Alberta Wetland Identification and Delineation Directive

June 2015

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Purpose

To provide identification and delineation standards and thereby improve consistency of wetland boundaries, area and assessments.

Policy Context

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

Reference Documents

- Alberta Wetland Regulatory Requirements Guide
- Alberta Wetland Assessment and Impact Report Directive
- Alberta Wetland Mitigation Directive
- Alberta Wetland Classification System
- Alberta Wetland Rapid Evaluation Tool – Actual (ABWRET-A) Manual

Enforcement / Compliance

All proponents must use this directive to delineate wetlands for the purpose of making a wetland assessment under the *Water Act* or *Public Lands Act.*

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Citation

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1. Introduction

This guide explains how to identify wetlands and delineate their ecological boundaries. The purpose of this Directive is to improve accuracy and consistency of wetland delineations by providing standardized identification and delineation methods.

This Directive *must* be used by proponents to:

1. Identify and delineate the ecological boundaries of all wetlands that may be impacted by a proposed activity
2. Define the assessment area of wetlands for conducting wetland classification, relative value and species survey assessments[1]
3. Digitize and submit spatial boundaries of wetland(s) that will be impacted by a proposed activity
4. Inform and plan activities to ensure avoidance and minimization of impacts to wetlands where practicable
5. Determine replacement ratio costs for wetland replacement where necessary

This Directive will also support the following initiatives:

1. Establishment of setbacks from wetlands[2]
2. Land use planning, conservation and stewardship
3. Wetland mapping and inventory creation or enhancement
4. Scientific research and education

1.1. Regulatory context

It is incumbent on the landowner and/or proponent to obtain all relevant authorizations for any activity within a wetland or near to a wetland that will potentially impact its area or water management – e.g., drainage path, volume, timing, intensity, duration, frequency or quality of water flowing into or out of a wetland.

[1] The assessment area for wetland classification using the Alberta Wetland Classification System is the entire delineated wetland. The assessment area for the Alberta Wetland Rapid Evaluation Tool Actual (ABWRET-A) may be the entire delineated wetland, or a portion thereof, which reflects the area of predicted impact to the wetland. The assessment area for species surveys may be greater than the delineated wetland, depending on the species and habitats being surveyed

[2] Incorporating additional setback distances from the ecological extent of a wetland is encouraged for the provisioning and maintenance of healthy wetlands. *Stepping Back from the Water* provides further information and recommendation on setbacks or buffers.

Wetland identification and delineation assessments should be conducted as early in the planning stage as possible. Wetlands are most evident before any development planning, engineering designs, or land-use changes have occurred.

Proactive identification and delineation of wetlands will help:

1. Ensure activities are conducted in compliance with provincial regulation and policies
2. Plan avoidance of impacts to wetlands where practicable, particularly those of high relative value (i.e. A- and B-value wetlands)
3. Facilitate appropriate and effective mitigation actions to minimize impacts to wetlands, reducing costs associated with replacement
4. Inform the proponent of regulatory requirements and potential costs up front prior to financial investment
5. Reduce risk and future costs associated with construction, maintenance or liability associated with development in wet areas that tend to flood

All elements of a wetland assessment, such as wetland classification, assessment of the actual relative value of a wetland, and plant and wildlife surveys should be conducted within the boundary of the wetland, (or a portion thereof if the wetland is large and/or inaccessible). The Alberta Wetland Rapid Evaluation Tool – Actual (ABWRET-A) manual provides more information on the Assessment Area used for ABWRET-A field surveys and must be read along with this document before conducting a wetland assessment.

1.2. Scope of this document

This Directive must be used to identify and delineate the extent of any wetland in Alberta, including fully restored and constructed wetlands. This document does not cover the identification and delineation of ephemeral water bodies, although they are subject to the *Water Act* if they affect water management. Ephemeral water bodies often occur at the interface between wetland and upland habitat or in close proximity to wetlands. However, they lack primary soil and vegetation indicators that are defined in Section 5 of this document. The Alberta Wetland Classification System (AWCS) provides complementary information that can support wetland identification and delineation, including key characteristics for differentiating wetland from non-wetlands, and wetland classes, forms and types.

