea nuttallii*	Western Waterweed		US	YES
Forb/Fern	*Epilobium anagallidifolium*	Pimpernel Willowherb		US	IF DOM
Forb/Fern	*Epilobium campestre*	smooth boisduvalia	F, M. W	AEP	
Forb/Fern	*Epilobium ciliatum*	northern willowherb	B, F, M, S	AEP	
Forb/Fern	*Epilobium glaberrimum*	Glaucous Willowherb		US	YES
Forb/Fern	*Epilobium halleanum*	Glandular Willowherb		US	YES
Forb/Fern	*Epilobium hornemannii*	Hornemann's Willowherb		US	YES
Forb/Fern	*Epilobium lactiflorum*	White-Flower Willowherb		US	YES
Forb/Fern	*Epilobium leptocarpum*	Slender-Fruit Willowherb		US	YES
Forb/Fern	*Epilobium leptophyllum*	narrow-leaved willowherb	B, F, M, S	AEP	
Forb/Fern	*Epilobium palustre*	marsh willowherb	F, M, S	AEP	
Forb/Fern	*Epilobium saximontanum*	Rocky Mountain Willowherb		US	YES
Forb/Fern	*Equisetum arvense*	common horsetail	B, F, M, S	AEP	IF DOM
Forb/Fern	*Equisetum fluviatile*	swamp horsetail	B, F, M, S	AEP	
Forb/Fern	*Equisetum hyemale*	common scouring-rush	M	AEP	
Forb/Fern	*Equisetum laevigatum*	smooth scouring-rush	M	AEP	IF DOM
Forb/Fern	*Equisetum palustre*	marsh horsetail	B, F, M, S	AEP	
Forb/Fern	*Equisetum pratense*	meadow horsetail	F, M, S	AEP	
Forb/Fern	*Equisetum scirpoides*	dwarf scouring-rush	B, F, M, S	AEP	IF DOM
Forb/Fern	*Equisetum sylvaticum*	woodland horsetail	B, M, S	AEP	
Forb/Fern	*Equisetum variegatum*	variegated horsetail	M, S	AEP	
Forb/Fern	*Erigeron acris*	northern daisyfleabane	M	AEP	IF DOM
Forb/Fern	*Erigeron elatus*	tall fleabane	M	AEP	
Forb/Fern	*Erigeron flagellaris*	Trailing Fleabane		US	IF DOM
Forb/Fern	*Erigeron glabellus*	Streamside Fleabane		US	YES
Forb/Fern	*Erigeron humilis*			US	YES
Forb/Fern	*Erigeron lonchophyllus*	fleabane	M	AEP	
Forb/Fern	*Erigeron philadelphicus*	Philadelphia fleabane	M, S	AEP	IF DOM
Forb/Fern	*Erigeron speciosus*	Aspen Fleabane		US	IF DOM
Forb/Fern	*Eriogonum androsaceum*	cushion umbrella-plant	F	AEP	
Forb/Fern	*Erysimum cheiranthoides*	wormseed mustard	M	AEP	NO

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Euphorbia esula*	Leafy Spurge		US	IF DOM
Forb/Fern	*Eurybia sibirica*	Arctic aster	M	AEP	NO
Forb/Fern	*Euthamia graminifolia*	flat-topped goldenrod	M	AEP	IF DOM
Forb/Fern	*Euthamia graminifolia*	flat-top goldentop		US	IF DOM
Forb/Fern	*Eutrochium maculatum*	spotted Joe-pye weed	S, M	AEP	
Forb/Fern	*Fallopia convolvulus*	wild buckwheat	F, M, W	AEP	NO
Forb/Fern	*Fragaria vesca*	woodland strawberry	M	AEP	NO
Forb/Fern	*Fragaria virginiana*	wild strawberry	M	AEP	NO
Forb/Fern	*Galearis rotundifolia*	round-leaved orchid	F, S	AEP	
Forb/Fern	*Galeopsis tetrahit*	hemp-nettle	F, M	AEP	NO
Forb/Fern	*Galium boreale*	Labrador bedstraw	B, S	AEP	NO
Forb/Fern	*Galium labradoricum*	northern bog bedstraw	B, F, M, S	AEP	
Forb/Fern	*Galium trifidum*	small bedstraw	B, F, M, S	AEP	
Forb/Fern	*Galium triflorum*	sweet-scented bedstraw	F, M, S	AEP	NO
Forb/Fern	*Gentiana fremontii*	Moss Gentian		US	YES
Forb/Fern	*Gentiana prostrata*			US	YES
Forb/Fern	*Gentianella amarella*	Autumn Dwarf-Gentian		US	YES
Forb/Fern	*Gentianella propinqua*			US	YES
Forb/Fern	*Gentianopsis detonsa*	northern fringed gentian	M	AEP	
Forb/Fern	*Geocaulon lividum*	northern bastard toadflax	B, F, S	AEP	IF DOM
Forb/Fern	*Geranium bicknellii*	Bicknell's Cranesbill		US	IF DOM
Forb/Fern	*Geranium richardsonii*	White Crane's-Bill		US	IF DOM
Forb/Fern	*Geum aleppicum*	yellow avens	F, M, S	AEP	NO
Forb/Fern	*Geum macrophyllum*	large-leaved yellow avens	F, M, S	AEP	
Forb/Fern	*Geum rivale*	purple avens	M, S	AEP	
Forb/Fern	*Glaux maritima*	Sea-Milkwort		US	YES
Forb/Fern	*Glycyrrhiza lepidota*	wild licorice	M	AEP	NO
Forb/Fern	*Gnaphalium palustre*	marsh cudweed	M	AEP	
Forb/Fern	*Gnaphalium uliginosum*	Marsh Cudweed		US	IF DOM
Forb/Fern	*Goodyera repens*	lesser rattlesnake plantain	S	AEP	NO
Forb/Fern	*Gratiola neglecta*	clammy hedge-hyssop	M	AEP	
Forb/Fern	*Gymnocarpium dryopteris*	oak fern	S	AEP	IF DOM
Forb/Fern	*Halenia deflexa*	American Spurred-Gentian		US	IF DOM
Forb/Fern	*Hedysarum alpinum*	alpine hedysarum	S	AEP	NO
Forb/Fern	*Helenium autumnale*	sneezeweed	M	AEP	
Forb/Fern	*Helianthus maximilianii*	narrow-leaved sunflower	M	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Helianthus nuttallii*	common tall sunflower	M	AEP	
Forb/Fern	*Heliotropium curassavicum*	spatulate-leaved heliotrope	M	AEP	
Forb/Fern	*Heracleum maximum*	American Cow-Parsnip		US	IF DOM
Forb/Fern	*Heracleum sphondylium* ssp. montanum	cow parsnip	S, M	AEP	
Forb/Fern	*Hieracium umbellatum*	narrow-leaved hawkweed	M	AEP	
Forb/Fern	*Hippuris vulgaris*	common maretail	F, M	AEP	
Forb/Fern	*Hypericum majus*	large Canada St. John's-wort	M	AEP	
Forb/Fern	*Impatiens capensis*	spotted touch-me-not	M, S	AEP	
Forb/Fern	*Impatiens noli-tangere*	western jewelweed	M, S	AEP	
Forb/Fern	*Iris missouriensis*	western blue flag	M	AEP	
Forb/Fern	*Isoetes bolanderi*	Bolander's quillwort	M	AEP	
Forb/Fern	*Isoetes echinospora*	northern quillwort	M, W	AEP	
Forb/Fern	*Iva axillaris*	povertyweed	M	AEP	IF DOM
Forb/Fern	*Kochia scoparia*	summer-cypress	M	AEP	
Forb/Fern	*Lactuca biennis*	tall blue lettuce	S	AEP	IF DOM
Forb/Fern	*Lactuca serriola*	prickly lettuce	M	AEP	IF DOM
Forb/Fern	*Lactuca tatarica*			US	IF DOM
Forb/Fern	*Lactuca tatarica*	chicory lettuce		US	IF DOM
Forb/Fern	*Laportea canadensis*	Canadian Wood-Nettle		US	IF DOM
Forb/Fern	*Lapsana communis*	Common Nipplewort		US	IF DOM
Forb/Fern	*Lathyrus ochroleucus*	cream-coloured vetchling	S	AEP	
Forb/Fern	*Lathyrus palustris*	Marsh Vetchling		US	YES
Forb/Fern	*Lathyrus venosus*	Veiny Vetchling		US	IF DOM
Forb/Fern	*Lemna minor*	common duckweed	M	AEP	
Forb/Fern	*Lemna trisulca*	ivy-leaved duckweed	M	AEP	
Forb/Fern	*Lemna turionifera*	Turion Duckweed		US	YES
Forb/Fern	*Lepidium densiflorum*	common pepper-grass	M	AEP	IF DOM
Forb/Fern	*Lepidium latifolium*	Broad-Leaf Pepperwort		US	YES
Forb/Fern	*Lepidium perfoliatum*	Clasping Pepperwort		US	IF DOM
Forb/Fern	*Liatris ligulistylis*	Strap-Style Gayfeather		US	IF DOM
Forb/Fern	*Lilium philadelphicum*	western wood lily	M	AEP	IF DOM
Forb/Fern	*Limosella aquatica*	mudwort	M	AEP	
Forb/Fern	*Linaria vulgaris*	common toadflax	M	AEP	
Forb/Fern	*Liparis loeselii*	Yellow Wide-Lip Orchid		US	YES
Forb/Fern	*Listera convallarioides*	Broad-Lip Twayblade		US	YES
Forb/Fern	*Lobelia dortmanna*	water lobelia	M	AEP	
Forb/Fern	*Lobelia kalmii*	Kalm's lobelia	M	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Lobelia spicata*	Pale-Spike Lobelia		US	IF DOM
Forb/Fern	*Lomatogonium rotatum*	marsh felwort	M	AEP	
Forb/Fern	*Lonicera oblongifolia*	Swamp Fly-Honeysuckle		US	YES
Forb/Fern	*Lotus corniculatus*	bird's-foot trefoil	M	AEP	IF DOM
Forb/Fern	*Lupinus polyphyllus*	Blue-Pod Lupine		US	YES
Forb/Fern	*Lycopodium annotinum*	stiff club-moss	S	AEP	IF DOM
Forb/Fern	*Lycopodium clavatum*			US	IF DOM
Forb/Fern	*Lycopus americanus*	American water-horehound	F, M, W	AEP	
Forb/Fern	*Lycopus asper*	western water-horehound	M	AEP	
Forb/Fern	*Lycopus uniflorus*	northern water-horehound	B, M, S	AEP	
Forb/Fern	*Lysimachia ciliata*	Fringed Yellow-Loosestrife		US	YES
Forb/Fern	*Lysimachia hybrida*	lance-leaved yellow loosestrife	M	AEP	
Forb/Fern	*Lysimachia lanceolata*	lance-leaved loosestrife	M	AEP	
Forb/Fern	*Lysimachia maritima*	sea milkwort	F, M	AEP	
Forb/Fern	*Lysimachia thyrsiflora*	tufted loosestrife	B, F, M, S	AEP	
Forb/Fern	*Lythrum salicaria*	purple loosestrife	F, M	AEP	
Forb/Fern	*Maianthemum canadense*	wild lily-of-the-valley	S	AEP	NO
Forb/Fern	*Maianthemum racemosum*	Feathery False Solomon's-Seal		US	IF DOM
Forb/Fern	*Maianthemum stellatum*	star-flowered Solomon's-seal	M, S	AEP	NO
Forb/Fern	*Maianthemum trifolium*	three-leaved Solomon's-seal	B, F, M, S	AEP	
Forb/Fern	*Malaxis monophyllos*			US	YES
Forb/Fern	*Malaxis paludosa*	Bog Adder's-Mouth Orchid		US	YES
Forb/Fern	*Marsilea vestita*	hairy pepperwort	M, W	AEP	
Forb/Fern	*Matricaria discoidea*	pineappleweed	M	AEP	NO
Forb/Fern	*Matteuccia struthiopteris*	ostrich fern	M, S	AEP	
Forb/Fern	*Melampyrum lineare*	narrowleaf cowwheat		US	IF DOM
Forb/Fern	*Melilotus officinalis*	yellow sweet-clover	M	AEP	NO
Forb/Fern	*Mentha arvensis*	wild mint	M, S	AEP	
Forb/Fern	*Mentha spicata*	spearmint	M	AEP	
Forb/Fern	*Menyanthes trifoliata*	buck-bean	F, S	AEP	
Forb/Fern	*Mertensia paniculata*	tall lungwort	S	AEP	IF DOM
Forb/Fern	*Mimulus floribundus*	Purple-Stem Monkey-Flower		US	YES
Forb/Fern	*Mimulus glabratus*	Round-Leaf Monkey-		US	YES

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
		Flower			
Forb/Fern	*Mimulus guttatus*	Seep Monkey-Flower		US	YES
Forb/Fern	*Mimulus ringens*	Allegheny Monkey-Flower		US	YES
Forb/Fern	*Mimulus tilingii*	Subalpine Monkey-Flower		US	YES
Forb/Fern	*Minuartia rubella*	Boreal Stitchwort		US	IF DOM
Forb/Fern	*Mitella breweri*	Feathery Bishop's-Cap		US	IF DOM
Forb/Fern	*Mitella nuda*	bishop's-cap	B, F, M, S	AEP	
Forb/Fern	*Mitella pentandra*	Five-Stamen Bishop's-Cap		US	IF DOM
Forb/Fern	*Mitella trifida*	Pacific Bishop's-Cap		US	IF DOM
Forb/Fern	*Moehringia lateriflora*	blunt-leaved sandwort	S	AEP	IF DOM
Forb/Fern	*Mollugo verticillata*	green carpetweed		US	IF DOM
Forb/Fern	*Moneses uniflora*	one-flowered wintergreen	B, S	AEP	IF DOM
Forb/Fern	*Monolepis nuttalliana*	spear-leaved goosefoot	F, M, W	AEP	IF DOM
Forb/Fern	*Montia linearis*	Linear-Leaf Candy-Flower		US	IF DOM
Forb/Fern	*Montia parvifolia*	Little-Leaf Candy-Flower		US	YES
Forb/Fern	*Muhlenbergia racemosa*	Green Muhly		US	YES
Forb/Fern	*Muhlenbergia richardsonis*	mat muhly	M	AEP	IF DOM
Forb/Fern	*Mulgedium oblongifolium*	blue lettuce	M	AEP	
Forb/Fern	*Myosotis arvensis*	Rough Forget-Me-Not		US	IF DOM
Forb/Fern	*Myosotis laxa*	Bay Forget-Me-Not		US	YES
Forb/Fern	*Myosurus apetalus*	Bristly Mousetail		US	YES
Forb/Fern	*Myosurus minimus*	Tiny Mousetail		US	YES
Forb/Fern	*Myriophyllum alterniflorum*	Alternateflower Watermilfoil		US	YES
Forb/Fern	*Myriophyllum sibiricum*	spike water-milfoil	M, W	AEP	
Forb/Fern	*Myriophyllum spicatum*	Eurasian Water-Milfoil		US	YES
Forb/Fern	*Myriophyllum verticillatum*	water-milfoil	F, M, W	AEP	
Forb/Fern	*Najas flexilis*	slender naiad	M	AEP	
Forb/Fern	*Najas guadalupensis*	Guadalupe Waternymph		US	YES
Forb/Fern	*Nasturtium officinale*	water cress	M	AEP	
Forb/Fern	*Navarretia leucocephala*	White-Flower Pincushion-Plant		US	YES
Forb/Fern	*Neottia cordata*	heart-leaved twayblade	S	AEP	
Forb/Fern	*Nuphar lutea*	yellow pond-lily	F, M	AEP	
Forb/Fern	*Nuphar variegata*			US	YES
Forb/Fern	*Nymphaea leibergii*	Dwarf Water-Lily		US	YES

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Nymphaea tetragona*	white water-lily	F, M	AEP	
Forb/Fern	*Oenothera flava*	Long-Tube Evening-Primrose		US	YES
Forb/Fern	*Onosmodium bejariense*	western marbleseed		US	IF DOM
Forb/Fern	*Orthilia secunda*	one-sided wintergreen	B, F, S	AEP	NO
Forb/Fern	*Osmorhiza longistylis*	smooth sweet cicely	S	AEP	IF DOM
Forb/Fern	*Osmorhiza purpurea*	Purple Sweet-Cicely		US	IF DOM
Forb/Fern	*Oxyria digyna*	Mountain-Sorrel		US	IF DOM
Forb/Fern	*Oxytropis monticola*	Yellowflower Locoweed		US	IF DOM
Forb/Fern	*Packera pauciflora*	few-flowered ragwort	S	AEP	IF DOM
Forb/Fern	*Packera paupercula*	balsam groundsel	S	AEP	
Forb/Fern	*Packera subnuda*	Buek's Groundsel		US	YES
Forb/Fern	*Packera pauciflora*	groundsel		US	IF DOM
Forb/Fern	*Parietaria pensylvanica*	Pennsylvania Pellitory		US	IF DOM
Forb/Fern	*Parnassia palustris*	northern grass-of-Parnassus	B, F, M, S	AEP	
Forb/Fern	*Parthenocissus quinquefolia*	Virginia creeper		US	IF DOM
Forb/Fern	*Pedicularis bracteosa*	Bracted Lousewort		US	IF DOM
Forb/Fern	*Pedicularis groenlandica*	elephant's-head	F, M	AEP	
Forb/Fern	*Pedicularis labradorica*	Labrador lousewort	B	AEP	IF DOM
Forb/Fern	*Pedicularis macrodonta*	muskeg lousewort	B, F, M	AEP	
Forb/Fern	*Pedicularis parviflora*	swamp lousewort	B, F, M	AEP	IF DOM
Forb/Fern	*Pedicularis sudetica*	Sudetic Lousewort		US	YES
Forb/Fern	*Penstemon confertus*	Yellow Penstemon		US	IF DOM
Forb/Fern	*Penstemon procerus*	slender blue beardtongue	F	AEP	NO
Forb/Fern	*Persicaria amphibia*	water smartweed	M, S	AEP	
Forb/Fern	*Persicaria lapathifolia*	pale persicaria	F, M, W	AEP	
Forb/Fern	*Petasites frigidus* var. frigidus	sweet coltsfoot	F, M	AEP	IF DOM
Forb/Fern	*Petasites frigidus* var. palmatus	palmate-leaved coltsfoot	F, M, S	AEP	IF DOM
Forb/Fern	*Petasites frigidus* var. sagittatus	arrow-leaved coltsfoot	F, M, S	AEP	IF DOM
Forb/Fern	*Physostegia ledinghamii*	Ledingham's False Dragonhead		US	YES
Forb/Fern	*Physostegia parviflora*	false dragonhead	M	AEP	
Forb/Fern	*Pinguicula villosa*	small butterwort	F, B	AEP	
Forb/Fern	*Pinguicula vulgaris*	California butterwort		US	YES
Forb/Fern	*Plagiobothrys scouleri*	Scouler's allocarya	M	AEP	
Forb/Fern	*Plantago elongata*	Prairie Plantain		US	YES
Forb/Fern	*Plantago eriopoda*	saline plantain	M	AEP	IF DOM