Prior to any activity taking place, it is necessary to determine whether the wetland bed and shore is owned by the Government of Alberta under the *Public Lands Act*. More information on assessing ownership of wetlands based on wetland permanence can be found in the *Public Lands Act* and shapefile the Guide for Assessing Permanence of Wetland Basins.

1.3. Definitions

Wetlands are land saturated with water for long enough to promote the formation of water altered soils, growth of water tolerant vegetation and biological activity adapted to a wet environment (Alberta Environment and Sustainable Resource Development, 2013).

The **wetland boundary** is the furthest ecological extent of a wetland bordering upland or other non-wetland habitat, as indicated by a shift from hydric to non-hydric soils and facultative wetland vegetation to upland vegetation in the majority of years. The wetland boundary is delineated by the absence of wetland soil and vegetation indicators. A wetland boundary may include multiple contiguous classes, forms and/or types of wetlands in the Alberta Wetland Classification System.

Wetland identification refers to the detection of wetland area

Wetland delineation refers to the process of delimiting the entire wetland boundary.

Desktop delineation refers to the acquisition and interpretation of multiple, representative images to delineate the wetland boundary.

Field delineation refers to the visitation of a wetland in the field and collection of waypoints using a GPS unit to delineate the wetland boundary.

Field verification refers to the visitation of a wetland in the field to confirm the desktop delineation at a number of sample points.

Wetland digitization refers to the process of creating a shapefile of delineated wetland boundaries.

Facultative wetland species refers to water tolerant plants found in wetlands between 66 and 99% of the time.

Obligate wetland species refers to water tolerant plants found in wetlands >99% of the time.

2. Desktop procedures for preliminary wetland identification and delineation

The first step in any wetland assessment is to identify any wetlands that may be impacted and require a *Water Act* and/or *Public Lands Act* application. The following section sets out the minimum requirement of a desktop evaluation to determine the likely presence of a wetland.

The review process conducted must be documented and the information collected must be retained for a minimum of 5 years and made available upon request. In situations where information is not available, the steps undertaken in an attempt to find the information must be documented. It is the responsibility of a landowner or proponent undertaking an activity to identify the presence of wetlands and to understand the required authorizations (approvals, permits, licenses, etc.) that need to be obtained **before** conducting an activity that may impact a wetland. Further information can be obtained in the Alberta Wetland Regulatory Requirements Guide.

During the review process, one may encounter previous impacts to wetland that may require a *Water Act* approval. Any previous or ongoing activities that have caused an impact to wetland(s) must be brought into compliance prior to the consideration of a new *Water Act* application. Evidence of unauthorized activities such as drainage ditches, tile drainage, excavation, vegetation removal, fill material or other alterations and activities affecting a wetland must be reported to the province by calling 1-800-222-6514 or by emailing erc.environment@gov.ab.ca. Please provide as much detail as possible, including the location (legal description), details of the non-compliance, the potential responsible party and your contact information should

further information be required. Be assured that the source of information will be kept confidential where requested.

2.1. Steps for identifying wetlands

1. Acquire and review the best available imagery from multiple dates and times of year. The imagery selection and photo interpretation process is explained in detail in Section 4 and Appendices 2, 5 and 6. Some suggested sources where imagery can be acquired are:
    - Air Photo Distribution Services
    - Imagery may be distributed or requested from some Counties and Municipalities
    - Private companies
2. Review available topographic maps to locate drainage patterns and potential wetland areas that may indicate where indirect impacts may occur by altering flow into and out of a wetland. At a minimum, use digital NTS 1:50,000 maps, which may be accessed free of charge from the Natural Resources Canada website
3. Identify the location of all potential wetlands and connectivity between wetlands that may be affected by the proposed activity
4. Draw a coarse boundary around the full extent of the wetland(s) in the majority of years, identifying any areas of connectivity, inflow and outflow

To enhance the accuracy of wetland identification and to minimize the costs and future work, it is highly recommended that you choose appropriate and representative imagery using methods described in Section 4. By acquiring representative imagery at an early stage, you will avoid having to acquire more or different imagery at later stages of the delineation process or for assessing permanence and class. Use of additional sources listed in Appendix 4 is recommended, particularly in cases where imagery is limited or unavailable. Additional information and knowledge will make desktop and field delineation more efficient and effective. Early visitation to the site to ground truth the wetlands is also recommended at this stage but not required.

If you identify potential wetlands **and** plan to proceed with a *Water Act* and/or *Public Lands Act* application, then the identified wetlands must be confirmed and delineated more accurately using one of the approaches described in Section 3 to 5.

3. Overview of wetland delineation methods

Wetland delineation can be accomplished by following one of five approaches or pathways as shown in **Figure 1**. The pathway required for wetland delineation depends on the characteristics of the wetland being assessed. Pathways reflect the requirement and comprehensiveness of **desktop delineation**, **field verification**, and/or **field delineation**, which are defined above in Section 0. The following questions will help define the pathway to follow for delineating a specific wetland site:

1. Is the wetland boundary simple or complex?

2. Does the wetland have wetland indicators that are not always present or visible due to fluctuations in water levels and soil saturation?
3. Has the wetland been physically disturbed or altered?
4. Do you have access to the wetland or a portion of the wetland?
5. Is the imagery high quality, readily available and representative of mid- to long-term conditions?

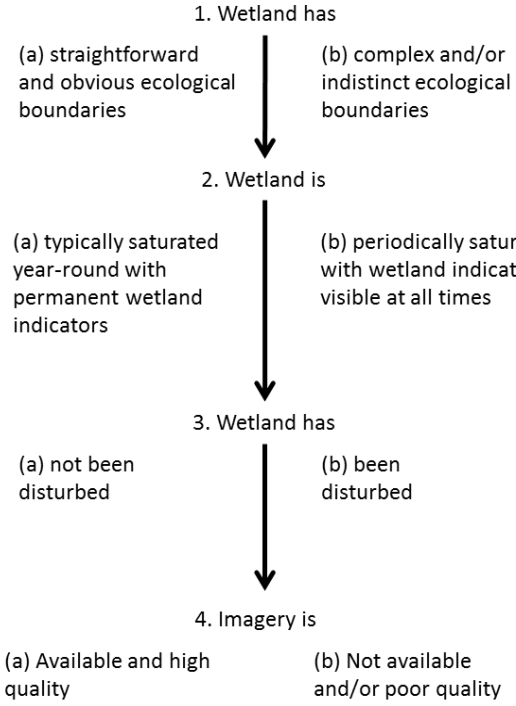
The pathways are intended to optimize efficiency of wetland delineations while maintaining consistency and accuracy. For example, the wetland delineation approach for wetlands with simple linear shorelines with obvious wetland indicators and boundaries can be done fairly rapidly using Pathway 1 or 3, while more complex sites require more comprehensive assessments such as Pathway 2, 4 and 5. Use the questions and options in **Figure 1** to choose the appropriate pathway for delineation of a specific site. Use of additional information listed in Appendix 4 is recommended and can help improve efficiency and accuracy of the delineation.

Question 1 refers to the morphologic or physical characteristics of a wetland. Visual indicators such as distinct topographical relief, steep shoreline slopes, simple shoreline perimeters, and obvious permanent cover (e.g. tamarack tree cover, open water, salt encrustations) may allow for simple delineation. A more comprehensive delineation pathway is required when a site has complex characteristics. Examples of a site with complex characteristics may be flat terrain with little relief, indistinct plant communities at the upland-wetland interface, convoluted and flat shorelines, interspersion of upland and wetland habitats, and/or fluctuating water levels and vegetation communities. Areas of a site that have more indistinct boundaries (e.g. due to an inlet or change in slope, etc.) should be sampled more intensely to clarify and verify the wetland boundary.

Question 2 refers to the water permanence type that can be keyed out using the Alberta Wetland Classification System. Only swamps, marshes and shallow open waters may be periodically saturated. Bogs and fens are typically permanent wetlands and will have characteristics of 2(a) in Figure 1. Less permanent wetlands, particularly temporary and seasonal wetlands, require a more comprehensive delineation pathway. Acquisition and analyses of a representative sample of historical images that reflects the wetland's inter-annual response to climate patterns and seasonal variability is required. If recent meteorological conditions have been exceptionally dry or wet, the desktop analysis must be more comprehensive as reliance on field indicators alone can be potentially misleading. More information on choosing representative imagery is provided in Section 4.