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Plantago major*	Great Plantain		US	IF DOM
Forb/Fern	*Plantago maritima*	sea-side plantain	F, M	AEP	
Forb/Fern	*Platanthera aquilonis*			US	YES
Forb/Fern	*Platanthera dilatata*	tall white bog orchid	B, F	AEP	
Forb/Fern	*Platanthera hyperborea*	northern green bog orchid	F, M, S	AEP	
Forb/Fern	*Platanthera obtusata* ssp. obtusata	blunt-leaved bog orchid	F, S	AEP	
Forb/Fern	*Platanthera orbiculata*	round-leaved bog orchid	F, S	AEP	IF DOM
Forb/Fern	*Platanthera stricta*	Slender Bog Orchid		US	YES
Forb/Fern	*Polemonium acutiflorum*	tall Jacob's-ladder	M	AEP	IF DOM
Forb/Fern	*Polemonium occidentale*	Western Jacob's-Ladder		US	YES
Forb/Fern	*Polygala paucifolia*	fringed milkwort	S	AEP	
Forb/Fern	*Polygonum achoreum*	striate knotweed	F, M	AEP	
Forb/Fern	*Polygonum amphibium*	Water Knotweed		US	YES
Forb/Fern	*Polygonum bistortoides*	American Bistort		US	IF DOM
Forb/Fern	*Polygonum erectum*	striate knotweed	M	AEP	IF DOM
Forb/Fern	*Polygonum lapathifolium*	Curlytop Knotweed		US	YES
Forb/Fern	*Polygonum minimum*	Zigzag Knotweed		US	IF DOM
Forb/Fern	*Polygonum persicaria*	Spotted Ladysthumb		US	YES
Forb/Fern	*Polygonum polygaloides*	White-Margin Knotweed		US	YES
Forb/Fern	*Polygonum ramosissimum*	bushy knotweed	M	AEP	
Forb/Fern	*Polygonum viviparum*	Alpine Bistort		US	IF DOM
Forb/Fern	*Portulaca oleracea*	Little-Hogweed		US	IF DOM
Forb/Fern	*Potamogeton alpinus*	Reddish Pondweed		US	YES
Forb/Fern	*Potamogeton berchtoldii*			US	YES
Forb/Fern	*Potamogeton crispus*	Curly Pondweed		US	YES
Forb/Fern	*Potamogeton filiformis*			US	IF DOM
Forb/Fern	*Potamogeton foliosus*	leafy pondweed	F, M, W	AEP	
Forb/Fern	*Potamogeton friesii*	Fries' pondweed	F, M, W	AEP	
Forb/Fern	*Potamogeton gramineus*	various-leaved pondweed	M, W	AEP	
Forb/Fern	*Potamogeton natans*	floating-leaf pondweed	F, M, W	AEP	
Forb/Fern	*Potamogeton nodosus*	Long-Leaf Pondweed		US	YES
Forb/Fern	*Potamogeton obtusifolius*	Blunt-Leaf Pondweed		US	YES
Forb/Fern	*Potamogeton pectinatus*	Sago Pondweed		US	YES
Forb/Fern	*Potamogeton perfoliatus*	Claspingleaf Pondweed		US	YES
Forb/Fern	*Potamogeton praelongus*	white-stem pondweed	F, M, W	AEP	
Forb/Fern	*Potamogeton pusillus*	small-leaf pondweed	W	AEP	
Forb/Fern	*Potamogeton richardsonii*	clasping-leaf pondweed	M	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Potamogeton robbinsii*	Fern Pondweed		US	YES
Forb/Fern	*Potamogeton strictifolius*	Straight-Leaf Pondweed		US	YES
Forb/Fern	*Potamogeton zosteriformis*	flat-stemmed pondweed	F, M, W	AEP	
Forb/Fern	*Potentilla anserina*	silverweed	F, M	AEP	
Forb/Fern	*Potentilla bimundorum*	Staghorn Cinquefoil		US	IF DOM
Forb/Fern	*Potentilla diversifolia*	Mountain-Meadow Cinquefoil		US	YES
Forb/Fern	*Potentilla glandulosa*	Sticky Cinquefoil		US	IF DOM
Forb/Fern	*Potentilla gracilis*	graceful cinquefoil	M	AEP	IF DOM
Forb/Fern	*Potentilla norvegica*	rough cinquefoil	F, M, S	AEP	IF DOM
Forb/Fern	*Potentilla plattensis*	Platte River Cinquefoil		US	YES
Forb/Fern	*Potentilla rivalis*	brook cinquefoil	M	AEP	
Forb/Fern	*Potentilla supina*	Bushy Cinquefoil		US	YES
Forb/Fern	*Primula egaliksensis*	Greenland Primrose		US	YES
Forb/Fern	*Primula incana*	mealy primrose	M	AEP	
Forb/Fern	*Primula mistassinica*	Lake Mistassini Primrose		US	YES
Forb/Fern	*Primula pauciflora* var. pauciflora	pretty shooting star	B, M, S	AEP	
Forb/Fern	*Prunella vulgaris*	Common Selfheal		US	IF DOM
Forb/Fern	*Psilocarphus brevissimus*	Dwarf Woollyheads		US	YES
Forb/Fern	*Pyrola minor*	lesser wintergreen	F, S	AEP	NO
Forb/Fern	*Pyrrocoma uniflora*	Plantain Goldenweed		US	IF DOM
Forb/Fern	*Ranunculus abortivus*	small-flowered buttercup	M, S	AEP	IF DOM
Forb/Fern	*Ranunculus acris*	tall buttercup	M	AEP	
Forb/Fern	*Ranunculus aquatilis* var. diffusus	large-leaved white water crowfoot	M, W	AEP	
Forb/Fern	*Ranunculus cardiophyllus*	Heart-Leaf Buttercup		US	YES
Forb/Fern	*Ranunculus cymbalaria*	seaside buttercup	M	AEP	
Forb/Fern	*Ranunculus eschscholtzii*	Spruce-Fir Buttercup		US	YES
Forb/Fern	*Ranunculus flabellaris*	Greater Yellow Water Buttercup		US	YES
Forb/Fern	*Ranunculus flammula*	creeping spearwort	F, M, W	AEP	
Forb/Fern	*Ranunculus glaberrimus*	Sagebrush Buttercup		US	IF DOM
Forb/Fern	*Ranunculus gmelinii*	yellow water crowfoot	B, F, M, S	AEP	
Forb/Fern	*Ranunculus hyperboreus*	Far-Northern Buttercup		US	YES
Forb/Fern	*Ranunculus inamoenus*	Graceful Buttercup		US	YES
Forb/Fern	*Ranunculus lapponicus*	Lapland buttercup	M, S	AEP	
Forb/Fern	*Ranunculus longirostris*	Long-Beak Water-Crowfoot		US	YES
Forb/Fern	*Ranunculus macounii*	Macoun's buttercup	F, M	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Ranunculus pedatifidus*	Northern Buttercup		US	YES
Forb/Fern	*Ranunculus pensylvanicus*	bristly buttercup	F, M, W	AEP	
Forb/Fern	*Ranunculus pygmaeus*	Dwarf Buttercup		US	YES
Forb/Fern	*Ranunculus repens*	Creeping Buttercup		US	YES
Forb/Fern	*Ranunculus sceleratus*	celery-leaved buttercup	M	AEP	
Forb/Fern	*Ranunculus uncinatus*	Woodland Buttercup		US	YES
Forb/Fern	*Rhinanthus minor*	northern rattle		US	IF DOM
Forb/Fern	*Romanzoffia sitchensis*	Sitka Mistmaiden		US	YES
Forb/Fern	*Rorippa austriaca*			US	IF DOM
Forb/Fern	*Rorippa curvipes*	Blunt-Leaf Yellowcress		US	YES
Forb/Fern	*Rorippa palustris*	marsh yellow cress	B, F, M, W	AEP	
Forb/Fern	*Rorippa sinuata*	Spreading Yellowcress		US	YES
Forb/Fern	*Rorippa sylvestris*	Creeping Yellowcress		US	YES
Forb/Fern	*Rorippa tenerrima*	Modoc Yellowcress		US	IF DOM
Forb/Fern	*Rubus arcticus*	dwarf-raspberry	B, F, M, S	AEP	
Forb/Fern	*Rubus chamaemorus*	cloudberry	B, F, S	AEP	IF DOM
Forb/Fern	*Rubus pubescens*	dewberry	B, F, M, S	AEP	
Forb/Fern	*Rumex acetosa*	Garden Sorrel		US	IF DOM
Forb/Fern	*Rumex acetosella*	Common Sheep Sorrel		US	IF DOM
Forb/Fern	*Rumex aquaticus*	Western Dock		US	YES
Forb/Fern	*Rumex britannica*	water dock	M, S	AEP	
Forb/Fern	*Rumex crispus*	curled dock	M, S	AEP	IF DOM
Forb/Fern	*Rumex fueginus*	Tierra del Fuego Dock		US	YES
Forb/Fern	*Rumex longifolius*	Door-Yard Dock		US	IF DOM
Forb/Fern	*Rumex maritimus*	golden dock	F, M, W	AEP	IF DOM
Forb/Fern	*Rumex occidentalis*	Western Dock		US	YES
Forb/Fern	*Rumex paucifolius*	Alpine Sheep Sorrel		US	IF DOM
Forb/Fern	*Rumex pseudonatronatus*	Field Dock		US	IF DOM
Forb/Fern	*Rumex stenophyllus*	Narrow-Leaf Dock		US	YES
Forb/Fern	*Rumex triangulivalvis*	narrow-leaved field dock	M	AEP	
Forb/Fern	*Rumex venosus*	Veiny Dock		US	IF DOM
Forb/Fern	*Ruppia cirrhosa*	widgeon-grass	M, W	AEP	
Forb/Fern	*Sagina decumbens*	Trailing Pearlwort		US	IF DOM
Forb/Fern	*Sagina nivalis*	Snow Pearlwort		US	YES
Forb/Fern	*Sagina saginoides*	Alpine Pearlwort		US	YES
Forb/Fern	*Sagittaria cuneata*	arum-leaved arrowhead	M	AEP	
Forb/Fern	*Sagittaria latifolia*	broad-leaved arrowhead	M	AEP	
Forb/Fern	*Salicornia rubra*	samphire	M	AEP	
Forb/Fern	*Salsola kali*	Russian-thistle	M	AEP	

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Sanicula marilandica*	snakeroot	S	AEP	IF DOM
Forb/Fern	*Sarracenia purpurea*	pitcher-plant	B, F, S	AEP	
Forb/Fern	*Saxifraga adscendens*	Wedge-Leaf Saxifrage		US	YES
Forb/Fern	*Saxifraga caespitosa*			US	IF DOM
Forb/Fern	*Saxifraga cernua*			US	YES
Forb/Fern	*Saxifraga ferruginea*	Russet-Hair Saxifrage		US	YES
Forb/Fern	*Saxifraga lyallii*	Red-Stem Saxifrage		US	YES
Forb/Fern	*Saxifraga mertensiana*	Woodland Saxifrage		US	YES
Forb/Fern	*Saxifraga occidentalis*	Mountain Saxifrage		US	IF DOM
Forb/Fern	*Saxifraga odontoloma*	Streambank Saxifrage		US	YES
Forb/Fern	*Saxifraga oppositifolia*	Purple Mountain Saxifrage		US	IF DOM
Forb/Fern	*Saxifraga oregana*	Bog Saxifrage		US	YES
Forb/Fern	*Scheuchzeria palustris*	scheuchzeria	B, F	AEP	
Forb/Fern	*Scrophularia lanceolata*	Lance-Leaf Figwort		US	IF DOM
Forb/Fern	*Scutellaria galericulata*	marsh skullcap	F, M, S	AEP	
Forb/Fern	*Selaginella selaginoides*			US	YES
Forb/Fern	*Senecio congestus*	marsh ragwort	M	AEP	YES
Forb/Fern	*Senecio eremophilus*	cut-leaved ragwort	M	AEP	IF DOM
Forb/Fern	*Senecio integerrimus*	Lamb-Tongue Ragwort		US	IF DOM
Forb/Fern	*Senecio lugens*	Small Black-Tip Ragwort		US	YES
Forb/Fern	*Senecio triangularis*	Arrow-Leaf Ragwort		US	YES
Forb/Fern	*Silene acaulis*	Cushion-Pink		US	IF DOM
Forb/Fern	*Sinapis alba*	White Mustard		US	YES
Forb/Fern	*Sinapis arvensis*	wild mustard	M	AEP	
Forb/Fern	*Sisyrinchium montanum*	common blue-eyed grass	F, M, W	AEP	IF DOM
Forb/Fern	*Sium suave*	common waterparsnip	F, M	AEP	
Forb/Fern	*Solidago canadensis*	Canada goldenrod	M, S	AEP	NO
Forb/Fern	*Solidago gigantea*	late goldenrod	M	AEP	IF DOM
Forb/Fern	*Sonchus arvensis*	perennial sow-thistle	M, S	AEP	IF DOM
Forb/Fern	*Sonchus asper*	prickly annual sow-thistle	M	AEP	IF DOM
Forb/Fern	*Spergularia rubra*			US	IF DOM
Forb/Fern	*Spergularia salina*	salt-marsh sand spurry	B, F, M	AEP	
Forb/Fern	*Spiranthes lacera*	Northern Slender Ladies'-Tresses		US	IF DOM
Forb/Fern	*Spiranthes romanzoffiana*	hooded ladies'-tresses	B, F, M, S	AEP	
Forb/Fern	*Spirodela polyrhiza*	common duckmeat		US	YES
Forb/Fern	*Stachys palustris*	marsh hedge-nettle	M	AEP	
Forb/Fern	*Stachys pilosa*			US	YES

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Stellaria borealis*	Boreal Starwort		US	YES
Forb/Fern	*Stellaria calycantha*	northern stitchwort	F, M, S, W	AEP	
Forb/Fern	*Stellaria crassifolia*	fleshy stitchwort	F, M	AEP	
Forb/Fern	*Stellaria crispa*	Ruffled Starwort		US	YES
Forb/Fern	*Stellaria longifolia*	long-leaved chickweed	F, M, S	AEP	
Forb/Fern	*Stellaria longipes*	long-stalked chickweed	M	AEP	
Forb/Fern	*Stellaria obtusa*	Rocky Mountain Starwort		US	YES
Forb/Fern	*Stellaria umbellata*	Umbrella Starwort		US	YES
Forb/Fern	*Stenanthium occidentale*	Western Featherbells		US	IF DOM
Forb/Fern	*Streptopus amplexifolius*	Clasping Twistedstalk		US	YES
Forb/Fern	*Streptopus lanceolatus* var. roseus	rose mandarin	S	AEP	
Forb/Fern	*Stuckenia filiformis*	thread-leaved pondweed	M	AEP	
Forb/Fern	*Stuckenia pectinata*	sago pondweed	M, W	AEP	
Forb/Fern	*Stuckenia pectinatus*	Sago Pondweed		US	YES
Forb/Fern	*Stuckenia vaginata*	large-sheath pondweed	W	AEP	
Forb/Fern	*Suaeda calceoliformis*	western seablite	M	AEP	
Forb/Fern	*Suckleya suckleyana*	poison suckleya	F, M, W	AEP	
Forb/Fern	*Suksdorfia ranunculifolia*	Buttercup-Leaf Mock Brookfoam		US	YES
Forb/Fern	*Symphyotrichum boreale*	marsh aster	F, M, W	AEP	
Forb/Fern	*Symphyotrichum ciliatum*	rayless aster	M	AEP	
Forb/Fern	*Symphyotrichum ciliolatum*	Lindley's aster	M, S	AEP	
Forb/Fern	*Symphyotrichum ericoides*	tufted white prairie aster	M	AEP	NO
Forb/Fern	*Symphyotrichum lanceolatum*	western willow aster	M	AEP	
Forb/Fern	*Symphyotrichum puniceum*	purple-stemmed aster	F, M, S, W	AEP	IF DOM
Forb/Fern	*Symphyotrichum subspicatum*			US	YES
Forb/Fern	*Tanacetum vulgare*	common tansy	M	AEP	NO
Forb/Fern	*Taraxacum erythospermum*	red-seeded dandelion	M	AEP	
Forb/Fern	*Taraxacum officinale*	common dandelion	M, S	AEP	NO
Forb/Fern	*Thalictrum dasycarpum*	tall meadow rue	S	AEP	IF DOM
Forb/Fern	*Thalictrum occidentale*	Western Meadow-Rue		US	IF DOM
Forb/Fern	*Thalictrum sparsiflorum*			US	IF DOM
Forb/Fern	*Thalictrum venulosum*	veiny meadow rue	S	AEP	IF DOM
Forb/Fern	*Thlaspi arvense*	stinkweed	M	AEP	NO
Forb/Fern	*Tiarella trifoliata*	Threeleaf Foamflower		US	IF DOM

Form	Scientific Name	Common Name	Wetland Classes	Wet Status Source	US Wetland status
Forb/Fern	*Tofieldia pusilla*	Scotch False Asphodel		US	IF DOM
Forb/Fern	*Triantha glutinosa*	sticky false asphodel	M, F, S	AEP	
Forb/Fern	*Trientalis borealis*	northern starflower	S, M	AEP	IF DOM
Forb/Fern	*Trientalis europaea*	Arctic starflower	F, S	AEP	NO
Forb/Fern	*Trifolium hybridum*	alsike clover	M	AEP	NO
Forb/Fern	*Trifolium repens*	white clover	M	AEP	NO
Forb/Fern	*Triglochin maritima*	seaside arrow-grass	F, M	AEP	
Forb/Fern	*Triglochin palustris*	slender arrow-grass	F, S, M	AEP	
Forb/Fern	*Trollius laxus*	American Globeflower		US	YES
Forb/Fern	*Ulmus americana*			US	IF DOM
Forb/Fern	*Urtica dioica*	common nettle	F, S, M	AEP	IF DOM
Forb/Fern	*Urtica urens*	small nettle	M	AEP	
Forb/Fern	*Utricularia cornuta*	horned bladderwort	M, W	AEP	
Forb/Fern	*Utricularia intermedia*	flat-leaved bladderwort	F, M, S, W	AEP	
Forb/Fern	*Utricularia macrorhiza*	Greater Bladderwort		US	YES
Forb/Fern	*Utricularia minor*	small bladderwort	F, M, S, W	AEP	
Forb/Fern	*Utricularia vulgaris*	common bladderwort	F, M, W	AEP	
Forb/Fern	*Utricularia macrorhiza*	common bladderwort		US	YES
Forb/Fern	*Valeriana dioica*	northern valerian	F, M, W	AEP	
Forb/Fern	*Verbena hastata*	swamp verbena		US	IF DOM
Forb/Fern	*Veronica americana*	American brooklime	M	AEP	
Forb/Fern	*Veronica anagallis-aquatica*	speedwell	F, M	AEP	
Forb/Fern	*Veronica peregrina*	hairy speedwell	M	AEP	
Forb/Fern	*Veronica scutellata*	marsh speedwell	F, M. W	AEP	
Forb/Fern	*Veronica serpyllifolia*	Thyme-Leaf Speedwell		US	YES
Forb/Fern	*Vicia americana*	wild vetch	F, M, S	AEP	NO
Forb/Fern	*Viola macloskeyi*	Macloskeyi's violet	M	AEP	
Forb/Fern	*Viola nephrophylla*	Northern Bog Violet		US	YES
Forb/Fern	*Viola palustris*	marsh violet	M, S	AEP	
Forb/Fern	*Viola renifolia*	kidney-leaved violet	F, S	AEP	
Forb/Fern	*Viola sororia* var. affinis	bog violet	B, F, M	AEP	
Forb/Fern	*Wolffia borealis*	northern ducksmeal	M, W	AEP	
Forb/Fern	*Wolffia columbiana*	watermeal	M, W	AEP	
Forb/Fern	*Xanthium strumarium*	cocklebur	W	AEP	IF DOM
Forb/Fern	*Zannichellia palustris*	horned pondweed	M, W	AEP	
Forb/Fern	*Zizia aptera*	heart-leaved Alexanders	M	AEP	IF DOM

Appendix B. How ABWRET-A Was Developed and Field-calibrated

1. ABWRET-A Origins and Evolution

ABWRET-A is a regionalized modification of WESP, the Wetland Ecosystem Services Protocol (Adamus et al. 2010 and updates). WESP and ABWRET-A build upon indicator-function relationships first described by the author in the early 1980s and in several agency publications since then (Adamus 1983, Adamus et al. 1987, Adamus et al. 1992, Adamus 1992a, 1992b). WESP and ABWRET also incorporate elements of the Hydrogeomorphic (HGM) Approach (Brinson 1993, Smith et al. 1995) and the Millennium Ecosystem Assessment (Finlayson et al. 2005). From 2006 to 2009 a regionalisation of WESP was conducted in Oregon, resulting in ORWAP[4], the Oregon Rapid Wetland Assessment Protocol (Adamus et al. 2009). That version is now required for all major wetlands permitting and compensation in Oregon. Another WESP regionalisation, applicable to all wetlands of Southeast Alaska, has been completed for the U.S. Fish and Wildlife Service and a final version will be published in 2015 for that region[5] .

In March 2011, the Ecosystem Services program within Alberta Environment and Parks (AEP) hosted a workshop of about 30 natural resource modellers to identify a protocol or set of models that would give absolute or relative measures of ecosystem services provided by Alberta's wetlands, was practical to use, and was ready (or close to ready) for application. An outcome of that workshop was that AEP staff determined that if WESP could be modified easily to reflect wetland and land use features specific to Alberta, it was the most likely of the protocols and models considered, to meet those criteria. Subsequently, AEP initiated and completed a pilot study of ways to assess ecosystem services of wetlands in the Shepard Slough region of east Calgary (Raudsepp-Hearne and Kerr 2011, Irena F. Creed Consulting 2011, DUC 2011, O2 Planning & Design Inc. 2011a). The pilot study was part of the longer term AEP Ecosystem Services Roadmap, which is intended as a tool under the Cumulative Effects Management Framework to help inform trade-off decisions and assure more robust decision-making. The pilot study aimed to demonstrate the use and replicability of ecosystem services approaches to support AEP priorities. One part of that study involved applying WESP, not yet modified for Alberta, to 21 wetlands in that study area (O2 Planning + Design Inc. 2011b). The assessments were done by a few environmental professionals from City of Calgary, AEP, and O2 Planning + Design Inc. All had first attended a training session in June 2011 taught by the author. At the completion of the pilot study, WESP was determined to have a strong potential for use in the wetlands approvals process in Alberta, provided it be modified and calibrated for each major region of the province. With partial support from the North American Waterfowl Management Plan (NAWMP), a regionalized precursor to ABWRET-A, initially termed WESPAB, was developed, field-calibrated, and published in 2013. With funding from AEP, over 100 consultants and AEP staff in southern Alberta were trained in its use.

Six months later the Government of Alberta released a long-anticipated Wetland Policy which, among other things, specified the development within a short time of a field-based tool for rapidly assessing wetland functions in each of Alberta's major natural regions. AEP determined that the framework provided by WESP and WESPAB offered the most practical and relevant foundation for that field tool, and termed it ABWRET-A (Alberta Wetland Rapid Evaluation Tool-Actual). Only indicators and models that estimated a function of a wetland (not a benefit or ecosystem service) carried over into the ABWRET-A tool. All models received some modifications to expand the models' relevance to both Grasslands and Parklands natural regions, and organize the tool to meet the five aggregate wetland functions (hydrologic health, water quality protection and

[4] http://www.oregon.gov/dsl/WETLAND/Pages/or_w et_prot.aspx

[5] WESPAK-SE (Wetland Ecosystem Services Protocol for Southeast Alaska): http://southeastalaskalandtrust.org/wetland-mitigation-sponsor/wespak-se/

improvement, ecological health and biodiversity, human use and recognition, and historical loss/current abundance) and relative value categories (A, B, C, D) managed by the policy. Early in 2014, AEP and the North American Waterfowl Management Plan (NAWMP) contracted the development and field-calibration of ABWRET-A in parts of the province's White Area that had not been the focus of WESPAB. After publication of ABWRET-A for the White Area, in 2015 they extended the effort to include major parts of the Green Area.

The basic steps of the ABWRET-A regionalisation process were:

1. Identify and review technical literature from this region and other regions as relevant. Use that review to modify or add to the indicator variables that ABWRET-A uses to assess wetland functions
2. Select a set of wetlands to which ABWRET-A will be applied in order to (a) calibrate (scale) ABWRET-A scores to this particular region, and (b) identify technical weaknesses in the ABWRET-A indicators and models that can be corrected
3. Collect ABWRET-A data from those wetlands
4. Modify as needed and then complete the protocol

Details of these steps are described below.

2. Literature Review

To better understand relationships among variables that might indicate functions of wetlands in the Boreal and Foothills natural regions specifically, it was first necessary to identify and read previously published studies. The author used keyword searches of Web of Science and Google Scholar to identify those. In addition to using such obvious keywords as Alberta and wetlands, the author expanded the query to include various forms of terms such as peatland, lake, pond, stream, river, groundwater, catchment, watershed, and paired those with keywords describing geographic features within the 2014 study area (e.g., North Saskatchewan River, Grande Prairie) or nearby regions. An indexed database was created that allows the citations to be sorted quickly by any combination of topics. Most of the citations refer to peer-reviewed scientific publications, and the abstracts of all (and sometimes the entire publication) were read. The database was subsequently used to document the reasons behind using particular variables in particular ABWRET-A models, as well as to support generally the weights assigned to various conditions of a given indicator.

3. Selection of Regional Calibration Wetlands

Although each of ABWRET-A's scoring models has a theoretical minimum score of 0 and a maximum of 1, the actual range for any given function is usually narrower, even when ABWRET-A is applied to a large number of wetlands. Moreover, in such an application, the resulting range of the raw scores found among all sites will be quite narrow (e.g., 0.3 to 0.8) for some functions whereas for others it will be broad (e.g., 0 to 1.0). Thus, to facilitate rough comparisons among functions, all raw scores had to be converted mathematically to the same 0 to 1 scale. This was done by comparing them with the range of scores determined for 102 wetlands that were visited and assessed in the boreal part of the Green Area during 2015 and foothills in 2016. This comparison process is termed "calibration" or "normalisation".

The wetlands that served as this base of comparison were chosen in a systematic manner from a population of 240,661 wetlands comprising the Alberta Merged Wetlands Inventory spatial data layer in the boreal part of the Green Area. Random sampling was not used because our objective was to define the likely range of ABWRET-A score variation with as few wetlands as possible -- not to use a sample to characterize the condition of wetlands in the study area generally. Our non-random but systematic sample was limited to mapped wetlands located within 300 m of roads because wetlands located farther from roads would require too much time to access, and identifying wetlands not previously mapped (e.g., many that are flooded only ephemerally or temporarily) would require costly and time-consuming analysis of imagery, much of which was not available for parts of the study region. Because the conditions of the ABWRET-A indicators could not be determined prior to field inspection, we used existing spatial data available for all or most of the region as surrogates for some of our indicators which are more accurately determined on-site. Doing so required (1) identifying those relevant layers, (2) using GIS to intersect them with the layer showing all the region's mapped wetlands that exist within the 300-m road-proximate buffer, (3) compiling the spatial data for each wetland in an Access database, and (4) conducting a k-means cluster analysis to place each of the road-proximate wetlands into one of 50 groups based on similarity of the wetland's attributes (as detected by existing spatial data) with those of the other mapped wetlands.

The number of groups (50) specified a priori for the clustering was chosen because that is the maximum number we initially estimated could be visited and assessed by field crews within the 2-3 months available for the calibration field effort. Our objective was to assess at least one wetland from each of the 50 clusters because that approach would most likely maximize the variation in indicator variables and thus scores for functions. Attributes used to define the statistical clusters included wetland class (17 classes), size (area), percentage of wetland with open water, presence/absence of an intersecting stream, climate, groundwater discharge/recharge area, index of linear disturbance, and surrounding land cover. We were able to visit and assess more than one representative of most clusters and were able to assess all but one cluster (#33). That cluster contained only 0.48% of the region's wetlands (Table B-1).

In 2015, we visited and applied ABWRET-A to 102 wetlands in the boreal. Locations of those wetlands are shown in Figure B-1. Foothills data will be included in the update to this manual.

Table B-1. Selected wetland representation by cluster in the boreal portion of Alberta's Green Area.
(Foothills data will be included following 2016 field season)

Cluster ID	# of mapped wetlands in the cluster	% of total	# of wetlands assessed in the cluster	assessed as % of wetlands in the cluster
0	782	2.11%	2	0.26%
1	487	1.31%	1	0.21%
2	780	2.10%	2	0.26%
3	213	0.57%	2	0.94%
4	577	1.56%	2	0.35%
5	133	0.36%	2	1.50%
6	331	0.89%	2	0.60%
7	330	0.89%	2	0.61%
8	811	2.19%	2	0.25%
9	831	2.24%	2	0.24%
10	578	1.56%	2	0.35%
11	502	1.35%	2	0.40%
12	890	2.40%	2	0.22%
13	1430	3.86%	2	0.14%
14	1170	3.16%	2	0.17%
15	290	0.78%	2	0.69%
16	400	1.08%	2	0.50%
17	1978	5.34%	2	0.10%
18	23	0.06%	2	8.70%
19	896	2.42%	2	0.22%
20	1363	3.68%	2	0.15%
21	385	1.04%	1	0.26%
22	1103	2.98%	2	0.18%
23	1510	4.07%	2	0.13%
24	436	1.18%	2	0.46%
25	379	1.02%	4	1.06%
26	179	0.48%	3	1.68%

Cluster ID	# of mapped wetlands in the cluster	% of total	# of wetlands assessed in the cluster	assessed as % of wetlands in the cluster
27	869	2.34%	2	0.23%
28	1170	3.16%	2	0.17%
29	1530	4.13%	2	0.13%
30	116	0.31%	2	1.72%
31	460	1.24%	2	0.43%
32	1612	4.35%	2	0.12%
33	178	0.48%	0	0.00%
34	210	0.57%	3	1.43%
35	838	2.26%	2	0.24%
36	377	1.02%	2	0.53%
37	707	1.91%	2	0.28%
38	2082	5.62%	2	0.10%
39	558	1.51%	2	0.36%
40	563	1.52%	2	0.36%
41	556	1.50%	2	0.36%
42	1122	3.03%	2	0.18%
43	523	1.41%	2	0.38%
44	240	0.65%	3	1.25%
45	103	0.28%	1	0.97%
46	1048	2.83%	2	0.19%
47	893	2.41%	2	0.22%
48	1149	3.10%	2	0.17%
49	1383	3.73%	2	0.14%

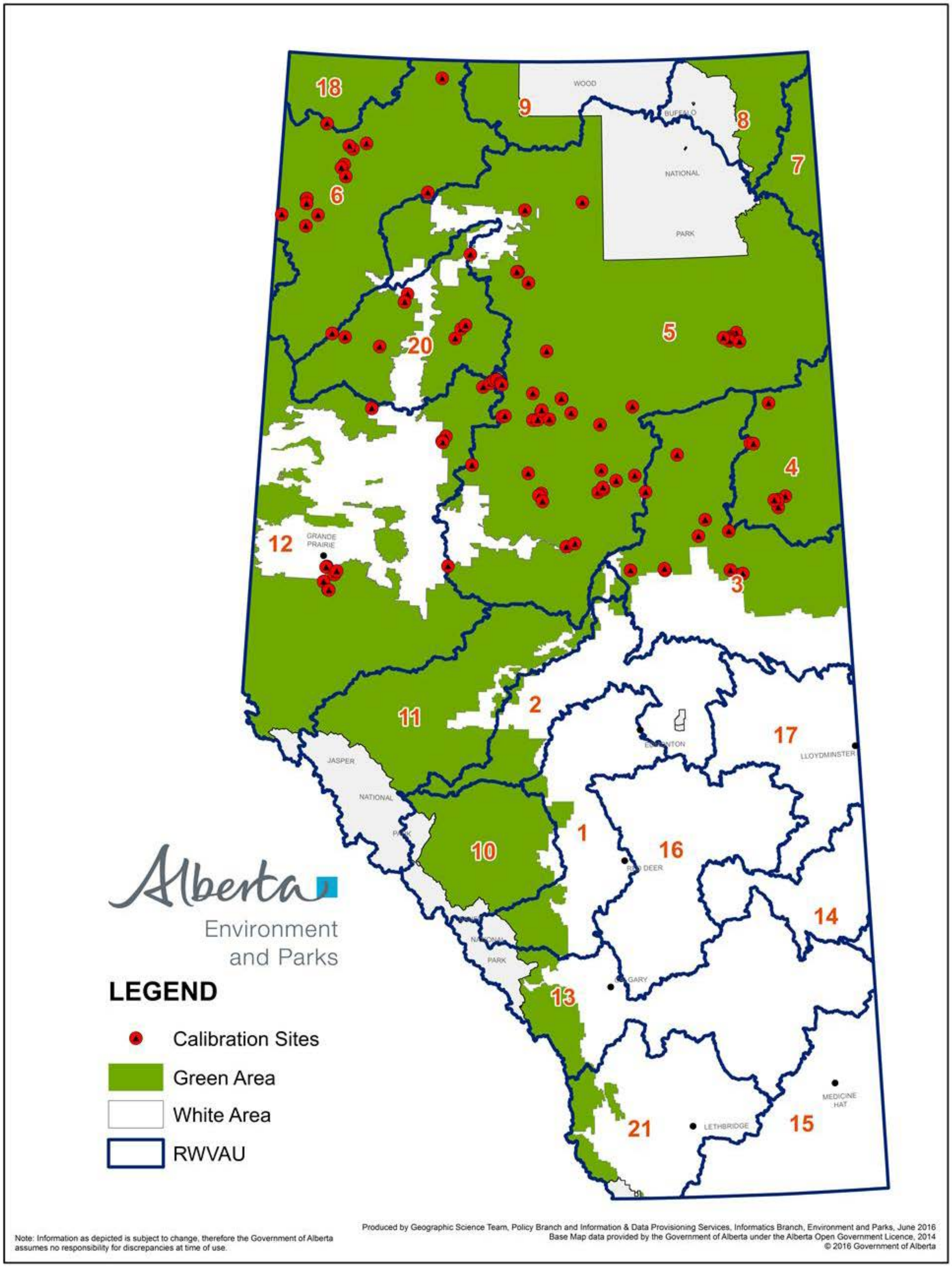


Figure B-1. General locations for 102 wetlands that were assessed in the Green Area during 2015.

(Foothills wetlands will be added following the 2016 field season)

4. Data Collection and Processing

4.1. Organizing and Conducting the Field Effort

In many instances, the wetlands chosen for visitation and assessment proved to be inaccessible or non-existent. In most such cases, attempts were made at a later date to visit and assess an alternate wetland belonging to the same statistical cluster. Visiting and assessing a wide variety of wetlands was essential not only to calibrate the indicators and model scores as described previously, but also to clarify the wording of questions on the data forms and streamline them by determining the most efficient order of questions, i.e., which sequencing allows users to skip the most questions in various contexts. Thus, limited parts of the data forms (but not the formulas in the scoring models) were changed iteratively by the author in the midst of the field efforts. Revisions were made in response to field observations of the author and field crews. The changing of questions throughout the data collection effort could potentially complicate data interpretation. However, close track was kept of revisions made to the data forms, allowing all data to later be successfully "cross-walked" to the final version.

4.2. Completing the Office Data Component

Field data alone are insufficient to accurately score a wetland's functions. Additional data must be obtained from interpreted aerial images and existing databases. After site visits had been completed, a set of GPS point coordinates were provided to GIS staff at AEP. They subsequently delineated the extent of each wetland polygon that contained the point coordinates. They then extracted from existing databases all the digital information required in ABWRET-A's worksheet OF and imported it into the models which combined it with the field observations to generate the function scores.

5. Literature Cited

Adamus, P. R. 1983. A Method for Wetland Functional Assessment. Vol. II. Methodology. Report No. FHWA-IP-82-24. Federal Highway Administration, Washington, D.C.

Adamus, P.R. 1992a. Condition, values, and loss of natural functions of prairie wetlands of the North-Central United States. EPA/600/R-92/249. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.

Adamus, P.R. 1992b. Conceptual process model for basin-type wetlands of the Prairie Pothole Region. EPA/600/R-92/249. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.

Adamus, P. R., E. J. Clairain, Jr., R. D. Smith, and R. E. Young. 1987. Wetland Evaluation Technique (WET) Volume II: Methodology. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Adamus, P.R., E.J. Clairain, Jr., D.R. Smith, and R.E. Young. 1992. Wetland Evaluation Technique (WET). Volume I: Literature review and evaluation rationale. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Adamus P.R., J. Morlan, and K. Verble. 2009. Oregon Rapid Wetland Assessment Protocol (ORWAP): Calculator spreadsheet, databases, and data forms. Oregon Dept. of State Lands, Salem, OR.

Adamus, P., J. Morlan, and K. Verble. 2010. Wetland Ecosystem Services Protocol for the United States (WESP). Beta test version 1.0. Online: http://people.oregonstate.edu/~adamusp/WESP/

Akbar, T. A., Q. K. Hassan, and G. Achari. 2011. A methodology for clustering lakes in Alberta on the basis of water quality parameters. Clean-Soil Air Water 39:916-924.

Brinson, M. M. 1993. A hydrogeomorphic classification of wetlands. Technical Report WRP-DE-11. Environmental Research Laboratory, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Ducks Unlimited Canada (DUC). 2011. Ecosystem service approach pilot on wetlands: assessment of current and historic wetland carbon stores in the Shepard Slough Area. Report to Alberta Environment and Sustainable Resource Development, Edmonton, AB.

Finlayson, C. M., R. D'Cruz, and N. Davidson. 2005. Ecosystems and Human Well-being: Wetlands and Water: Synthesis. World Resources Institute, Washington, DC.

Irena F. Creed Consulting. 2011. Ecosystem service approach pilot on wetlands: Ecosystem service assessment of wetland water purification for the Shepard Slough Study Area. Report to Alberta Environment and Sustainable Resource, Edmonton, AB. http://environment.gov.ab.ca/info/library/8686.pdf

O2 Planning + Design Inc. 2011a. Ecosystem service approach pilot on wetlands: Assessment of Water Storage and Flood Control Ecosystem services. Report to Alberta Environment and Sustainable Resource, Edmonton, AB. http://environment.gov.ab.ca/info/library/8687.pdf

O2 Planning + Design Inc. 2011b. Ecosystem service approach pilot on wetlands:Wetland Ecosystem Services Protocol for the United States (WESP) Site Assessments. Report to Alberta Environment and Sustainable Resource, Edmonton, AB. http://environment.gov.ab.ca/info/library/8688.pdf.

Raudsepp-Hearne, C. and G. Kerr. 2011. Ecosystem service approach pilot on wetlands: Operationalizing an ecosystem service approach within the Government of Alberta: Steps and lessons learned. Report to Alberta Environment and Sustainable Resource, Edmonton, AB. http://environment.gov.ab.ca/info/library/8683.pdf

Rosen, B. H., P. Adamus, and H. Lal. 1995. A conceptual model for the assessment of depressional wetlands in the Prairie Pothole Region. Wetlands Ecology and Management 3:195-208.

Smith, R.D., A. Ammann, C. Bartoldus, and M.M. Brinson. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. Tech. Rept. WRP-DE-9, Waterways Exp. Stn., US Army Corps of Engineers, Vicksburg, MS.

Appendix C. Description of ABWRET-A Calculations for Scoring and Categorizing Alberta Wetlands

1. Organization of This Appendix

This appendix begins with a discussion of general principles used to score ABWRET-A's indicator variables (questions in data forms) as well as principles used to structure the models of wetland functions which the indicators are intended to predict. The section then proceeds to describe, for each function, specifically how the indicator variables were combined in scoring models.