If a wetland has been physically altered or disturbed and **Question 3** is answered (b) in Figure 1, the type of disturbance and the date of its occurrence should be examined. Some disturbances occur only once while others may be ongoing and periodic (e.g. agricultural disturbances in wetlands or episodic events like drought or flood). If the wetland has been disturbed, attempt to acquire imagery from both before and after the disturbance. Field verification is required when a disturbance has occurred and the number of samples at and around the point of disturbance should be increased appropriately. If the disturbance is widespread and/or affects the entire wetland, increase the number of samples (i.e. more vegetation plots) or sampling intensity (i.e. more soil samples) around a representative portion of the wetland. Disturbances include both natural and anthropogenic causes that may affect the hydrology of the site, including drainage path, volume, velocity, timing, duration and frequency of water flowing into or out of a wetland.

Question 4 relates to the quality, availability and representation of imagery for that legal land location. Use Section 4 to pick the best and most representative air photographs out of the imagery available to you for that site, or you may acquire other sources of air borne imagery (e.g. satellite) for delineation and interpretation.



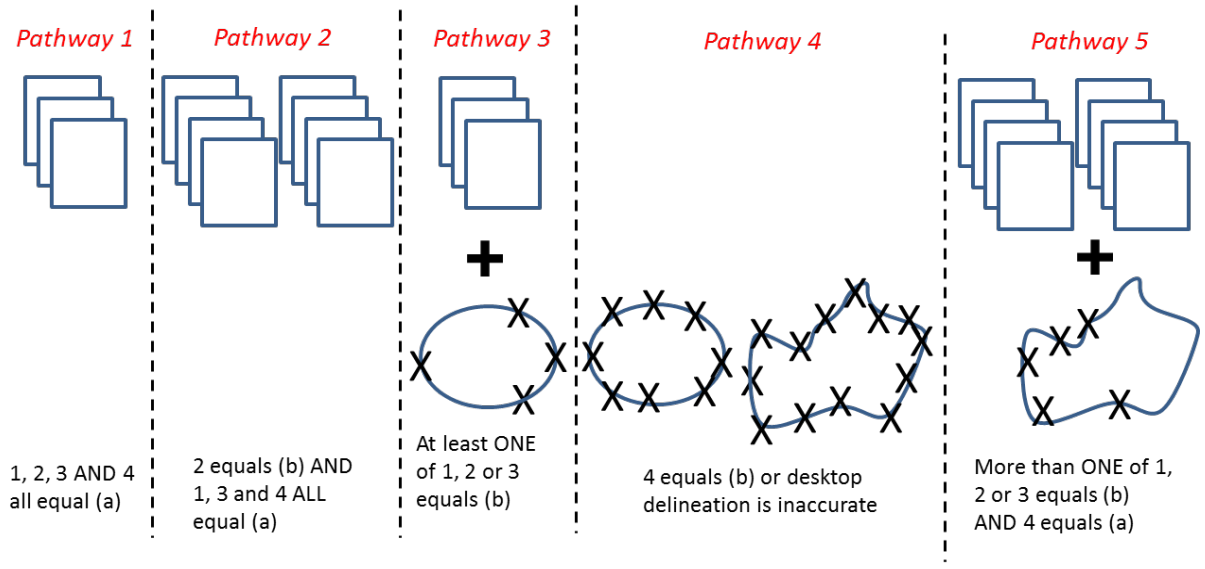


Figure 1. Wetland pathways based on combinations of answers to five questions. Each pathway is based on the comprehensiveness of desktop and field delineation.

3.1. Pathway 1 – Simple desktop delineation

Questions 1, 2, 3 and 4 all equal (a)

When a wetland has straightforward and obvious boundaries, has fairly permanent indicators, and has not been disturbed, delineation of a wetland can occur through pathway 1. In pathway 1, the delineated wetland boundary must be interpreted and delineated using an appropriate sample of representative images.

3.2. Pathway 2 – Comprehensive desktop delineation only

Questions 2 equals (b), AND 1, 3 and 4 ALL equal (a)

In pathway 2, the wetland boundary is interpreted and delineated using a more comprehensive desktop assessment. Pathway 2 may be also be used in drought or flood years, or other natural disturbances (e.g. fire) that make the wetland inaccessible or field delineation too challenging and potentially misleading.

3.3. Pathway 3 – Simple desktop delineation with field verification

At least ONE of Questions 1, 2 or 3 equals (b)

Pathway 3 is followed when the wetland boundary is obvious and simple to delineate AND imagery is available. In pathway 3, the desktop delineation is done by a desktop assessment, but the wetland boundary is subsequently verified in the field at a representative number of points using a GPS unit.

3.4. Pathway 4 – Field delineation only

Question 4 equals (b) or if field verification finds that desktop delineation is inaccurate

In pathway 4, the boundary of the entire wetland is delineated in the field. This pathway should be used if imagery is not available, of poor quality or not representative of current site conditions (e.g. recent or ongoing disturbance to the site). If you do not have access or permission to access the entire wetland, a portion of the wetland can be delineated in the field and the remainder can be delineated using imagery analyses and interpretation.

3.5. Pathway 5 – Comprehensive desktop delineation with field verification

More than ONE of Questions 1, 2 or 3 equals (b) AND 4 equals (a)

Pathway 5 uses a combination of more comprehensive desktop interpretation to delineate the wetland boundary and field verification to confirm the desktop delineation. Pathway 5 must be used when a site has complex or indistinct wetland boundaries, wetland indicators that are not always present, and/or has been disturbed AND has available and representative imagery.

This document does not provide rigid methodology or requirements for sampling because wetland delineation complexity, permanence and degree of disturbance exist along a continuum as shown in **Figure**

2. Furthermore, availability of imagery will vary from location to location, making it impossible to establish a minimum standard or methodology. Nonetheless, it is expected that the degree of comprehensiveness corresponds to the complexity and situation of the individual site and that sampling procedures are rigorous enough to provide accurate and reproducible delineations.

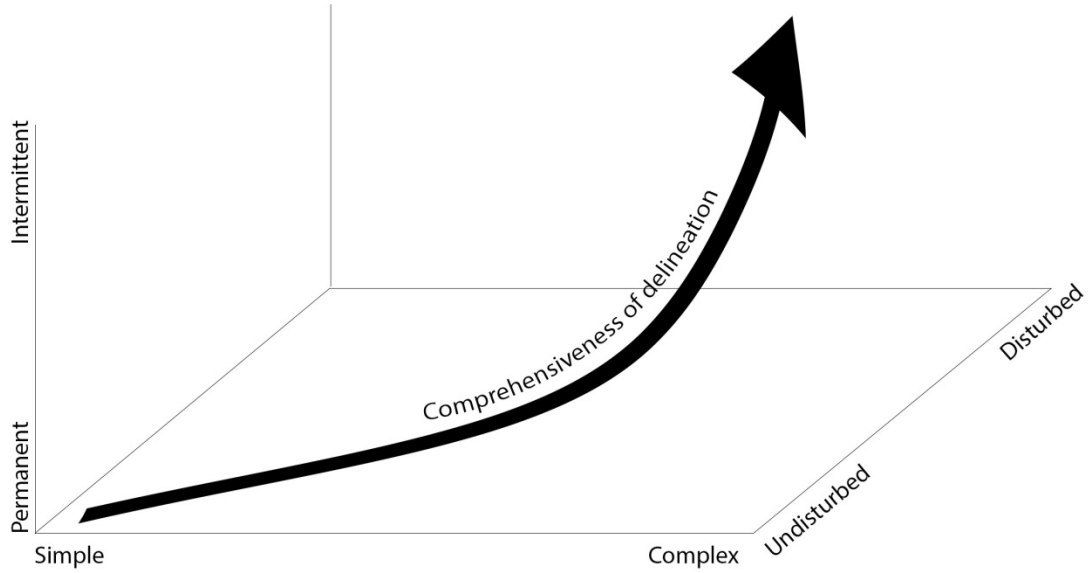


Figure 2. More comprehensive delineation methods are required as the complexity of the wetland edge (x-axis), periodicity of wetland indicators (y-axis) and degree of disturbance (z-axis) increases.