2. Principles Used to Score Indicators and Structure the Models

2.1. Introduction

Many models in ecology and especially hydrodynamics are deterministic. That is, rates are first estimated or measured for individual processes that comprise (for example) a river channel function, and then mathematical formulas (e.g., hydraulic or thermodynamic equations) are prescribed to combine variables that determine those processes into an actual rate for a function, e.g., grams of phosphorus retained per square meter per year. However, generally applicable measurements of the processes and the variables that determine them simply do not exist for the types of wetlands occurring in much of Alberta. Attempts have been made to build such models on whatever regional data do exist (e.g., Feng et al. 2011, Rahbeh et al. 2011). But due to the lack of data involving direct measures of wetland function from a broad array of wetlands, ABWRET-A uses a different approach to model the various things that wetlands do naturally. Rather than being deterministic, that approach is at times speculative but logic-based and heuristic. Such approaches are well-regarded as an interim or alternative solution when knowledge of system behaviour is scant (e.g., Haas 1991, Starfield et al. 1994, Doyle 2006).

2.2. Indicators

For most ABWRET-A models, physical or biological *processes* that influence a given function were first identified and then *indicators* of those processes were chosen and grouped accordingly. (The term *indicators* is comparable to the term *metrics* used by some other methods). The indicators then were phrased as questions in the data forms. Very few of ABWRET-A's field-level indicators require *measurement*; they are based on visual estimates. While the *precision* of measurements is typically greater than for visual estimates, their *accuracy* in predicting functions may or may not be. That is because it is often difficult to obtain sufficient measurements of an indicator, in the span of time typically available to wetland regulators or consultants, to create a full representation of any particular indicator of wetland function, let alone all the indicators that would be needed to assess a common suite of functions.

ABWRET-A's indicators were mainly drawn from inferences based on scientific literature and the author's experience throughout North America (e.g., Adamus 1993, Adamus et al. 1987, Adamus et al. 1992) and particularly the prairies (e.g. Adamus 1992a,b). Indicators used by other methods for rapidly assessing functions of wetlands in North America were also considered. To qualify as an indicator, a variable not only had to be correlated with or a driver of the named process or function, but it also had to be rapidly observable during a single visit to a typical wetland during the Alberta growing season, or information on the indicator's condition had to be obtainable from aerial imagery, existing spatial data, and/or landowner interview.

When developing models of any kind, the factors that contribute to the output can be categorized in three ways: (1) unknown influencers, (2) known influencers that are difficult to measure within a reasonable span of time, and (3) influencers that can be estimated visually during a single visit and/or from existing spatial data. ABWRET-A provides an incomplete estimate of wetland functions because it incorporates only #3. Also, some of the indicator variables it uses may be *correlates* of wetland functions rather than actual influencers. For example, changes in water levels are correlated with changes in nutrient cycling, but it is the difficult-to-measure changes in sediment oxygen and pH that induce the changes in nutrient cycling, not the water level changes themselves (which happen to correlate loosely with those changes in oxygen and pH). These types of limitations apply to all rapid assessment methods.

For regulatory and management applications (e.g., wetland functional enhancement), it's often helpful to understand to which of four categories an indicator belongs:

1. **Onsite modifiable.** These indicators are features that may be either natural or human-associated and are relatively practical to manage. Examples are water depth, flood frequency and duration, amount of large woody debris, and presence of invasive species. More important than the simple presence of these are their rates of formation and resupply, but those factors often are more difficult to control.
2. **Onsite intrinsic.** These are natural features that occur within the wetland and are not easily changed or managed. Examples are soil type and groundwater inflow rates. They are poor candidates for manipulation when the goal is to enhance a particular wetland function.
3. **Offsite modifiable.** These are human or natural features whose ability to be manipulated in order to benefit a particular wetland function depends largely on property boundaries, water rights, local regulations, and cooperation among landowners. Examples are watershed land use, stream flow in wetland tributaries, lake levels, and wetland buffer zone conditions.
4. **Offsite intrinsic.** These are natural features such as a wetland's topographic setting (catchment size, elevation) and regional climate that in most cases cannot be manipulated. Still, they must be included in a wetland assessment method because of their sometimes-pivotal influence on wetland functions.

2.3. Weighting and Scoring

Explicitly or implicitly, ABWRET-A assigns relative weights or scores at seven junctures:

1. Scoring of the *conditions* of an indicator variable, as they contribute to that indicator's prediction of a given wetland process, function, or other attribute
2. Scoring of *indicators* (metrics) relative to each other, as they together may predict a given wetland process, function, or other attribute
3. Scoring of wetland *processes*, as they together may predict a given wetland function or other attribute
4. Combining scores for 15 wetland functions into function *group* scores (4 per wetland)
5. Combining function group scores into wetland *value scores* (1 per wetland)
6. Converting wetland value scores to relative value *categories*
7. Scaling wetland categories in some regions (Relative Wetland Value Assessment Units) by applying an **abundance factor**

Each of these is now described.

2.3.1. Weighting of Indicator Conditions

As an example of #1, consider the following conditions of the indicator, Ponded Open Water Percentage as it is applied by ABWRET-A to estimate the Waterbird Habitat function:

A	B	C	D	E	F	G
F33	% of Ponded Water That Is Open	In ducks-eye aerial view, the percentage of the ponded water that is open (lacking emergent vegetation during most of the growing season, and unhidden by a forest or shrub canopy) is:				0.00
		<1% or none, or largest pool occupies <0.01 hectares. Enter "1" and SKIP to F41 (Floating Algae & Duckweed).	0	1	0	
		1-5% of the ponded water. Enter "1" and SKIP to F41.	0	2	0	
		5-30% of the ponded water.	0	4	0	
		30-70% of the ponded water.	1	6	0	
		70-99% of the ponded water.	0	4	0	
		100% of the ponded water.	0	3	0	

Each row following the first one describes a possible *condition* of this indicator. You must select the one condition that best describes the wetland being assessed by entering a "1" next to that condition in column D). In column E, ABWRET-A's author previously assigned relative weights to each of these conditions as they relate to the function. You cannot alter those. In this case, the assessor's visual observation of the wetland met the fourth condition (30-70%), and so had been given a weight of six. This does not necessarily mean it is 6 times more influential than the first condition which has a weight of 1, because this is not a deterministic model. However, available literature seemed to suggest that this intermediate condition is distinctly better than the second and fourth condition choices, and so it was assigned a weight of 6, separating it by 2 points from the next closest conditions, rather than a weight of 5, thus signifying that the relationship of these conditions to the function is believed to be slightly nonlinear rather than linear. When the same indicator is used to score a different function, the weight scheme might be reversed or otherwise differ.

In many instances, considerable scientific uncertainty surrounds the exact relationship between various indicator conditions and a function, and thus which weights should be assigned. However, keep in mind that Ponded Open Water is just one of 47 indicators used to assign a score to the Waterbird Habitat function. To some degree, the use of so many indicators will serve to buffer the uncertainty in our knowledge of exact relationships.

ABWRET-A users will also notice that the weighting scale for some indicators ranges from 1 to 8 (especially if there are 8 condition choices) while for others it ranges only from 0 to 2, or some other range. This does not mean that the first indicator is secretly being weighted 4 times that of the second, because before the indicators are combined, their scores are "normalized" to a 0 to 1.00 scale. The Excel spreadsheet accomplishes that by multiplying the "1" signifying a user's choice (in column D) by the pre-determined condition weight in column E, and placing the product in the last column, whereupon a formula (not visible here) in the green cell takes the maximum of the values pertaining to this indicator in that last column and divides it by the maximum weight in column E, the condition weight column. The formula in the green cell could just as easily have taken the only non-zero value in the last column and divided it by the maximum weight pre-assigned to the indicator conditions.

Note also that the weight scale for some indicators begins at 0 while for others it begins at 1. Often, "0" was reserved for instances where, if the indicator was the only one being used, that condition of the indicator would suggest a nearly total absence of the function. Because each of the indicator scores is normalized, this difference (0 vs. 1) at the bottom end of the scales for different indicators is probably trivial.

2.3.2. Weighting and Scoring of Indicators of Wetland Functions

In most cases, ABWRET-A does not assign weights explicitly (i.e., as multipliers) to the various indicators of a function. More often, weights are implicit in the manner in which indicators are combined. For example, if a function model is:

Indicator A + (Average of: Indicator B, Indicator C, Indicator D)

This implies that Indicators B, C, and D individually are likely to have less weight than Indicator A because they are only contributing to an average rather than standing alone, and as such, a low score for one may compensate somewhat for a high score on another.

If one indicator is so important that occurrence of a particular condition of that indicator can solely determine whether a function even exists in a wetland, then conditional ("IF") statements are used in ABWRET-A models to show that. For example, if a wetland dries up annually, it is not on a floodplain, and it contains no inlets or outlets, the Fish Habitat function is automatically scored "0". In this case, "access" (presence/absence of inlets or outlets) is a controlling indicator. If a few indicators are not individually so controlling but at least one is likely to be strongly limiting in some instances, ABWRET-A takes the maximum score among the indicators, rather than the average. Averages are applied to situations where indicators are thought to be compensatory, collinear, or redundant. ABWRET-A uses averaging as the default operator unless situations can be identified where there is compelling evidence that an indicator is controlling or strongly limiting.

There also are instances where the condition of one indicator (such as wetland type) is used to determine the relevance of others for predicting a wetland function. For example, the effect of vegetation structure within a wetland on the wetland's ability to slow the downslope movement of water in a watershed can be ignored if the wetland has no outlet channel. In the ABWRET-A calculator spreadsheet, all such contingent relationships among indicators that we identified and incorporated into ABWRET-A models are documented in the Rationale column.

2.3.3. Weighting and Scoring of Wetland Processes That Influence Functions

For many functions, dozens of hydrologic (e.g., evapotranspiration) and/or ecological (e.g., juvenile fish dispersal) processes contribute to its ultimate level of performance. Often, too little is known about the relative importance of these processes in determining a wetland function, and for some processes there are no known indicators that can be estimated visually. Nonetheless, processes were used as an organizing framework for the many indicators it employed to score each function. For most functions, the processes are weighted like indicators and used as a "subscore" when computing the score for a function. For example, for the function Phosphorus Retention, the function model that estimates the ability of the wetland to trap sediments is

=(AVERAGE(OpenWpct3, Interspers3, WetVegArea) + AVERAGE(1-Sub0Days, Persis3, Lake3, VegWabs3, ThruFlo3, Constric3, Gradient3, Gcover3, Girreg3, SoilAlt3) + WetPctCA3) / 3

That means that WetPctCA3 was given one-third (1/3) of the weight, and the average of the other two groups of indicators are given the remaining two-thirds.

2.3.4. Normalizing of ABWRET-A Function Scores

ABWRET-A automatically normalizes (converts to a 0-to-1 scale) the raw scores from all wetlands in a study region. Normalizing answers the question, "How does this wetland compare with a large set of others in the study region?" In that sense, normalized scores are like percentiles. Normalizing also allows for straightforward comparison of any function score with any other function score from the same or a different wetland. The normalizing process, which was applied to the scores for each function, employed this widely-recognized formula:

raw score of **"wetland x"** – **minimum** score from all wetlands in the calibration suite

maximum score of all wetlands in sample set **-** **minimum** of all wetlands in calibration suite

2.3.5. Combining of Multiple Wetland Functions Into Rating Categories

A few more steps were required to convert a wetland's series of normalized function scores to a single A, B, C, or D value category for the wetland. Criteria used in these steps were policy-based rather than science-based:

1. For a given wetland, its highest normalized function score in each of the following function groups was used to define that group:
   - **Hydrologic Health:** highest score of Water Storage or Stream Flow Support
   - **Water Quality:** highest score of Water Cooling; Sediment Retention; Phosphorus Retention; Nitrate Removal
   - **Ecological Health:** highest score of Organic Nutrient Export; Invertebrate Habitat; Fish Habitat; Amphibian Habitat; Waterbird Habitat; Songbird, Raptor, and Mammal Habitat; Plant & Pollinator Habitat
   - **Human Use:** highest score of Fire Barrier or Human Use
2. The scores for these four function groups were combined into a "relative value score" by taking a weighted average, wherein the first three function groups (Hydrologic, Water Quality, Ecological) each accounted for 30 percent of the value score and the last (Human Use) accounted for 10 percent
3. The resulting relative value scores that were above the 90th percentile in the frequency distribution of all wetlands in the calibration sites were categorized as A, between the 70th and 90th percentile as B, between the 40th and 70th percentile as C, and scores below the 40th percentile as D
4. The resulting wetland's category was either left unchanged, or elevated one level (e.g., from C to B) if estimates of historical losses of wetland area and number in its Relative Wetland Value Assessment Unit (RWVAU) were large relative to those in other RWVAUs, or decreased one level if such losses were estimated as relatively minor and current abundance was high (See Figure 1 in main body of this document). This was called the "Abundance Factor." Procedures for estimating these historical losses and descriptions of criteria for large and small losses are provided in another document
5. Any wetland that scored in the 95th or 5th percentile of the calibration sites was exempt from the abundance factor, in order to retain at least 5% of D's and A's in every RWVAU

3. Model Descriptions

In each section below, a definition is provided of the function, followed by summaries of scientific evidence of it being performed by wetlands generally and in Alberta. This is followed by a simplified description of how the score for that function is computed by ABWRET-A, and finally, a brief note on how the ABWRET-A model for the function might be validated with direct measures of the function. The indicators (i.e., data form questions) that are mentioned in the narratives below are shorthand descriptions of indicators that are defined and explained fully in the ABWRET-A data forms.

3.1. Water Storage (WS)

Function Definition: The effectiveness of a wetland for (a) intercepting snow, (b) storing water aboveground, (c) recharging the moisture in subsurface soils and groundwater, and/or (d) delaying the downslope movement of surface water for long or short periods. In doing so, wetlands potentially influence the height, timing, duration, and frequency of inundation in other wetlands and in downstream or downslope areas. Prediction accuracy is anticipated to be much greater for (a) and (b) because for (c) and (d), measurements of soil depth and texture (at greater depth than is practical to dig during a rapid assessment) would be required, along with an understanding of subsurface water levels, flow direction, and exchange rates during different seasons.

Scientific Support for This Function in Wetlands Generally: Moderate to high. Many wetlands are capable of slowing the downslope movement of water, regardless of whether they have significant storage capacity, simply because wetlands are *relatively* flat areas in the landscape. When that slowing occurs in multiple wetlands, flood peaks further downstream are muted somewhat. When wetlands are, in addition, capable of storing (not just slowing) runoff, that water is potentially available for recharging aquifers and supporting local food webs. Wetlands are least effective when they act like impervious surfaces, transmitting rather than absorbing precipitation, and accelerating rather than delaying runoff.

In Alberta Wetlands: Many of the province's wetlands should be capable of performing this function, and efforts have been made to quantify it (e.g., Hubbard & Linder 1986, Gleason & Tangen 2008, Huang et al. 2011). Hydrologic functions of prairie wetlands have been described by LaBaugh et al. (1998) and others. Recharge of groundwater by some wetland depressions, especially drier ones (types I, II, and III) has been documented (e.g., Lissey 1971, Richardson and Arndt 1989, Loken 1991, Degenhardt et al. 2011) and occurs regardless of size of the depression. In at least some cases the recharge is shallow, potentially helping to support adjoining crops but usually not infiltrating into deeper aquifers (Hayashi et al. 1998, van der Kamp and Hayashi 2009). This may be a major contributor for sustaining cropland moisture (Berthold et al. 2004, Pham et al. 2009) but can increase the soil salinity along the edges of wetlands, thus limiting crop productivity in that zone. In many Alberta wetlands, the amount of surface water in late spring may be influenced more by snow accumulation during the previous fall and winter than by spring rainfall or by air temperature effects on evapotranspiration.

Where this function is performed to some degree, its benefit will depend partly on wetland location relative to areas potentially damaged by floods, and public dependency on aquifers that have a proven linkage to wetlands. In one case, recharge from wetlands in a 650-hectare prairie pothole area was estimated to provide 1.48 hectare-meters to the aquifer, enough to support 1699 head of cattle for one year (Hubbard and Linder 1986). A 15% reduction in winter precipitation and 2.5 degrees C increase in winter mean air temperature could dry up many streams in this region (Fang et al. 2010). Thus, any role that wetlands may play in storing water and supporting streamflow is important.

Model Structure:

- The score increases with decreasing surface water connectivity to downgradient channels (OutDura) and equally with **Surface Storage** (STORE), which together account for two-thirds of the score, the remainder being the average of **Flow Resistance & Delay** (RESIST) and **Infiltration/Evapotranspiration** (INFILT).

ABWRET-A FUNCTION MODEL
Water Storage & Delay
10*[2*AVERAGE(OutDura1, STORE) + AVERAGE(INFILT, RESIST)] /3

In the above calculations[6]:

- **Surface Storage** is assumed to be indicated by the average of the scores for wetland area (1/4 of the score, +, "WetArea"), amplitude of annual water level fluctuation (1/4 of the score, +, "Fluctual1"), percentage of the wetland that is inundated only seasonally (1/4 of the score, +, "SeasPct1")), and the average of 2 indicator scores: wetland area as a percentage of watershed area (+, WetPctCA1), and position in watershed (+ if closer to headwater, "ElevPctileHUC8")

Surface Storage Capacity [STORE]
AVERAGE(WetArea, AVERAGE(WetPctCA1, ElevPctileHUC8),Fluctua1, SeasPct1)

- **Flow Resistance & Delay** is indicated by the average of the scores for wetland gradient (+ if flatter, "Gradient1"), microtopography (+ if more varied, "Girreg1"), percentage of surface water that is ponded (+, "IsoDry1"), vegetated width (+, "vwidth1"), outlet constriction (+, "Constric1"), and the type and pattern of vegetation that intercepts surface waters flowing through the wetland ("ThruFlo1"). The first 2 of these indicators are applied to all wetlands, whereas the others are applied only to wetlands with surface water (and the last 2, only if an outlet is present)

Flow Resistance & Delay [RESIST]
AVERAGE(ThruFlo1, Gradient1, Girreg1, Constric1, IsoDry1, vwidth1)

- **Infiltration /Evapotranspiration** is expressed as the average of four groups, each consisting of averages of scores for multiple indicators. The first group is the average of springs (- if present, "GWDspring"), presence of groundwater indicators (-, "Groundw1"), and wetland class that is not a fen (-, "Type1"). The second is the average of score for soil texture (+ if coarse, "SoilTex1") combined with the score for subzero days (-, "Sub0Days"). The third group is the average of scores for precipitation

[6] Throughout this appendix, a "+" symbol means that indicator tends to increase the function or the referenced process, while a "-" tends to decrease it.

surplus (-, "PPET"), summertime wind (+, "WindSumm"), wetland perimeter-area ratio (+, "WetPerim2Area"), and percent of surface water that is open (+, "OpenPct1"). The fourth group is the average of scores for wetland vegetated area (+, "WetVegArea") and percentage of wetland vegetation that is woody (both +).

Infiltration or Evapotranspiration Capacity of Wetland [INFILT]
AVERAGE(1-GWDspring, Type1, Groundw1) + AVERAGE(1-Sub0Days, SoilTex1) + AVERAGE(1-PPET, WindSumm, WetPerim2Area, OpenPct1) + AVERAGE(WetVegArea, Burn1, AllWoody1)] / 4

Important Note: The model imperfectly addresses the role of wetland surface ***area*** in storing water. Obviously, larger wetlands can potentially store more water. Because the model is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores for this function than larger ones.