Comprehensiveness can be enhanced by either by increasing sampling intensity (e.g. number of images, number of field verification plots), by gathering and analyzing additional information (e.g. conversations with landowners) or by acquiring or collecting better and/or more reliable data (e.g. high resolution imagery or soil pits). It is important to document your pathway and processes that you used to gather and interpret data. In situations where information is not available, the steps undertaken in an attempt to find the information must be documented.

3.6. Reporting requirements

The methodology and data that you collected, analyzed and interpreted must be reported to the provincial regulatory body if you are submitting an application. If the site cannot be visited or accessed (i.e. pathway 1 and 2), clearly articulate why. For imagery, the image source, date taken (day, month and year), resolution and other attributes must be catalogued. In the case of field data collected, the number of samples taken, sampling locations, sampling procedures (e.g. point transect, 1 x 1 m quadrat, 10 x 10 m plots), and data confirming the boundary of the wetland (e.g. species common and Latin names and percent cover, soil attributes, photographs) must be documented. Details on the reporting requirements are provided in the Alberta Wetland Assessment and Impact Report Directive. Final delineated boundaries must be digitized and submitted according to submission standards provided in Section 6.

4. Desktop methods for wetland delineation

The preliminary analysis for wetland identification and delineation utilizes interpretation of best available and most representative airborne imagery. This can include aerial photographs or other remotely sensed images. When necessary, stereoscopic image pairs are encouraged to aid in delineation where there are disturbances to a wetland or to help differentiate vegetation communities. Airborne imagery can be acquired as hard copy aerial photographs or in digital format that can be imported into Geospatial Information System (GIS) software. Once the images are ortho-rectified, a recent representative image can be used as a base map upon which wetland boundaries can be digitized and submitted to the regulatory body. The following section explains the necessary steps for interpreting the ecological boundaries of a wetland. Photo interpretation of wetlands requires a highly qualified skillset. The photo interpreter should have a strong background in photo interpretation, vegetation identification, wetland delineation and GIS skills for digitizing wetland boundaries.

4.1. Choosing imagery

When choosing imagery for wetland identification and delineation, it is important to consider the type of imagery, the resolution, colour bands, and date captured in addition to taking into account the climate conditions. Imagery selection should include both the best and most recent image(s) available, and represent a time of the year when it is easiest to delineate the wetland boundary for that wetland class and form. Additional sources of information are shown in Appendix 4 and examples are shown in Appendix 5.

4.1.1. Imagery type and resolution

Three types of air photo imagery are available: Black and White, True Colour, or Colour Infrared (Colour IR). Other kinds of imagery include satellite imagery (e.g. SPOT) and derivatives from remotely-sensed imagery (e.g. LiDAR Bare Earth Digital Elevation Models, Wet Areas Mapping [WAM] tool). Appendix 1 provides a comparison of several common kinds of imagery, assuming the same resolution. Based on the advantages and disadvantages of different image sources, the following sources are recommended from best to least desirable:

1. Combination of air photos (colour IR preferable) and LiDAR Bare Earth DEM
2. Colour IR air photographs
3. True colour air photographs
4. Black and White air photographs
5. LiDAR Bare Earth DEM and SPOT imagery (if air photos are unavailable)

A combination of LiDAR Bare Earth DEM and air photos will provide the best imagery for identification and delineation of wetlands (Creed, pers. comm.). Colour IR air photos are the best for differentiating vegetation communities and may provide best delineation results if captured between mid-summer and early fall for most wetlands; leaf-off imagery in spring or fall may be best for delineating treed wetlands from treed uplands. In the absence of air photos, a combination of LiDAR DEM and SPOT imagery would also provide good imagery for wetland identification and delineation (Creed, pers. comm.). If resolution differs among available imagery, then the resolution must be taken into consideration and weighed with other factors. If unsure, acquire as much imagery as necessary to facilitate accurate interpretation. Large-scale photography (1:24,000 or greater) is necessary for acceptable photointerpretation.

Some suggested sources where imagery can be acquired are:

- Air Photo Distribution Services
- Imagery distributed or requested from Counties and Municipalities
- Private companies

APRS Search Results

When ordering aerial photography there are two methods:
- provide the roll and print/frame numbers (e.g. AS-5112-014) from the flight index maps (refer to "Readme" file in the zip file for more instructions).

User Information:
- Blue Underlined Project numbers (e.g. 92-159) - click on the project number to download and view the flight index map(s) associated with that project. Index maps show photo centres/locations not the actual photographic image.
- "P" (in red) - identifies incomplete or partial coverage of the specified section. View the index map(s) to determine if second/third choices should be included with your request.
- "Tr" Projects (e.g. 06-078**Tr**) - in general projects with this suffix are of superior quality. For example, well-site details can usually be observed even at small scales (e.g. 1:60,000). Check "Comments" column for product availability.
- More detailed instructions on using the flight indices (a "Read Me" file) are included as part of the map download.

Legal Description (Sec. Twp. Rge. Meridian): 14 - 53 - 25 - 4

Project No.	Sub. ID	Coverage (Partial/Complete)	Date	Scale (1:)	Emulsion	Comments
T08-270	11	C	2008-10-02	20000	B/W	Neg.scans-2,032 ppi
07-007	2	P	2007-08-30	30000	True Colour*	Big Lake
07-EDM	9	C	2007-00-00	20000	B/W	Laser/Digital only
05-EDM	22	C	2005-04-21	20000	B/W Pan-80	
03-EDM	13	C	2003-05-14	20000	B/W Ap-80	
01-EDM	7	C	2001-04-00	20000	B/W	Roll:ED-2001-01,02
T97-83F	90	C	1997-00-00	20000	B&W	
92-146	2	C	1992-07-00	20000	B/W PAN	
T91-077 P9	4	C	1991-09-26	20000	B/W Pan-XX	Hwy.16; Roll:AS-4213
T91-077 P7	1	P	1991-09-25	20000	B/W Pan-XX	Hwy.16 - Roll:AS-4212
T90-182	6	C	1990-11-06	40000	B/W Kodak-2405	Roll:AS-4075
T90-185	5	C	1990-10-00	20000	B/W Kodak-2405	
T90-185	3	C	1990-10-00	20000	B/W Kodak-2405	
S88-026 P10	3	C	1988-09-01	20000	B/W Pan-XX	Hwy.2; Roll:AS-3695
87-089 83H	3	C	1987-00-00	30000	B/W Pan-2405	
S86-030	1	P	1986-05-30	25000	B/W Kodak-2405	Hwy.16X; Roll:AS-3285
S85-021I	4	P	1985-06-28	25000	B/W Pan-2405	Jasper Ave.; Roll: AS-3164
S85-021H P7	8	C	1985-05-05	25000	B/W Kodak-2405	Hwy.16; Roll: AS-3114
S85-021D-1 P6	6	C	1985-04-12	25000	B/W Kodak-2405	Hwy. 2; Roll:AS-3110
S84-057	1	P	1984-04-15	25000	B/W Pan-2405	Hwy.16
83-145 83H 6	1	C	1983-10-01	60000	B/W Pan-2405	Roll: AS-2793
83-303	1	P	1983-05-12	25000	B/W Pan-2405	Roll:AS-2698
F82-124 P9	23	C	1982-10-01	25000	B/W Pan	Roll:AS-2582
82-089 83H	5	C	1982-09-00	30000	B/W Pan-2405	Neg. scan-1270dpi
S82-015B P2	3	C	1982-04-29	25000	B/W Pan-2405	Hwy.16; Roll:AS-2454
80-121 83H	3	C	1980-00-00	60000	B/W Pan-2405	
F79-085	1	P	1979-10-26	10000	B/W Pan-2405	Roll:AS-1829
79-099	1	C	1979-00-00	30000	B/W Pan-2405	Rolls:AS-1955,2118
S78-208	1	P	1978-05-18	10000	B/W Pan-2405	Hwy.2; Roll:AS-2944
S78-200 P2	12	C	1978-04-26	25000	B/W Pan-2405	Hwy 2; Roll:AS-2945
77-102	27	C	1977-06-07	31680	B/W Pan-2405	Rolls:AS-1591,1592,1593
76-170 83H	21	C	1976-09-00	20000	B/W Pan-2405	Rolls:AS-1545-1549
76-023B 83H	4	C	1976-07-00	31680	B/W Pan-2405	Rolls:AS-1540,1541
S76-173	9	C	1976-04-30	25000	B/W Pan-2405	Roll: AS-2983
75-148	1	C	1975-07-19	40000	B/W Pan-2405	Roll:AS-1391
75-094	6	C	1975-05-21	12000	B/W Pan-2405	Roll:AS-1372
73-186	2	C	1973-10-08	12000	B/W Estar-Pan	Roll:AS-1289
73-025 83H	15	C	1973-07-00	31680	B/W IR-2424.	Rolls: AS-1248,1249
70-268	1	P	1970-04-16	12000	B/W Pan-2405	Roll:AS-1466
70-322 83H	3	C	1970-00-00	80000	B/W Pan-2405	Rolls:AS-1109,1110,1113
69-200	12	C	1969-11-06	24000	B/W	Roll:AS-1043
69-225	4	C	1969-04-28	24000	B/W Pan-2405	Roll:AS-1034
67-83H	19	C	1967-00-00	31680	B/W.	Neg.Scan-1270dpi
62-83H	14	C	1962-06-00	31680	B/W.	Neg.Scan-1270dpi
S52-017	25	C	1952-00-00	11600	B/W Pan-2405	Roll: AS-0004
49-83H	3	C	1949-00-00	40000	B/W Super XX.	Years 49-51; Neg. Scan-1270dpi
20-315	1	C	1920-00-00	VARY	B/W	Lasers/Scans only