Potential for Future Validation: The volume, duration, and frequency of water storage could be measured in a series of wetlands that encompass the scoring range, and flows could be measured at their outlets, and at various points downstream. This could be done to calibrate detailed mechanistic models of water storage, e.g., SWAT (Abbaspour et al. 2010). Measurements should especially be made during major storm or snowmelt events. Procedures that might be used are described generally by Warne & Wakely (2000) and US Army Corps of Engineers (2005) and for prairie wetlands specifically by Conly et al. (2004) and Minke et al. (2010).

3.2. Stream Flow Support (SWS)

Function Definition: The effectiveness of a wetland for contributing water to streams during the driest part of a growing season.

Scientific Support for This Function in Wetlands Generally: Moderate.

In Alberta Wetlands: No measurements are available on the degree to which wetlands in this region may be performing this function. A study in Alaska found that 55% of the stream flow during a dry period originated from the near surface layers of peatlands within a watershed (Gracz et al. 2015).

Model Structure:

- If a wetland lacks an outlet (i.e., water never flows out during a typical year), it automatically is scored 0 for this function
- For all other wetland types, the score increases with increasing average of the scores for 4 indicator groups
  - The first group is the average of scores for presence of a spring (+, "GWDspring") or other indicators of groundwater discharge (+, "Groundw2"), predominant wetland class (Wettype2, fen preferred), and soil texture (organics considered best, "Soil2")
  - The second group is the average of scores for subzero days (+, "Sub0Days"), precipitation surplus (+, "PPET"), summertime wind (-, "WindSumm"), wetland perimeter-area ratio (-, "WetPerim2Area"), percentage of wetland that is open ponded water (- "OpenPonded2"), and wetland vegetated area (-, "WetVegArea")

- The third group is the average of scores for ratio of wetland area to watershed area (+, "WebPctHUC8"), watershed position (+ if closer to headwaters, "ElevPctileHUC8"), and location within a riparian or floodplain area (+, "RipFloodpl")
- The fourth group is the average of scores for wetland depth (+, "Depth2") and duration of outflow (+, "OutDur2")

ABWRET-A FUNCTION MODEL
Stream Flow Support
IF((OutNone + OutNone1>0),0, ELSE: 10*[AVERAGE(GWDspring, Groundw2_, Wettype2, Soil2_) + AVERAGE(Sub0Days, PPET, 1-WindSumm, 1-WetPerim2Area, OpenPonded2, 1-WetVegArea) + AVERAGE(WetPctHUC8, ElevPctileHUC8, RipFloodpl) + AVERAGE(Depth2_, OutDur2_)] / 4

The model does not account for the surface area of the wetland or the receiving water body's volume and flow rate. Obviously, larger wetlands could potentially contribute a greater *volume* of water to streams if other factors support this function. Because the model for this function is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores than larger ones. Thus, in the case of this particular function, a multiplication of function score by effective wetland area may sometimes be appropriate.

3.3. Water Cooling (WC)

Function Definition: The effectiveness of a wetland for maintaining or reducing the water temperature, primarily in headwater streams. This is potentially significant for supporting the habitat of many recreationally-important coldwater fish, as well as for avoiding conditions that support blooms of nuisance algae (which limit swimming and deprive aquatic animals of oxygen) and proliferation of microbes that cause disease in humans and livestock.

Scientific Support for This Function in Wetlands Generally: Low to moderate.

In Alberta Wetlands: A limited subset of the province's wetlands, particularly those with shade and substantial discharge of groundwater, should be capable of performing this function.

Model Structure:

- If a wetland lacks an outlet (i.e., water never flows out during a typical year, "OutNone + OutNon1), it automatically is scored 0 for this function
- For all other wetland types, the score increases with increasing scores for **Shading** (SHADE), **Groundwater Input** (GWin), and persistence of **Outflow** (OUT). These are all considered equally influential in most cases and so are averaged

ABWRET-A FUNCTION MODEL
Water Cooling
IF((OutNone + OutNone1>0),0, ELSE: 10*AVERAGE(SHADE, GWin, OUT)

In the above calculations:

- **Shading** is indicated by the average of two groups. One group averages the scores for wetland class (swamp and fen having the most potential, "WclassDom7"), percent of the wetland that never has surface water (because subsurface water is more protected from sunlight, "SatPct7"), and the percent of the summertime surface water that is shaded (+, "Shade7"). The other group averages the scores for water depth (+ for deeper water, "Depth7"), percent of wetland that is not ponded ("ISOdry7"), and percent of ponded water that is not open (+, "OpenPonded7").

Shading [SHADE]
AVERAGE [AVERAGE(SatPct7, Shade7) + AVERAGE(Depth7, ISOdry7, OpenPonded7)]

- **Groundwater Input** is assumed greater (and thus more cooling potential) if a spring is present (GWDspring), predominant wetland class (Fen is highest, "WclassDom7"), and indicators of groundwater discharge are present (Gwater7). The scores of these 3 indicators are averaged.

Groundwater Input [GWin]
AVERAGE(Gwater7, GWDspring, WclassDom7)

- **Export** is indicated by averaging the scores for outflow duration (+, "OutDur7"), location in a riparian or floodway area (+, RipFloodPl), and position in the watershed (+ if closer to headwater, "ElevPctileHUC8").

Export [OUT]
AVERAGE(OutDur7, RipFloodPl, ElevPctileHUC8)

The model does not account for the surface area of the wetland or the receiving water body's volume and flow rate. Obviously, larger wetlands could potentially provide a greater *volume* of cooled water if other factors support this function. Because the model for this function is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores than larger ones.

3.4. Sediment Retention and Stabilization (SR)

Function Definition: The effectiveness of a wetland for intercepting and filtering suspended inorganic sediments thus allowing their deposition, as well as reduce current velocity, resist erosion, and stabilize underlying sediments or soil.

Scientific Support for This Function in Wetlands Generally: High. Being relatively flat areas located low in the landscape, many wetlands are areas of sediment deposition, a process facilitated by wetland vegetation that intercepts suspended sediments and stabilizes (with root networks) much of the sediment that is deposited.

In Alberta Wetlands: Net retention of suspended sediment in some Alberta wetlands was demonstrated by Ontkean et al. (2003) and Preston et al. (2013). Many of the region's wetlands should be capable of retaining much of the sediment that enters them. Well-flushed wetlands, such as those intersected by channels or located on steep slopes, are least capable. In this region the extensive cropland, frequent winds and erosion caused by ice provide opportunities for wetlands to trap sediment and/or to stabilize underlying soils and sediments.

Potentially, the performance of this function has both positive and negative effects. Positives include reduction in turbidity in downstream waters, provision of substrate for outward expansion of marsh vegetation into deeper water, and improved detoxification or immobilisation of some contaminants associated with the retained sediment. Sediment, especially its clay and components, serves as a carrier for heavy metals (Miller & Beasley 2010), phosphorus, and some toxic household chemicals (Hoffman et al. 2009, Kronvang et al. 2009). Negative effects of excessive sedimentation potentially include progressive filling of productive wetlands, slowing of natural channel migration, and increased exposure of organisms within a wetland to contaminants.

Model Structure:

- If a wetland lacks a surface-flow outlet, i.e., is isolated, then the highest possible score for this function (10.00) is assigned automatically
- For all other wetland types, the score increases with decreasing **Duration of Outflow** (half the final score, "OUT") and with the average of the scores from 3 indicator groups which together characterize the potential for **Sediment Entrainment and Storage** ("TRAP")

ABWRET-A FUNCTION MODEL
Sediment Retention
IF((OutNone + OutNone1>0),10, ELSE: AVERAGE(TRAP, OUT)

- The first group is the average of the scores for wetland vegetated area (+, "WetVegArea"), percentage of ponded water that is open (-, "OpenPonded2"), and interspersion between vegetation and open water (+, "Interspers2")
- The second group is the average of the scores for wetland gradient (+ if flat, "Gradient2"), subzero days (-, "Sub0Days"), and slope of the buffer area around the wetland (-, "SlopeBuffer")
- The third group is the average of the scores for 11 indicators: percentage that is flooded only seasonally (+, "SeasPct2"), annual water level fluctuation (-, "Fluc2"), depth class (+, "DepthC2"), percentage of water edge having a flat slope (+, "WatEdgeSlope2"), vegetated width (+, "WidthAbs2"), ground cover density (+, "Gcover2"), percentage of surface water that is ponded (+, "Iso2"), constrictedness of outlet (+, "Constic2"), throughflow sinuosity (+, "ThruFlo2"), microtopographic variation (+, "Girreg2"), burn history (+, "Burn2"), and absence of human-related soil alterations (+, "SoilAlt2")
- The fourth group is the indicators representing the ratio of the wetland's size to that of its contributing area (+, "WetPctCA")

Entrainment and Storage [TRAP]
[AVERAGE(WetVegArea, OpenPonded2, Interspers2) + AVERAGE(1-Sub0Days, SlopeBuffer, Gradient2) + AVERAGE (SeasPct2, Fluc2, DepthC2, WatEdgeSlope2, WidthAbs2, Iso2,ThruFlo2, Constric2, Gcover2, Girreg2, Burn2, SoilAlt2) + WetPctCA2] / 4

The model does not account for the wetland's surface area, and obviously, larger wetlands could potentially trap and store more sediment if other factors support this function. Because the model for this function is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores than larger ones.

Potential for Future Validation: The volume of accreted sediments could be measured in a series of wetlands that encompass the scoring range. This might be done with sediment markers, with isotopic analysis of past sedimentation rates, or with SET tables (Boumans & Day 1993). Suspended sediment could be measured at inlets and outlets, with simultaneous measurement of changes in water volume and flow rate (e.g., Detenbeck et al. 1995).

3.5. Phosphorus Retention (PR)

Function Definition: The effectiveness for retaining phosphorus for long periods (>1 growing season) as a result of chemical adsorption and complexation, or from translocation by plants to belowground zones or decay-resistant peat, resulting in less potential for physically or chemically remobilizing phosphorus into the water column.

Scientific Support for This Function in Wetlands Generally: Moderate. Because phosphorus (P) is commonly adsorbed to suspended sediment, it will be deposited when suspended sediment is intercepted and deposited in wetlands. However, in snowmelt-dominated parts of the region, most P is in soluble rather than particulate form. These soluble forms of P can be chemically precipitated from the water column if there are sufficient levels of certain elements (iron, aluminum, calcium), the water is aerobic, and the pH is acidic (with iron, aluminum) or basic (calcium). This chemical precipitation of P also results in retention within a wetland. Plant roots also can facilitate P retention by aerating the sediment and translocating aboveground P to belowground areas where P-bearing sediments are less likely to be eroded. Phosphorus can potentially accumulate in wetlands more rapidly than nitrogen, and a state can be reached (perhaps after several decades of increased P loading) where sediments become saturated and no more P is retained, at least not until some is desorbed and exported by wind or other means. This saturated state may occur when water extractable soil phosphorus reaches a concentration of about 4 mg P per kg (van Bochove et al. 2012).

Throughout the year, a variable proportion of retained P will re-enter the water column (i.e., be desorbed from sediments or leached from organic matter) and be exported from the wetland (Ontkean et al. 2003). This can happen when sediments or the water column become anaerobic or the pH changes. These changes can be caused by excessive loads of organic matter, rising temperature, and/or reduced aeration due to slowed water exchange rates, increased water depth, or ice (especially snow-covered) that reduces light and seals off diffusion of atmospheric oxygen into the water. The wetland's P balance also depends on the physical stability of deposited sediments or soil. Wind can resuspend sediments rich in P making them vulnerable to being exported downstream by currents, but can also aerate the water column, which helps retain the P in the sediments.

Model Structure: The function model is somewhat similar to the model for Sediment Retention.

- If a wetland lacks a surface-flow outlet, i.e., is isolated, then the highest possible score for this function (10.00) is assigned automatically, based on an assumption that most phosphorus is associated with suspended sediment. However, some amount of phosphorus is soluble and could still escape in groundwater. That pathway cannot be estimated with a rapid assessment method
- For all other wetland types, the score increases with increasing scores for **Sedimentation** (SEDTRAP), **Adsorption** (ADSORB), and persistence of **Outflow** (OUT). These are all considered equally influential in most cases and so are averaged

ABWRET-A FUNCTION MODEL
Phosphorus Retention
IF((OutNone + OutNone1>0),10, ELSE: AVERAGE(ADSORB, SEDTRAP, OUT)

In the above calculations:

- **Adsorption potential** is represented by 8 indicators organized in 2 groups and then averaged. The first group averages the scores for soil texture (+ in clay and peat soils, "SoilTex3"), and conductivity (+, "Salin3"). The second group averages the scores for water level fluctuation (-, "SatPct3"), depth (+, "DomDepth3"), percentage of the wetland that never floods (+, "Fluctu3"), and dominance of algae or duckweed (-, "Algae3")

Adsorption [ADSORB]
[AVERAGE(SoilTex3, Salin3) + AVERAGE(Wettype3, SatPct3, Algae3, Fluctu3, DomDepth3)] / 2

- **Sedimentation potential** is indicated by averaging two groups. The first group is the average of the scores for wetland vegetated area (+, "WetVegArea"), vegetation-water interspersion (+, "Interspers3"), and percent of surface water that is open (-, "OpenWpct3"). The second group is the average of the scores for subzero days (-, "Sub0Days"), percentage that is flooded persistently (+, "Persis3"), vegetated width (+), ground cover density (+), constrictedness of outlet (+), throughflow sinuosity (+), wetland gradient (-), microtopographic variation (+), and absence of human-related soil alterations (+). The third is the indicator representing the ratio of the wetland's size to that of its contributing area (+, WetPctCA).

Sedimentation [SEDTRAP]
[AVERAGE(OpenWpct3, Interspers3, WetVegArea) + AVERAGE(1-Sub0Days, Persis3, Lake3, VegWabs3, ThruFlo3, Constric3, Gradient3, Gcover3, Girreg3, SoilAlt3) + WetPctCA3] / 3

The model does not account strongly for the wetland's surface area. Obviously, larger wetlands could potentially retain more phosphorus if other factors support this function. Because the model for this function is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores than larger ones.

Potential for Future Validation: Among a series of wetlands spanning the scoring range, total phosphorus could be measured simultaneously at wetland inlet and outlet, if any, and adjusted for any dilution occurring from groundwater or runoff (or concentration effect from evapotranspiration) over the intervening distance.

Measurements should be made at least once monthly and more often during major runoff events (e.g., Detenbeck et al. 1995). A particular focus should be on the relative roles of soil vs. vegetation characteristics, as they affect adsorption vs. uptake processes.

3.6. Nitrate Removal and Retention (NR)

Function Definition: The effectiveness for retaining particulate nitrate and converting soluble nitrate and ammonia to nitrogen gas, primarily through the microbial process of denitrification, *while generating little or no nitrous oxide* (a potent "greenhouse gas"). Note that many published definitions of Nitrate Removal do not include the important restriction on N_2O emission.

Scientific Support for This Function in Wetlands Generally: High. Wetlands are perhaps the single most effective landscape feature for removing nitrate from runoff.

Nonetheless, a variable proportion of the nitrate that enters a wetland in runoff will not be effectively processed and may be exported from the wetland (e.g., Ontkean et al. 2003). Wetlands also emit nitrous oxide, but probably not in as large amounts as many other types of landscapes (Pennock et al. 2010, Badiou et al. 2011).

Although nitrate is essential for plant growth, in chronically high concentrations, such as from urban and agricultural runoff, it can be a significant "nonpoint source" that shifts species composition and habitat structure in ways that sometimes are detrimental to sensitive plants, aquatic food chains, and benefitted species (Carpenter et al. 1998, Anderson et al. 2002). High concentrations of nitrate in well water also are a human health hazard, and some levels of ammonia impair aquatic life. Nitrate concentrations as low as 1 mg/L can change the structure of freshwater algae communities of streams (Pan et al. 2004) and contribute to blooms of toxic algae in lakes and wetlands. Nitrate concentrations in surface waters receiving runoff from croplands sometimes exceed 18 mg/L (Corriveau et al. 2010).

Model Structure:

- If a wetland with surface water lacks a surface-flow outlet, i.e., is isolated, then the highest possible score (10.00) for this function is assigned automatically
- For all other wetland types, the score increases with increasing scores for **Denitrification: Temperature Control** (Temp), **Denitrification: Labile Carbon Control** (Carb), **Redox** (Redox), **Processing Time** (Delay), and less **Export** (OUT). These are all considered equally influential in most cases and so their scores are averaged

ABWRET-A FUNCTION MODEL
Nitrogen Removal
IF((OutNone + OutNone1>0),10, ELSE: 10*AVERAGE(TEMP, CARB, REDOX, DELAY, OUT)

In the above calculations:

- **Denitrification:** Temperature Control reflects warmer temperatures that favor N loss by accelerating denitrification, and are indicated by the average of the scores for subzero days (-, Sub0Days), growing season length (+, "GrowDD"), southerly aspect (+, "Aspect"), and intermediate levels of woody cover ("HerbWoodMix4"), and ground cover ("Gcover").

Denitrification: Temperature Control [Temp]
AVERAGE(1-Sub0Days, GrowDD, 1-Aspect, HerbWoodMix4,Gcover4)

- **Denitrification: Labile Carbon Control** reflects abundant carbon that favors N loss by accelerating denitrification, and is indicated by the average of the scores for soil texture (organic and finer are better, "SoilTex4"), undisturbed soil condition (+, "SoilDisturb4"), wetland class ("Wettype4"), not coniferous tree cover ("WoodyPct4"), not a newly created or expanded wetland ("NewWet"), and percentage of the wetland that is open water (-, "OWpct4").

Denitrification: Labile Carbon Control [Carb]
AVERAGE(SoilTex4, SoilDisturb4, OWpct4, Wettype4, WoodyPct4, NewWet)

- **Redox** reflects the interfacing of oxic and anoxic conditions in close proximity, which increases the potential for N removal. This is assumed to be greater in wetlands that are mostly swamp or marsh ("SwampMarshPct"), with a large ratio of upland edge to wetland area ("WetPerim2Area"), greater interspersion of vegetation and open water ("Interspers4"), greater water level fluctuation ("Flluctu4") and percentage that is flooded only seasonally ("SeasWpct4"), presence of upland inclusions ("Inclus4"), and evidence of groundwater input ("Groundw4"). These are considered equally influential and so are averaged

Nitrification- Denitrification: Redox [Redox]
AVERAGE(WetPerim2Area, SwampMarshPct, Interspers4, Inclus4, Groundw4, PermWpct4, SatPct4, SeasWpct4, Fluctu4)

- **Processing Time** is indicated by the average of the scores for wetland gradient (-), sinuosity of flow (+), constrictedness of outlet (+), percentage of the surface water that is ponded (+), wetland vegetated width (+), and microtopographic variation (+).

Processing Time [Delay]
AVERAGE(PondPct4, Gradient4, Thruflo4, Girreg4, Constric4, VwidthAbs4)

- **Export** is assumed to be less, and thus favor N retention, in wetlands that have outflow for shorter periods

Export [OUT]
OutDura4

The model does not account for the wetland's surface area, and obviously, larger wetlands could potentially remove more nitrates if other factors support this function. Because the model for this function is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores than larger ones.

Potential for Future Validation: Among a series of wetlands spanning the scoring range, nitrate and ammonia could be measured simultaneously at wetland inlet and outlet, if any, and adjusted for any dilution occurring from groundwater or runoff (or concentration effects from evapotranspiration) over the intervening distance. Measurements should be made at least once monthly and more often during major runoff events (e.g., Detenbeck et al. 1995). Monitoring should also measure denitrification rates (at least potential), the nitrogen fixing rates of particular wetland plants, and nitrous oxide emissions.

3.7. Organic Matter Export (OE)

Function Definition: The effectiveness of a wetland for producing and subsequently exporting organic matter, either particulate (detritus) or dissolved, and including net export of nutrients (C, N, P, Si, Fe) comprising that matter. It does not include exports of carbon in gaseous form (methane and carbon dioxide).

Scientific Support for This Function in Wetlands Generally: Moderate-High. Wetlands which have outlets are potentially major exporters of organic matter to downstream waters. That is partly because many wetlands support exceptionally high rates of primary productivity (i.e., carbon fixation, which provides more carbon that is available for export). Numerous studies have shown that watersheds with a larger proportion of wetlands tend to export more dissolved and/or particulate carbon, and that is important to downstream food webs. The benefit of the exported matter to food webs depends partly on the quality and timing of the export, but those factors cannot be estimated with a rapid assessment method.

In Alberta Wetlands: Both cumulatively and on a per-unit-area basis, the carbon reserves (mainly in the form of peat) in the province's wetlands are enormous, and during snowmelt and spring runoff much of this carbon is exported to streams, rivers, and lakes. Once there, much of it supports food chains important to fish, wildlife, and people. While it is true that much organic matter (and associated nutrients) can be exported even from isolated wetlands by means of the emergence of the adults of aquatic insects during the growing season, that export pathway could not be accounted for by a rapid assessment method.

Model Structure:

If no surface flow exits a wetland during a typical year, its OE function is automatically scored 0. For all other wetlands, the score increases with increasing **Organic Matter Stock** (CStock), **Decomposition & Mobility** (LabileC), and **Export Potential** (OutC)

ABWRET-A FUNCTION MODEL
Organic Nutrient Export
IF((OutNone + OutNone1>0), 0, ELSE: 10*AVERAGE(CStock, LabileC, OutC)

In these calculations:

- **Organic Matter Stock** is indicated by the average of the scores for wetland vegetated area (+, “WetVegArea”), vegetated width (+, “VwidthAbs6”), percentage of the wetland that is fen, bog, or marsh (+), percentage of the vegetated area that contains moss (+),percentage of the wetland that is open water (-), soil texture is predominantly organic (+), percent organic matter in soil (+), water acidity (+), and water level fluctuation (+).

Organic Matter Stock [Cstock]
AVERAGE(WetVegArea, OWpct6, SoilTex6, Moss6, Fluctu6, NewWet6, Burn6, VwidthAbs6)

- **Decomposition & Mobility** is indicated by the average of the scores for growing season length (+, "GrowDD"), nitrogen-fixers (+, "Nfixer6"), ground cover (+, "Gcover6"), wetland class (fen or marsh, "Wettype6"), percentage of wetland that has ponded water (-, "PondedPct6"), wetland gradient (+, "Gradient6"), vegetation-water interspersion (+, "Interspers6"), channel sinuosity (+, "ThruFlo6"), percentage of wetland that is flooded only seasonally (+, "SeasWpct6"), percentage of water that is shaded (+, "Shade6")

Decomposition and Mobility [LabileC]
AVERAGE(GrowDD, Wettype6, Gradient6, Interspers6, ThruFlo6, Gcover6, PondedPct6, SeasWpct6, Shade6, Nfixer6)

- **Export Potential** is the average of the scores for outlet constrictedness (-, "Constric6"), outflow duration (+, "OutDura6"), woody cover type (+, "WoodType6"), and location in a riparian or floodway area (+, "RipFloodpl")

Export [OutC]
AVERAGE(Constric6, OutDura6, RipFloodpl, WoodType6)

The model does not account for the wetland's surface area, and obviously, larger wetlands could potentially produce and export more carbon if other factors support this function. Because the model for this function is estimating relative effectiveness per unit area, some smaller wetlands will have higher scores than larger ones.

Potential for Future Validation: Among a series of wetlands spanning the scoring range, particulate and dissolved organic carbon would need to be measured regularly at wetland inlet and outlet, if any, along with measurements of changes in water volume and flow rate.

3.8. Aquatic Invertebrate Habitat (INV)

Function Definition: The capacity to support an abundance and diversity of invertebrate animals which spend all or part of their life cycle underwater, on the water surface, or in moist soil. Includes dragonflies, aquatic flies, clams, snails, crustaceans, aquatic beetles, aquatic worms, aquatic bugs, and others, including semi-aquatic species. The model described below will not predict habitat suitability accurately for every species, nor the importance of any species or functional group in the diet of important fish or birds.

Scientific Support for This Function in Wetlands Generally: High. All wetlands support invertebrates, and many wetlands support aquatic invertebrate species not typically found in streams or lakes, thus diversifying the local fauna. Their ecological roles have been described by Euliss et al. (1999) and others.

In Alberta Wetlands: Invertebrates occur in the province's wetlands at seasonally high densities and are highly diverse. On a landscape level, invertebrate production within wetlands may subsidize other ecosystem types (e.g., upland passerines feeding on emerging insects) and wetlands in other regions (e.g., via transport in guts or plumage of migratory birds). However, most invertebrate production probably is utilized or recycled in or near the depressional basins in which it originates. Thus, invertebrate production is primarily a site-specific function. High densities of invertebrates (which usually indicate, but are not synonymous with, high production) have been documented in several prairie basins (e.g., Schultz 1987, LaBaugh and Swanson 1988

Model Structure:

The score is the average of 3 indicators. One is a score for the percentage of the wetland that is marsh (+, MarshPct), the second is a score for the percentage of the wetland that is marsh compared with the percentage of the surrounding landscape that is marsh (+, MarshUniq), and the third is a score based on the average of 4 groups: **Aquatic Habitat Structure** (HabStrucI), **Primary Productivity** (CfixI), **Hydrologic Environment** (WaterI), and **Stressors** (StressI).

ABWRET-A FUNCTION MODEL
Aquatic Invertebrate Habitat
10*AVERAGE(WetType8, UniqMarshShallowOW, AVERAGE(WaterI, HabStrucI, CfixI, StressI))

In these calculations:

- **Aquatic Habitat Structure** is represented by the average of the scores for vegetated wetland area (+, ("WetVegArea"), number of wetland classes present (+, "ClassRichIn8"), interspersion of open water and vegetation (+, "Interspers8"), submerged aquatic cover (+, "AqCov8"), water depth diversity (+, "DepthDiv8"), sinuosity of channels (+, "ThruFlo8"), wetland perimeter-area ratio (+, "WetPerim2Area"), herbaceous plant diversity (+, "HerbDiv8"), interspersion of herbaceous and woody vegetation (+, "VegIntersp8"), downed wood (+, "WoodDown8"), burn history (intermediate, "Burn8"), and percentage of wetland that is open water (+, "OWpct8"). In wetlands larger than 10 ha, open water percentage and number of wetland classes within the wetland are represented instead by scores derived using GIS with coarser spatial data, rather than onsite observations

Aquatic Habitat Structure [HabStrucI]
AVERAGE(WetPerim2Area, WetVegArea, MAX(ClassRichIn8, ClassRichIn),OWpct8, HerbDiv8, ThruFlo8, WoodDown8, Interspers8, VegIntersp8, Burn8, DepthDiv8, AqCov8)

- **Primary Productivity** is indicated by the average of scores for growing season length (+, "GrowDD"), deciduous tree cover (+, "WoodyPct8"), cover of nitrogen-fixing plants (+, "Nfixers8"), water depth (-, "Depth8"), water level fluctuation (+, "Fluc8"), percentage moss cover (-, "Moss8"), and acidic waters (-, "Stain8")

Primary Productivity [CfixI]
AVERAGE(GrowDD, Conduc8, AVERAGE(Wettype8, Moss8, Stain8), Depth8, Fluc8, Nfixers8, WoodyPct8)

- **Hydrologic Environment** is indicated by the average of the scores representing the percentage of the wetland that is flooded persistently (+, "PermWpct8"), and not just seasonally (-, "SeasPct8"), evidence of beaver presence (+, "Beaver8"), irregular microtopography (+, "Girreg8"), and springs (+, "GWDspring"), and other evidence of groundwater discharge (+, "Groundw8")

Hydrologic Environment [WaterI]
AVERAGE(Girreg8, Groundw8, GWDspring, SatPct8, PermWpct8, SeasPct8, Beaver8)

- **Stressors** are represented by the average of the scores for soil disturbance (-, "SoilDisturb8"), sediment inputs (-, "SedCA8"), recently altered hydroperiod (-, "AltTime8"), contaminants (-, "Toxic8"), upland buffer extent (+, "BuffNatPct"), and percentage of natural cover within 1 km (+, "NatCov1k").

Stressors (or lack of) [Stress I]
AVERAGE(SedCA8, Toxic8, AltTime8, SoilDisturb8, BuffNatPct8, NatCov1k, CUbuffPctNat8)

Potential for Future Validation: The aquatic invertebrate richness, density, and (ideally) productivity would need to be measured regularly throughout the year among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity).

3.9. Fish Habitat (FH)

Function Definition: The capacity to support an abundance and diversity of *native* fish. The model described below will not predict habitat suitability accurately for every species, nor is it intended to assess the ability to restore fish access to a currently inaccessible wetland.

Scientific Support for This Function in Wetlands Generally: Generally low, but high in accessible wetlands. Many such wetlands provide fish with rich feeding opportunities and shelter from predators.

Model Structure:

- A wetland automatically scores a 10 if it hosts a fish species at risk ("RareFish")
- Unless a wetland is known to contain fish, it automatically scores a 0 if it contains surface water for fewer than 4 consecutive weeks annually
- For all other wetlands, the score is the average of the scores for **Wetland Productivity** (CfixF), **Water Permanence** (Water), **Habitat Structure** (HabStrucF), **Avoidance of Anoxia** (AnoxF), and **Avoidance of Other Stressors** (StressF)

ABWRET-A FUNCTION MODEL
Fish Habitat
IF((RareFish=1),10, IF((AllSat1=1),0, ELSE: 10*AVERAGE(Fish10, AVERAGE(CfixF, HabStrucF, Water, AnoxF, StressF)

In these calculations:

- **Wetland Productivity** is indicated by the average of two groups. The first consists of the maximum of the known presence of fish ("Fish10") or it is a class A or B waterbody ("FishPres"). The second is the average of the scores for growing season length (+, "GrowDD"), fringe wetland (+, "Fringe10"), the wetland adjoins a lake (+, "Lake10"), beaver evidence (+, "Beaver10"), groundwater evidence (+, "Groundw10"), acidic conditions (-, "AcidicPool10"), and salinity (-, "Conduc10")

Productivity [CfixF]
[MAX(FishPres, Fish10), AVERAGE(GrowDD, Groundw10, Lake10, Fringe10, Conduc10, Beaver10, Burn10, AcidicPool10)] /2

- **Water Permanence** is indicated by the average of the scores outflow duration (+, "Outdura10"), percentage of the wetland that is persistent water (+, "PermWpct10"), percentage of the wetland that never contains surface water (-, "SatPct10"), and groundwater discharge area or spring (+, "GWDspring")

Water Permanence [Water]
AVERAGE(OutDura10, PermWpct10, SatPct10, GWDspring)

- **Habitat Structure** is indicated by the average of the scores for percentage of the water that is shaded (+, "Shade10"), abovewater wood (+, "WoodAbove10"), vegetation-water interspersion (+, "Interspes10"), channel sinuosity (+, "ThruFlo10"), water depth (+, "Depth10"), and diversity of depth classes (+, "DepthEven10")

Habitat Structure [HabStrucF]
AVERAGE(Interspers10, ThruFlo10, Depth10, DepthEven10, Shade10, WoodAbove10)

- **Avoidance of Anoxia** is indicated by the average of the scores for wetland area (+, "WetArea"), water depth (+, "Depth10"), percentage of wetland that is open water (+, "OWpct10"), outflow duration (+, "OutDura10"), extent of flowing water (+, "IsoDry10"), location in a riparian or floodway area (+, "RipFloodpl"), and subzero days (-, "Sub0Days").

Avoidance of Anoxia [AnoxF]
AVERAGE(1-Sub0Days, WetArea, RipFloodpl, OutDura10, Depth10, IsoDry10, OWpct10)

- **Avoidance of Other Stressors** are represented by the average of the scores for altered flow timing (-, "AltTime10"), probable contaminant exposure (-, "Toxic10"), distance to road (+, "Dist2Road"), road density in HUC8 (-, "RdDens1k"), and percentage of the upland buffer containing natural land cover (+, "NatVegCUpct10")

Avoidance of Other Stressors [StressF]
AVERAGE(Dist2Road,1-RdDens1k,Toxic10, AltTime10, NatVegCUpct10)

Potential for Future Validation: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), the number of native fish and their onsite productivity and diversity would need to be measured regularly.

3.10. Amphibian Habitat (AM)

Function Definition: The capacity of a wetland to support an abundance and diversity of native amphibians (frogs, toads, salamanders). The model described below will not predict habitat suitability accurately for every species.

Scientific Support for This Function in Wetlands Generally: High. Many amphibian species occur almost exclusively in wetlands. Densities of amphibians are noticeably higher in some wetlands, partly due to high productivity of algae and invertebrates, and partly because submerged and emergent vegetation provides shelter and sites for egg-laying and larval rearing.

Model Structure:

- A wetland automatically scores a 10 if it hosts a rare amphibian.

- For all other wetlands, the score is the average of the scores of 7 indicators: within the range of an amphibian species at risk (Northern Leopard Frog, Canadian Toad, Western Toad, Columbia Spotted Frog, Long-toed Salamander, "RareAM"), within an AEP-defined "Sensitive Amphibian Range" (+, "SensAm"), percentage of the wetland that is marsh (+, "MarshPct"), and the following groups: **Aquatic Habitat Structure** (HabStrucA), **Aquatic Productivity** (CfixA), **Offsite Habitat Support** (LscapeAM), **Reduced Predation Risk** (PredA), and **Stressors** (StressA).

ABWRET-A FUNCTION MODEL
Amphibian Habitat
IF((RareAM=1),10,10*AVERAGE(SensAm, Wettype11,HabStrucA, CfixA, LscapeAM,StressA)

In these calculations:

- **Aquatic Habitat Structure** is indicated by averaging the scores for wetland vegetated area (+, "WetVegArea"), wetland perimeter-area ratio (+, "WetPerim2Area"), wetland vegetated width (+, "Vwidth11"), number of wetland classes within a wetland (+, "ClassRichin"), percentage of the wetland containing ponded water (+, "IsoWet11"), percentage of the wetland containing open water (+, "OWpct11"), interspersion of vegetation and open water (+, "Interspers11"), interspersion of herbaceous and woody vegetation (+, "HerbWoodMix11"), microtopographic variation (+, "Girreg11"), tree diameter diversity (+, "TreeVar11"), down wood (+, "WoodDown11"), and abovewater wood (+, "WoodAbove11").

Aquatic Habitat Structure [HabStrucA]
AVERAGE(Interspers11, HerbWoodMix11, IsoWet11, AVERAGE(ClassRichIn, WetPerim2Area, OWpct11, Girreg11, Vwidth11, TreeVar11,WoodDown11, WoodAbove11)

- **Aquatic Productivity** is represented by averaging the scores for two indicators. One is conductivity/TDS (-, "Salin11") and the other is the average of scores for: growing season length (+, "GrowDD"), wetland gradient (-, "Gradient11"), number of wetland classes within 1 km (+, "ClassRich1k"), percentage of the wetland that is marsh (+, "MarshPct"), presence of a spring or groundwater discharge area (+, "GWDspring"), other evidence of groundwater input (+, "GroundW11"), beaver (+, "Beaver11"), water level fluctuation (-, "Fluctu11"), and percentage of the wetland that never has surface water (-, "SatPct11")

Aquatic Productivity [CfixA]
AVERAGE(GrowDD, GWDspring, GroundW11, Beaver11, Salin11, Gradient11, SatPct11, Fluctu11)

Stressors is represented by averaging the scores for fish presence (-, Maximum of "FishPres" and "Fish11") with the average of the scores for wind energy in the summer (-, "WindSumm"), probable contaminant exposure (-, "Toxic11"), road density (-, "RdDens1k"), distance to nearest road (-, "DistRd"), distance to cropland or developed land (-, "Dist2DevCrop"), percentage of wetland visited often by people (-, Core1_11,"Core2_11"), and presence of best management practices to limit recreation impacts (+, "BMP_11")

Reduced Risk from Stressors and Fish Predation [StressA]
AVERAGE(MAX(1-FishPres, Fish11), AVERAGE(WindSumm, Toxic11, 1-RdDens1k, Dist2Rd, Dist2DevCrop, Core1_11, Core2_11, BMP_11)

Offsite Habitat Support [LscapeAM] is represented by the average of scores for the proportion of fen marsh or swamp area within 1 km that is represented by the target wetland (+, UniqFenMarshSwamp), number of wetland classes within 1 km (+, "ClassRich1k"), number of wetlands within 1 km that are not bogs ("WetDens1k_noBog"), and the extent of a vegetated buffer around the wetland (+, BuffNatPct11).

Offsite Habitat Support [LscapeAm]
AVERAGE(UniqFenMarshSwamp, ClassRich1k, WetDens1k_noBog, BuffNatPct11, NatCov1k)

Potential for Future Validation: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), amphibian density and (ideally) productivity and survival would need to be measured during multiple years and seasons by comprehensively surveying (as applicable) the eggs, tadpoles, and adults.

3.11. Waterbird Habitat (WB)

Function Definition: The capacity to support an abundance and diversity of waterbirds (e.g., ducks, geese, swans, loons, grebes, cormorants, gulls, shorebirds, herons, egrets). The model described below will not predict habitat suitability accurately for every species in this group.

Scientific Support for This Function in Wetlands Generally: High. No other wetland function has been documented as thoroughly. See reviews, for example, by Weller 1981, 1999.

In Alberta Wetlands: High. At a continental scale, waterfowl populations have been declining for many decades. Although a trend towards more frequent drought has been a factor, several statistical analyses, such as that of Bethke & Nudds (1995), have determined that wetland losses in Alberta have been at least partly to blame.

Model Structure: If the wetland has any of the following it automatically scores a 10:

- presence of a waterbird species at risk (“RareWB”), or
- designated as: Important Bird Area or Trumpeter Swan Use Area

Otherwise, the score is the average of the scores for percentage of the wetland that is marsh (+, “MarshPct”), and ratio of marsh and shallow open water area within the wetland to area of these classes in the surrounding 1 km (+, “UniqMarshShallowOW”), and the following 4 groups: **Habitat Structure** (HabStrucW), **Habitat Productivity** (CfixW), **Offsite Habitat Influence** (LscapeW), and **Stressors** (StressW).

ABWRET-A FUNCTION MODEL
Waterbird Habitat
IF((MAX(RareWB, IBirdArea, RareBirdUse,TrumSwan)>0),10, ELSE: 10*AVERAGE(PermWPct13, UniqMarshShallowOW, HabStrucW, CfixW, LscapeW, StressW))

In these calculations:

- **Habitat Structure** is represented by averaging the scores for wetland vegetated area (+, “WetVegArea”), vegetated width (+, “VwidthAbs13”), percentage of wetland containing ponded water (+, “ISOdry13”), percentage of wetland having open water, (+, “OWpct13”), interspersion of vegetation and open water (+, “Interspers13”), herbaceous vegetation as a percentage of all vegetative cover (+, “”), diversity of water depths (+, “DepthEven13”), extent of shorebird habitat (+, “SBhab13”), extent of flat shoreline (+, “ShoreSlope13”), presence of an island (+, “Island13”), presence of large-diameter trees (+, “TreeForm13”), and snags suitable for nesting (+).

Habitat Structure [HabStrucW]
MAX(SBhab13, AVERAGE(WetVegArea,ISOdry13, OWpct13, Interspers13, EmPct13, DepthEven13, ShoreSlope13, TreeForm13, SnagB13, Island13, VwidthAbs13))

- **Habitat Productivity** is represented by averaging the scores of 2 subgroups. The first averages the scores for wetland gradient (-, “Gradient13”) and wetland class where marsh and shallow open water is given the most weight (“Wettype13”). The second subgroup averages the scores for these 11 indicators: growing season length (+, “GrowDD”), located in riparian or floodway area (+, “RipFloodpl”), located on a lake (+, “Lake13”), presence of fish (+, “Fish13”), presence of beaver (+, “Beaver13”), percentage of wetland that never has surface water (-, “SatPct13”), acidic water (-, “Acidic13”), water level fluctuation (-, “Fluctu13”), and percentage of vegetation that is woody (-, “Woody13”)

Habitat Productivity [CfixW]
AVERAGE(Gradient13, Wettype13, AVERAGE(GrowDD, RipFloodpl, Lake13, Fish13, SatPct13, Acidic13, Woody13, Beaver13, SeasWetPct13, Fluctu13))

- **Offsite Habitat Influence** is indicated by averaging the scores for wetland density within 1 km (+, "WetDens1k"), and percentage of undeveloped open land within 1 km (+, "UndevOpenL1k")

Offsite Habitat Influence [LscapeW]
AVERAGE(WetDens1k_OW,UndevOpenL1k, OWpct_WB)

- **Stressor** exposure potential is represented by averaging the scores for frequency and extent of human visitation (-, "Core1_13" and "Core2_13"), implementation of best management practices to minimize human disturbance of waterbirds (+, "BMP_13"), distance to developed lands or cropland (+, "Dist2DevCrop"), probable contamination (-, "ToxSource13"), and percentage of buffer that contains natural land cover (+, "BuffNatPct13")

Stressors (Lack of) [StressW]
AVERAGE(Dist2DevCrop, HazPond, BuffNatPct13, Core1_13, Core2_13, BMP_13, ToxSource13)

Potential for Future Validation: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), nesting waterbird species richness and density would need to be determined during the usual breeding period -- approximately April through August. Ideally, nest success and juvenile survival rates should be measured.

3.12. Songbird, Raptor, And Mammal Habitat (SBRM)

Function Definition: The capacity to support, at multiple spatial scales, an abundance and diversity of songbirds, raptors, and mammals, especially species most dependent on wetlands or water. It cannot be assumed that Alberta wetlands that are most suitable for a variety of waterbirds will also be suitable for a variety of songbirds (Koper & Schmiegelow 2006, 2007). The model described below will not predict habitat suitability accurately for every species in this group.

Scientific Support for This Function in Wetlands: High. During the nesting season in Alberta, individual wetlands contain more species than any other habitat type (Hvenegaard 2011). And in winter, many or most of the species that remain depend on wetlands for shelter, especially during periods of severe weather. Examples include sharp-tailed grouse and deer (Kramlich 1985, Sather-Blair and Linder 1980, Fritzell 1987). Wind velocity within some wetlands is 95% less than in deciduous-wooded shelterbelts (Schneider 1985). In one area of South Dakota, over 70% of the suitable wintering habitat for pheasants was wetland, even though wetlands comprised a relatively small proportion of the landscape (Sather-Blair and Linder 1980.

Model Structure:

- If a wetland hosts any of the songbird or mammal species considered at risk it automatically scores a 10. Likewise if it is within AEP-designated Caribou Range, or radiotracking data indicates very frequent use by woodland caribou in the general vicinity of the wetland
- Otherwise the score is the maximum of less-frequent caribou use, or the average of the scores for the following: **Wetland Class Uniqueness** (+, UniqClass), **Habitat Structure** (HabStrucS), **Habitat**

Productivity (CfixS), **Offsite Habitat Influence** (LscapeS), **Stressors** (StressS). These are described as follows:

ABWRET-A FUNCTION MODEL
Songbird, Raptor, and Mammal Habitat
IF((RareSBM=1),10, IF((OR(CaribouRange=1, CaribouFound=1)),10, ELSE: 10*MAX(CaribouFound, AVERAGE(UniqClass, HabStrucS, CfixS, LscapeS, StressS))

In these calculations:

- For **Wetland Class Uniqueness**, the percentage of various wetland classes that are present within a wetland is compared with the percentages of those classes within the surrounding landscape (within 1 km). The percentage of the class with the largest ratio (most disproportionately represented by the wetland) is converted to a score.
- **Habitat Structure** for wetland-dependent mammals, songbirds, and raptors is represented by the average of 5 groups of indicators. The first group averages the scores for wetland vegetated area (+, "WetVegArea"), vegetated width (+, "Vwidth14"), and number of wetland classes within a wetland (+, "ClassRichIn14"). The second averages the scores for upland inclusions (+, "Inclus14") and the wetland perimeter-area ratio (+, "WetPerim2Area"). The third group averages the scores for percentage of the wetland with ponded open water (-, "PondedOWpct14"), and percentage of the wetland that never has surface water (+, "SatPct14"). The fourth group averages the scores for interspersion of water and vegetation (+, "Interspers14"), and interspersion of herbaceous and woody vegetation (+, "WoodPatt14"). The fifth and largest group averages the scores for snags (+, "SnagD14"), down wood (+, "WoodDown14"), cliffs (+, "Cliffs14") , tree diameter diversity (+, "TreeTypes14"), species dominance among shrubs (-, "ShrubDiv14"), species dominance among herbs (-, "HerbDom14"), and the percentage of vegetation that is woody (+, WoodyPct14")

Habitat Structure [HabStrucS]
[AVERAGE[WetVegArea, MAX(ClassRichIn, ClassRichIn14),Vwidth14] + AVERAGE(WetPerim2Area, Inclus14) + AVERAGE(SatPct14, PondedOWpct14) + AVERAGE(WoodyPct14,ShrubDiv14, HerbDom14, TreeTypes14, SnagD14, WoodDown14, Cliffs14) + AVERAGE(Interspers14, HerbWoodMix14)] / 5

- **Habitat Productivity** for wetland-dependent mammals, songbirds, and raptors is represented by the average of 2 groups of indicators. For the first group, the maximum indicator score (of 1) is assigned if the wetland contains a raptor nest ("RaptorNest"), or is within a designated Key Wildlife Biodiversity Zone ("BioDivZone"). The second group averages the scores for growing season length (+, "GrowDD"), location in a riparian area or floodway (+, "RipFloodpl"), Wetland class where marshes and shallow open waters are given the most weight, followed by swamps and fens, then bogs ("Wettype14"), beaver presence (+, "Beaver14a"), percentage of herbaceous cover that is sedges (+, "Sedge14"), percentage of herbaceous cover that is forbs (+, "ForbCov14")

Habitat Productivity [CfixS]
[MAX(RaptorNest, BioDivZone) + AVERAGE(GrowDD, RipFloodpl, Wettype14, Sedge14, ForbCov14, Beaver14a)] /2

- **Offsite Habitat Influence** is the average of the scores for wetland density within 1 km (+, "WetDens1k"), other natural cover within 1 km (+, "NatCov1k"), number of wetland classes within 1 km (+, "ClassRich1k"), and percentage of wetland buffer having natural cover (+, "CUbuffNatPct14").

Offsite Habitat Influence [LscapeS]
AVERAGE(NatCov1k, ClassRich1k, WetDens1k, CUbuffNatPct14)

- **Stressor** exposure potential is represented by the average of scores for road density within 1 km (-, "RdDens1k"), distance to road (+, "DistRd"), distance to settled area (+, "DistPop"), distance to cropland or developed lands (+, "Dist2DevCrop"), human visitation frequency and extent (-, "Core14a" and "Core14b"), probably contamination (-, "ToxSource14") and best management practices for reducing wildlife disturbance (+, "BMP_14").

Stressors (Lack of) [StressS]
AVERAGE(Dist2DevCrop,1-RdDens1k, DistRd, DistPop, 1-Linear, Dist2Industrial, Core14a, Core14b, BMP_14, ToxSource14)

Potential for Future Validation: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), species richness and density of songbirds, raptors, and mammals would need to be determined monthly, and more often during migration or seasonal movements (see USEPA 2001 for methods). Ideally, daily duration of use, interannual consistency of use, and seasonal weight gain of key species should be measured.

3.13. Habitat for Native Plants and Pollinators (PH)

Function Definition: The capacity to support, at multiple spatial scales, a diversity of native vascular and non-vascular (e.g., bryophytes, lichens) species and functional groups, especially those that are most dependent on wetlands or water, as well as the pollinating insects that depend on them. It is recognized that conditions which are optimal for pollinators do not always coincide with conditions that are optimal for plant diversity.

Scientific Support for This Function in Wetlands Generally: High. Many plant species grow only in wetlands and thus diversify the local flora, with consequent benefits to food webs and energy flow.

In Alberta Wetlands: The diversity of plants found within a particular wetland is influenced by factors both within the wetland and in the local and regional landscape. With regard to landscape influences, plant diversity in many Alberta wetlands is most correlated with land cover and other features measured within 300 m of a wetland, as opposed to variables measured at distances of up to 2000 m from the wetland (Rooney & Bayley 2011).

Model Structure:

- If a wetland supports a vascular plant that is tracked at risk ("RarePlant"), it automatically scores a 10
- Otherwise, the score is the average of the scores for **Wetland Class Uniqueness** ("UniqClass") and the average of 5 subgroups: **Vegetation Form & Distribution** ("Vstruc"), **Wetland Productivity** ("CfixV"), **Habitable Substrate** ("Vspace"), **Offsite Habitat Influence** ("Vscape"), and **Stressors** ("StressV")

ABWRET-A FUNCTION MODEL
Native Plant & Pollinator Habitat
IF((RarePlant2=1),10, 10*AVERAGE(UniqClass, AVERAGE(Vstruc, Vspace, CfixV, Vscape, StressV))

In these calculations:

- **Wetland Class Uniqueness** (+) compares the percentage of various wetland classes that are present within a wetland with the percentages of those classes within the surrounding landscape (within 1 km). The percentage of the class with the largest ratio (most disproportionately represented by the wetland) is converted to a score
- **Vegetation Form & Distribution** is represented by averaging the scores of 10 indicators: number of wetland classes within the wetland (+, "ClassRichIn15"), tree diameter diversity (+, "dbhPD"), species dominance among herbs (-, "herbdom15"), species dominance among shrubs (-, "wood2pd"), percentage of woody vegetation that is deciduous (+, "WoodyCovPD"), interspersion of water and vegetation (+, "InterspersPD"), interspersion of herbaceous and woody vegetation (+, "HerbWood15"), percentage of herbaceous cover that is sedges (+, "sedgePD"), percentage of herbaceous cover that is forbs (+, "forbsPD")

Vegetation Form & Distribution [Vstruc]
AVERAGE(InterspersPD, WoodyCovPD, HerbWood15, ClassRichIn15, wood2pd, herbdom15, dbhPD, sedgePD, forbsPD)

- **Wetland Productivity** is represented by averaging the scores of 12 indicators: growing season length (+, "GrowDD"), location is in a riparian area or floodway (+, "RipFloodpl"), beaver presence (+, "BeaverPD"), presence of an inflow channel (+, "InfloPD"), not a new wetland ("NewWetPd"), water depth (-, "Depth15"), water level fluctuation (+, "FlucPD"), percentage of cover that is nitrogen-fixing plants (+, "NfixPD"), and predominant soil texture is something other than sand or other coarse material (+)

Wetland Productivity [CfixV]
AVERAGE(GrowDD, RipFloodpl, InfloPD, SoilTexPD, BeaverPD, GWpd, NfixPD, NewWetPD, FlucPD, Depth15)

- **Habitable Substrate** is indicated by averaging 2 subgroups. One averages the scores for vegetated width (+, "WidthPD"), percentage of the wetland with persistent water (-, "PesisPD"), and percentage of the wetland with ponded open water (-, "PondedOWpctPD"). The other subgroup specifically targets some breeding site needs of pollinators, and averages the scores for down wood (+, "DownedWood15"), snags (+, "Snags15"), cliffs (+, "Rock15"), and microtopographic variation (+, "GirregPD"). If the wetland is larger than 10 ha, the onsite estimate of open water is replaced by an estimate using existing spatial data and GIS

Habitable Substrate [Vspace]
(AVERAGE(WetVegArea, WidthPD, PondedOWpctPD, PersisPD) + AVERAGE(DownedWood15, Snags15, GirregPD, Rock15)] /2

- **Offsite Habitat Influence** is represented by averaging the scores of wetland density within 1 km (+, "WetDens1k"), other natural cover within 1 km (+, "NatCov1k"), number of wetland classes within 1 km (+, "ClassRich1k"), Upland buffer cover type (+, "BuffLUpd"), and nearby cropland or developed area (-, "NatVegCApd")

Offsite Habitat Influence [Vscape]
AVERAGE(NatCov1k, WetDens1k, ClassRich1k, BuffLUpd, NatVegCApd)

- **Stressor** exposure potential is represented by averaging the score for invasive plant cover within the wetland (-, "Invasives") with a score calculated as the average of the scores of 11 indicators. Those indicators are altered timing of flows or runoff (-, "AltTime20"), road density within 1 km (-, "RdDens1k"), distance to road (+, "Dist2Road"), distance to cropland or developed lands (+, "Dist2DevCrop"), likely presence of pesticides (-, "Toxic20"), extent of weeds along the wetland border (-, "WeedSourcePD"), distance to settled area (+, "DistPop"), human visitation frequency and extent (-, "Core1pd" and "Core2pd"), observed or potential soil disturbance (-, "SedDisturb20"), and best management practices for reducing soil disturbance (+, "BMPsoils20")

Stressors (Lack of) [StressV]
[Invasives + AVERAGE(Dist2DevCrop, 1-RdDens1k, Dist2Road, DistPop, Core1pd, Core2pd, BMPsoils20, WeedSourcePD, AltTime20, Toxic20, SedDisturb20)] / 2

Potential for Future Validation: Among a series of wetlands spanning the function scoring range and a range of wetland condition (integrity), all plant species would be surveyed and percent-cover determined at their appropriate flowering times during the growing season. Species richness and evenness would then be calculated and if possible, related to the functional traits of the species. Pollinator species surveys and development of interaction networks would be completed. Habitat connectivity for plant and pollinator species can be assessed through quantifying pollinator diversity in surrounding land use types and estimating foraging distances based on body size measurements.

3.14. Fire Barrier (FIRE)

Definition: The capacity to resist ignition by wildfire, thus limiting wildfire spread. As explained by Benscoter et al. (2012):

- In western Canadian bogs, high soil moisture retention capacity of the dominant ground-layer moss (Sphagnum fuscum) creates conditions unfavorable to burning even under drought conditions, influencing local fire behavior and preserving soil carbon stocks over multiple fire intervals. Repeated surface burning may concentrate soil inorganic material in surface peat, thereby decreasing fuel quality and the likelihood of burning in subsequent fires. Additionally, removal of standing vegetation by fire resets the successional sequence

Also, when a peat fire smolders for many months, increasing the burn depth or proportion of a wetland that burns, that can depress the surface elevation slightly, leading to more ponding of water within a wetland which in turn can make a wetland more resistant to future ignitions (Watts et al. 2015).

Scientific Support for This Function in Wetlands Generally: High, depending on the type of wetland.

Model Structure: The score is calculated as the maximum of four indicators (the first 3 are potentially redundant but use different data sources):

- Mapped and classified as "non-fuel" by Alberta Agriculture and Forestry ("Firebreak")
- Percentage of the wetland containing open water (+, "OWpct")
- Percentage of the wetland containing surface water for entire growing season (+, "PermWpct")
- Years elapsed since last time the wetland's vegetation burned (-, "Burn")

ABWRET-A FUNCTION MODEL
Fire Barrier
10*MAX(Firebreak, OWpct, PermWpct15, Burn15)

3.15. Human Use (HU)

Definition: The potential and actual capacity of a wetland to sustain low-intensity human uses such as resource use, hiking, nature photography, education, and research.

Model Structure: The score for Human Use is calculated as the average of the scores of 5 indicators: **Ownership** (+ if public), **Investment** (+ if existing mitigation site, research site, or park), and 3 thematic groups: **Access** (Access), **Resource Use & Best Management Practices** (Use), and **Wetland Morphology** (Wet), described as follows:

ABWRET-A FUNCTION MODEL
Human Use
10*AVERAGE(Ownership, Invest21, Access, Use, Wet)

In these calculations:

- **Access** is represented by averaging the scores of 2 subgroups. One subgroup is the average of the scores for distance to road (-, "Dist2Road"), distance to settled area (-, "DistPop"), and road density (+, RdDens1k). The other assigns maximum indicator score (=1) if the wetland is within a designated natural area or ecological reserve (+, "Reserve")

Potential Access [Access]
[AVERAGE(1-Dist2Road, RdDens1k, 1-DistPop, Reserve)] /2

- **Resource Use & Best Management Practices** is indicated by averaging the scores for the following indicators: visibility (+, "Visibility"), proximity to domestic well (+, "Wells21"), extent and frequency of human visitation (+, "Core1PU" and "Core2PU"), best management practices to minimize disturbance of soils and wildlife (+, "BMPsoilsPU" and "BMPwildPU"), consumptive uses or provisioning services ("Provis21") and recreational facilities such as interpretive signs, parking area, public boat ramp (+, "RecreaPot")

Resource Use and Best Management Practices [Use]
AVERAGE(Provis21, Visibility, Core1PU, Core2PU, RecreaPot, BMPsoilsPU, BMPwildPU, Wells21)

- **Wetland Morphology** is described by the average of the scores for wetland area (+, "WetArea"), fringe wetland (+, "Fringe21"), lakeside wetland (+, "Lake21"), and percentage of the wetland that has ponded open water (+, "PondedOWpct21"). However, if the wetland is mostly covered by nuisance algal blooms at some times of the year, the score for Wetland Morphology is set to 0. (+, "Algae").

Wetland Morphology [Wet]
IF((Algae=1),0, ELSE: AVERAGE(WetArea, OWarea, Fringe21, Lake21,PondedOWpct21)

4. Literature Cited

Abbaspour, K.C., M. Faramarzi, and E. Roulohlanejad. 2010. Hydrological modeling of Alberta using SWAT model: A preliminary report. Alberta Innovates, Edmonton, AB.

ABMI. 2011. Alberta Biodiversity Monitoring Institute. Wetland field data collection protocols (abridged version) 2012-06-27. Alberta Biodiversity Monitoring Institute, Edmonton, Alberta, Canada. http://www.abmi.ca/abmi/reports/reports.jsp?categoryId=0

Adamus P.R., J. Morlan, and K. Verble. 2009. Oregon Rapid Wetland Assessment Protocol (ORWAP): Calculator spreadsheet, databases, and data forms. Oregon Dept. of State Lands, Salem, OR.

Adamus, P. R. 1983. A Method for Wetland Functional Assessment. Vol. II. Methodology. Report No. FHWA-IP-82-24. Federal Highway Administration, Washington, D.C.

Adamus, P. R., E. J. Clairain, Jr., R. D. Smith, and R. E. Young. 1987. Wetland Evaluation Technique (WET) Volume II: Methodology. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Adamus, P., J. Morlan, and K. Verble. 2010. Wetland Ecosystem Services Protocol for the United States (WESPUS). Beta test version 1.0. Online: http://people.oregonstate.edu/~adamusp/WESP/

Adamus, P.R. 1992a. Condition, values, and loss of natural functions of prairie wetlands of the North-Central United States. EPA/600/R-92/249. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.

Adamus, P.R. 1992b. Conceptual process model for basin-type wetlands of the Prairie Pothole Region. EPA/600/R-92/249. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.

Adamus, P.R., E.J. Clairain, Jr., D.R. Smith, and R.E. Young. 1992. Wetland Evaluation Technique (WET). Volume I: Literature review and evaluation rationale. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Anderson, D., P. Gilbert, and J. Burkholder. 2002. Harmful algal blooms and eutrophication: nutrient sources, composition, and consequences. Estuaries and Coasts 25(48):704-726.

Anderson, J., R. Beduhn, D. Current, J. Espeleta, C. Fissore, B. Gangeness, J. Harting, S. Hobbie, E. Nater, and P. Reich. 2008. The potential for terrestrial carbon sequestration in Minnesota. A report to the Terrestrial Carbon Sequestration Initiative. Minnesota Department of Natural Resources, St. Paul, MN.

Badiou, P., R. McDougal, D. Pennock, and B. Clark. 2011. Greenhouse gas emissions and carbon sequestration potential in restored wetlands of the Canadian prairie pothole region. Wetlands Ecology and Management 19:237-256.

Benscoter, B., M. R. Turetsky, and J. Johnson. 2012. Regulation of soil carbon storage by wildfire in boreal and subtropical peatlands. In: AGU Fall Meeting Abstracts (Vol. 1, p. 0520).

Berthold, S., L. R. Bentley, and M. Hayashi. 2004. Integrated hydrogeological and geophysical study of depression-focused groundwater recharge in the Canadian prairies. Water Resources Research 40(6).

Bethke, R. W. and T. D. Nudds. 1995. Effects of climate-change and land-use on duck abundance in Canadian Prairie-Parklands. Ecological Applications 5(3):588-600.

Boumans, R. M. J. and J. W. Day. 1993. High-precision measurements of sediment elevation in shallow elevation in shallow coastal areas using a sedimentation-erosion table. Estuaries 16(2):375-380.

Brander, L. M., R. Florax, and J. E. Vermaat. 2006. The empirics of wetland valuation: A comprehensive summary and a meta-analysis of the literature. Environmental & Resource Economics 33(2):223-250.

Brander, L., R. Brouwer, and A. Wagtendonk. Economic valuation of regulating services provided by wetlands in agricultural landscapes: A meta-analysis. Ecological Engineering.

Bridgham, S. D., J. P. Megonigal, J. K. Keller, N. B. Bliss, and C. Trettin. 2006. The carbon balance of North American wetlands. Wetlands 26:889-916.

BRPRC. 2010. The Bow River Project Research Consortium, Bow River Project final report. Alberta Water Research Institute, Edmonton, AB. www.waterinstitute.ca

Carpenter, S. R., N. F. Caraco, D. L. Correll, R. W. Howarth, A. N. Sharpley, and V. H. Smith. 1998. Nonpoint pollution of surface waters with phosphorus and nitrogen. Ecological Applications 8:559-568.

Conly, F. M., M. Su, G. van der Kamp, and J. J. Millar. 2004. A practical approach to monitoring water levels in prairie wetlands. Wetlands 24(1): 219-226.

Coombs, M. 2008. Indicators for assessing environmental performance of watersheds in Parkland Region: A summary document. Alberta Environment, Edmonton, AB. www.environment.gov.ab.ca/info/library/7944.pdf.

Corriveau, J., P. A. Chambers, A. G. Yates, and J. M. Culp. 2011. Snowmelt and its role in the hydrologic and nutrient budgets of prairie streams. Water Science and Technology 64(8):1590-1596.

Degenhardt, A., J. Cessna, R. Raina, A. Farenhorst, and D. J. Pennock. 2011. Dissipation of six acid herbicides in water and sediment of two Canadian prairie wetlands. Environmental Toxicology and Chemistry 30:1982-1989.

Dehnhardt, A. and I. Bräuer. 2008. The value of floodplains as nutrient sinks: Two applications of the replacement cost approach. in: B. Schweppe-Kraft, editor. Ecosystem Services of Natural and Semi-Natural Ecosystems and Ecologically Sound Land Use. Bundesamt für Naturschutz (BfN), Bonn, Germany.

Detenbeck, N. E., D. L. Taylor, A. Lima, and C. Hagley. 1995. Temporal and spatial variability in water quality of wetlands in the Minneapolis/St. Paul, MN metropolitan area: Implications for monitoring strategies and designs. Environmental Monitoring and Assessment 40(1):11-40.

Doyle, M.W. 2006. A heuristic model for potential geomorphic influences on trophic interactions in streams. Geomorphology 77 (3-4):235-248.

Ducks Unlimited Canada (DUC). 2011. Ecosystem service approach pilot on wetlands: assessment of current and historic wetland carbon stores in the Sheppard Slough Area. Report to Alberta Environment and Sustainable Resource Development, Edmonton, AB.

Euliss, N. H. and D. M. Mushet. 1996. Water-level fluctuation in wetlands as a function of landscape condition in the prairie pothole region. Wetlands 16:587-593.

Euliss, N. H. and D. M. Mushet. 2004. Impacts of water development on aquatic macroinvertebrates, amphibians, and plants in wetlands of a semi-arid landscape. Aquatic Ecosystem Health & Management 7(1):73-84.

Euliss, N. H., Jr., D. A. Wrubleski, and D. M. Mushet. 1999. Wetlands of the Prairie Pothole Region: Invertebrate species composition, ecology, and management. Pages 471–514 in D. P. Batzer, R. B. Rader, and S. A. Wissinger, editors. Invertebrates in Freshwater Wetlands of North America: Ecology and Management. John Wiley & Sons, Inc., New York, NY, USA.

Euliss, N. H., L. M. Smith, D. A. Wilcox, and B. A. Brwaine. 2008. Linking ecosystem processes with wetland management goals: Charting a course for a sustainable future. Wetlands 28(3):553-562.

Feng, M., S. G. Liu, N. H. Euliss, C. Young, and D. M. Mushet. 2011. Prototyping an online wetland ecosystem services model using open model sharing standards. Environmental Modelling & Software 26:458-468.

Fissore, C., C. P. Giardina, R. K. Kolka, and C. C. Trettin. 2009. Soil organic carbon quality in forested mineral wetlands at different mean annual temperature. Soil Biology and Biochemistry 41(3): 458-466.

Fritzell, E. K. 1988. Mammals and wetlands. Pages 213-226 in D. D. Hook, editor. The Ecology and Management of Wetlands, Vol. 1: Ecology of Wetlands. Timber Press, Portland, OR.

Gascoigne, W. R., D. Hoag, L. Koontz, B. A. Tangen, T. L. Shaffer, and R. A. Gleason. 2011. Valuing ecosystem and economic services across land-use scenarios in the Prairie Pothole Region of the Dakotas, USA. Ecological Economics 70:1715-1725.

Ghermandi, A., J. C. Van den Bergh, L. M. Brander, H. L. De Groot, and P. A. Nunes. 2008. The economic value of wetland conservation and creation: a meta-analysis. FEEM Working Paper No. 79.2008. http://ssrn.com/abstract=1273002 or http://dx.doi.org/10.2139/ssrn.1273002

Gleason, R. A. and N. H. Euliss Jr. 1998. Sedimentation of prairie wetlands. Great Plains Research 8:97-112.

Gleason, R. A., M. K. Laubhan, and N. H. Euliss, Jr. 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.

Gleason, R. A., and B.A. Tangen, B. A. 2008. Chapter D: Floodwater storage. In: Ecosystem services derived from wetland conservation practices in the United States Prairie Pothole Region with an emphasis on the US Department of Agriculture Conservation Reserve and Wetlands Reserve Programs. U.S. Geological Survey Professional Paper Issue 1745.

Gracz, M.B., Moffett, M.F., Siegel, D.I. and Glaser, P.H. 2015. Analyzing peatland discharge to streams in an Alaskan watershed: An integration of end-member mixing analysis and a water balance approach. Journal of Hydrology 530:667-676.

Haas, T. C. 1991. A Bayesian Belief Network advisory system for aspen regeneration. Forest Science 37:627-654.

Hansson, L., C. Bronmark, P. A. Nilsson, and K. A. Bjornsson. 2005. Conflicting demands on wetland ecosystem services: Nutrient retention, biodiversity or both? Freshwater Biology 50(4):705-714.

Hayashi, M., G. van der Kamp, and D. L. Rudolph. 1998. Water and solute transfer between a prairie wetland and adjacent uplands, 1. Water balance. Journal of Hydrology 207: 42-55.

Hayashi, M., G. A. Mohammed, C. R. Farrow, G. van der Kamp, and L. R. Bentley. 2011. Little pond on the prairie: Effects of land-surface hydrology on groundwater recharge. Geohydro. http://www.geohydro2011.ca/gh2011_user/cle_usb/pdf/doc-2197.pdf.

Hoffmann, C. C., C. Kjaergaard, J. Uusi-Kamppa, H. C. B. Hansen, and B. Kronvang. 2009. Phosphorus retention in riparian buffers: Review of their efficiency. Journal of Environmental Quality 38(5):1942-1955.

Huang, S. L., C. Young, M. Feng, K. Heidemann, M. Cushing, D. M. Mushet, and S. G. Liu. 2011. Demonstration of a conceptual model for using LiDAR to improve the estimation of floodwater mitigation potential of Prairie Pothole Region wetlands. Journal of Hydrology 405:417-426.

Hubbard, D. E. and R. L. Linder. 1986. Spring runoff retention in Prairie Pothole Wetlands. Journal of Soil and Water Conservation 41(2):122-125.

Hvenegaard, G. T. 2011. Validating bird diversity indicators on farmland in east-central Alberta, Canada. Ecological Indicators 11(2):741-744.

Koper, N. and F. K. A. Schmiegelow. 2006. A multi-scaled analysis of avian response to habitat amount and fragmentation in the Canadian dry mixed-grass prairie. Landscape Ecology 21(7):1045-1059.

Koper, N. and F. K. A. Schmiegelow. 2006. Effects of habitat management for ducks on target and nontarget species. Journal of Wildlife Management 70(3):823-834.

Koper, N. and F. K. A. Schmiegelow. 2007. Does management for duck productivity affect songbird nesting success? Journal of Wildlife Management 71:2249-2257.

Kramlich, T. J. 1985. Evaluation of Seasonal Habitat Use by White-Tailed Deer in Eastern South Dakota. Master's Thesis. South Dakota State University, Brookings, South Dakota.

Kronvang, B., G. H. Rubaek, and G. Heckrath. 2009. International phosphorus workshop: Diffuse phosphorus loss to surface water bodies-risk assessment, mitigation options, and ecological effects in river basins. Journal of Environmental Quality 38(5):1924-1929.

LaBaugh, J. W. and G. A. Swanson. 1988. Algae and invertebrates in the water column of selected prairie wetlands in the Cottonwood Lake Area, Stutsman County, North Dakota, 1984. Open file Report 88 451. U.S. Geological Survey, Lakewood, CO.

LaBaugh, J.V., T.C. Winter, and D.O. Rosenberry. 1998. Hydrologic functions of prairie wetlands. Great Plains Research 8: 17-37.

Lissey, A. 1971. Depression-focused transient groundwater flow patterns in Manitoba. Geological Association of Canada Special Paper No. 9:333–341.

Liu, K., Elliott, J. A., Lobb, D. A., Flaten, D. N., and Yarotski, J. 2013. Critical factors affecting field-scale losses of nitrogen and phosphorus in spring snowmelt runoff in the Canadian Prairies. Journal of Environmental Quality 42(2):484-496.

Loken, L. G. 1991. Wetland soil characteristics of basins in closed groundwater catchment systems. Master's Thesis. North Dakota State University, Fargo, ND.

Lougheed, V. L., M. D. McIntosh, C. A. Parker, and R. J. Stevenson. 2008. Wetland degradation leads to homogenization of the biota at local and landscape scales. Freshwater Biology 53(12):2402-2413.

Miller, J. J. and B. W. Beasley. 2010. Trace elements in the Oldman River of Parkland Region. Water Quality Research Journal of Canada 45(3):365-377.

Minke, A. G., C. J. Westbrook, and G. van der Kamp. 2010. Simplified volume-area-depth method for estimating water storage of prairie potholes. Wetlands 30:541-551.

Neuman, A. D. and K. W. Belcher. 2011. The contribution of carbon-based payments to wetland conservation compensation on agricultural landscapes. Agricultural Systems 104:75-81.

Niemi, G. J., P. DeVore, N. Detenbeck, D. Taylor, A. Lima, J. Pastor, J. D. Yount, and R. J. Naiman. 1990. Overview of case studies on recovery of aquatic systems from disturbance. Environmental Management 14(5): 571-587.

Ontkean, G. R., D. S. Chanasyk, S. Riemersma, D. R. Bennett, and J. M. Brunen. 2003. Enhanced prairie wetland effects on surface water quality in Crowfoot Creek, Alberta. Water Quality Research Journal of Canada 38:335-359.

Pan, Y. D., A. Herlihy, P. Kaufmann, J. Wigington, J. van Sickle, and T. Moser. 2004. Linkages among land-use, water quality, physical habitat conditions and lotic diatom assemblages: A multi-spatial scale assessment. Hydrobiologia 515(1-3):59-73.

Pennock, D., T. Yates, A. Bedard-Haughn, K. Phipps, R. Farrell, and R. McDougal. 2010. Landscape controls on N2O and CH4 emissions from freshwater mineral soil wetlands of the Canadian Prairie Pothole region. Geoderma 155:308-319.

Pham, S. V., P. R. Leavitt, S. McGowan, B. Wissel, and L. I. Wassenaar. 2009. Spatial and temporal variability of prairie lake hydrology as revealed using stable isotopes of hydrogen and oxygen. Limnology and Oceanography 54(1):101-118.

Preston, T. M., R.S. Sojda, and R.A. Gleason. 2013. Sediment accretion rates and sediment composition in Prairie Pothole wetlands under varying land use practices, Montana, United States. Journal of Soil and Water Conservation 68(3):199-211.

Rahbeh, M., D. S. Chanasyk, and J. J. Miller. 2011. Two-way calibration-validation of SWAT model for a small prairie watershed with short observed record. Canadian Water Resources Journal 36(3): 247-270.

Richardson, J. L. and J. L. Arndt. 1989. What use prairie potholes? Journal of Soil and Water Conservation 44(3):196-198.

Richardson, J. L., J. L. Arndt, and J. Freeland. 1994. Wetland soils of the prairie potholes. Advances in Agronomy 52:121-171.

Robarts, R. D., D. B. Donald, and M. T. Arts. 1995. Phytoplankton primary production of 3 temporary northern prairie wetlands. Canadian Journal of Fisheries and Aquatic Sciences 52(5):897-902.

Robarts, R. D., M. S. Evans, and M. T. Arts. 1992. Light, nutrients, and water temperature as determinants of phytoplankton production in two saline, prairie lakes with high sulphate concentrations. Canadian Journal of Fisheries and Aquatic Sciences 49(11):2281-2290.

Rooney, R. C. and S. E. Bayley. 2012. Community congruence of plants, invertebrates and birds in natural and constructed shallow open-water wetlands: Do we need to monitor multiple assemblages? Ecological Indicators 20:42-50.

Royer, F. and R. Dickinson. 2007. Plants of Alberta: Trees, Shrubs, Wildflowers, Ferns, Aquatic Plants and Grasses. Lone Pine Publishing, Edmonton, Canada.

Sather-Blair, S. and R. L. Linder. 1980. Pheasant use of South Dakota wetlands during the winter. South Dakota Academy of Science Proceedings 59:147–155.

Schneider, T. M. 1985. Effectiveness of shelterbelts in improving microclimatic conditions for pheasants in eastern South Dakota. Master's Thesis. South Dakota State University, Brookings, SD.

Schultz, B. D. 1987. Biotic responses of Typha-monodominant semi-permanent wetlands to cattle grazing. Master's Thesis. South Dakota State University, Brookings, SD.

Starfield, A.M., K.A. Smith, and A.L. Bleloch. 1994. How to Model It: Problem Solving for the Computer Age. McGraw-Hill, New York.

Stevenson, R. J. and F. R. Hauer. 2002. Integrating hydrogeomorphic and index of biotic integrity approaches for environmental assessment of wetlands. Journal of the North American Benthological Society 21:502-513.

Stewart, R. E. and H. A. Kantrud. 1971. Classification of Natural Ponds and Lakes in the Glaciated Prairie Region. Resource Publication 92., Northern Prairie Wildlife Research Center, Jamestown, ND. http://www.npwrc.usgs.gov/resource/wetlands/pondlake/index.htm

USACE. 2005. US Army Corps of Engineers. Technical Standard for Water Table Monitoring of Potential Wetland Sites. WRAP Technical Notes Collection (ERDC TN-WRAP-05-2). U. S. Army Engineer Research and Development Center, Vicksburg, MS.

USEPA. 2001. Methods for Evaluating Wetland Condition: Biological Assessment Methods for Birds. EPA-822-R-02-023. U.S. Environmental Protection Agency Office of Water, Washington, DC. http://www.epa.gov/waterscience/criteria/wetlands/13Birds.pdf.

van der Kamp, G. and M. Hayashi. (2009). Groundwater-wetland ecosystem interaction in the semiarid glaciated plains of North America. Hydrogeology Journal, 17(1), 203-214.

van Bochove, E., G. Thériault, J. Denault, F. Dechmi, S. E. Allaire, and A. N. Rousseau. 2012. Risk of phosphorus desorption from Canadian agricultural land: 25-year temporal trend. Journal of Environmental Quality 41: 1402-1412.

Vezie, C., J. Rapala, J. Vaitomaa, J. Seitsonen, and K. Sivonen. 2002. Effect of nitrogen and phosphorus on growth of toxic and nontoxic Microcystis strains and on intracellular microcystin concentrations. Microbial Ecology 43(4):443-454.

Vitt, D. H., L. A. Halsey, C. Campbell, S. E. Bayley, and M. N. Thormann. 2001. Spatial patterning of net primary production in wetlands of continental western Canada. Ecoscience 8(4):499-505.

Waiser, M. J. 2006. Relationship between hydrological characteristics and dissolved organic carbon concentration and mass in northern prairie wetlands using a conservative tracer approach. Journal of Geophysical Research: Biogeosciences 111(G2).

Warne, A. G. and J. S. Wakely. 2000. Guidelines for conducting and reporting hydrologic assessments of potential wetland sites. WRAP Technical Notes Collection ERDC TN-WRAP-00-01. U. S. Army Research and Development Center, Vicksburg, MS.

Watts, A. C., C. A. Schmidt, D. L. McLaughlin, and D.A. Kaplan. 2015. Hydrologic implications of smoldering fires in wetland landscapes. Freshwater Science 34(4): 1394-1405.

Weller, M.W. 1981. Freshwater Marshes: Ecology and Wildlife Management. University of Minnesota Press, Minneapolis, MN.

Weller, M.W. 1999. Wetland Birds: Habitat Resources and Conservation Implications. University of Cambridge Press, Cambridge, UK.

Whalen, S. C. 2005. Biogeochemistry of methane exchange between natural wetlands and the atmosphere. Environmental Engineering Science 22:73-94.

White, J. S. and S. E. Bayley. 2001. Nutrient retention in a northern prairie marsh (Frank Lake, Alberta) receiving municipal and agro-industrial wastewater. Water, Air, and Soil Pollution 126:63-81.

Contact Information

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

Water Policy Branch
Alberta Environment and Parks
7th Floor, Oxbridge Place
9820 – 106th Street
Edmonton, Alberta T5K 2J6
Phone: 780-644-4959
Email: ESRD.Web-SWQ@gov.ab.ca

Additional copies of this document may be obtained by contacting:

Alberta Environment and Parks
Information Centre
Main Floor, Great West Life Building
9920 – 108 Street
Edmonton, Alberta T5K 2M4
Call Toll Free Alberta: 310-ESRD (3773)
Toll Free: 1-877-944-0313
Fax: 780-427-4407
Email: ESRD.Info-Centre@gov.ab.ca
Website: AEP.alberta.ca

Authorities

Original signed by: Date: Jul 4, 2016

Andy Ridge, Executive Director
Water Policy Branch
Alberta Environment and Parks