Figure 3. Sample of search output from the Air Photo Records System (APRS).

4.1.2. Year of imagery

Examination of past climate data is especially important in identifying the presence and boundaries of mineral wetlands (i.e., swamps, marshes and shallow open waters) that exhibit fluctuating water levels over seasons and years (See AWCS for more explanation on this subject). In contrast, the boundaries of peatlands (i.e., fens and bogs) are less likely to be as influenced by precipitation cycles.

Basing a wetland assessment on a single snapshot in time is unsuitable for the assessment of a wetland that exhibits fluctuating water levels in differing years and different times of the year. A time series of imagery is necessary for the delineation of many types of wetlands, particularly in the Grassland Natural Region where temporary and seasonal wetlands are abundant. Delineation of wetlands that have fluctuating water levels and wetland indicators can be problematic due to less obvious differences between wet and dry terrain and concurrent changes in vegetation structure and overall appearance. For wetlands that exhibit changes in appearance due to cycles in water levels and hydroperiod, a time series of imagery is required to capture hydrologic dynamics over time and to provide a more accurate estimate of a wetland's ecological boundary. Examining a time series of historical air photos will also help to understand past disturbances that may have impacted wetland presence and extent.

To choose imagery that is representative of the wetland over time, it is helpful to examine the precipitation record in the area of interest. This will allow the practitioner to correlate precipitation data and inferred climate state with the date when the photo was captured. The steps below outline procedures for choosing appropriate imagery.

4.1.3. Time of year of imagery

Time of year is a particularly important consideration when determining the presence and class of marshes and shallow open waters. Spring imagery captured after freshet is useful for identifying all wetland basins usually full of water. Ephemeral water bodies and temporary wetlands typically have little to no surface water by early July. Early to mid-summer imagery will aid in the identification of all wetlands that are seasonal, semi-permanent and permanent in nature (all ephemeral water bodies and temporary wetlands should be dry now). Late summer or early fall imagery can be used to determine semi-permanent and permanent wetlands because they usually contain surface water until the end of the growing season. This time of year may also help distinguish wetland from non-wetland vegetation using colour IR imagery.

Natural disturbances such as fires may affect the delineation of peatlands. Fall Colour IR or True Colour imagery is recommended for delineating treed wetlands and/or peatlands. Autumn colouration evident on this imagery will help identify vegetation communities and their extent. Appendix 2 provides interpretation keys for water and wetland vegetation and Appendix 4 provides tips and recommendations for imagery interpretation.

4.2. Steps for choosing representative imagery

The steps below provide standard methods for selection and interpretation of imagery.

1. Correlate precipitation levels (relative to norms) with dates of available air photos. Alberta Agriculture and Rural Development's AgroClimatic Information Service (ACIS) provides a convenient set of maps and tools for working with historical precipitation records (Figure 4).

Precipitation data specific to the area of interest can be obtained through the interpolated weather data viewer for Alberta Townships under the Historical Weather Data tab (Figure 5).

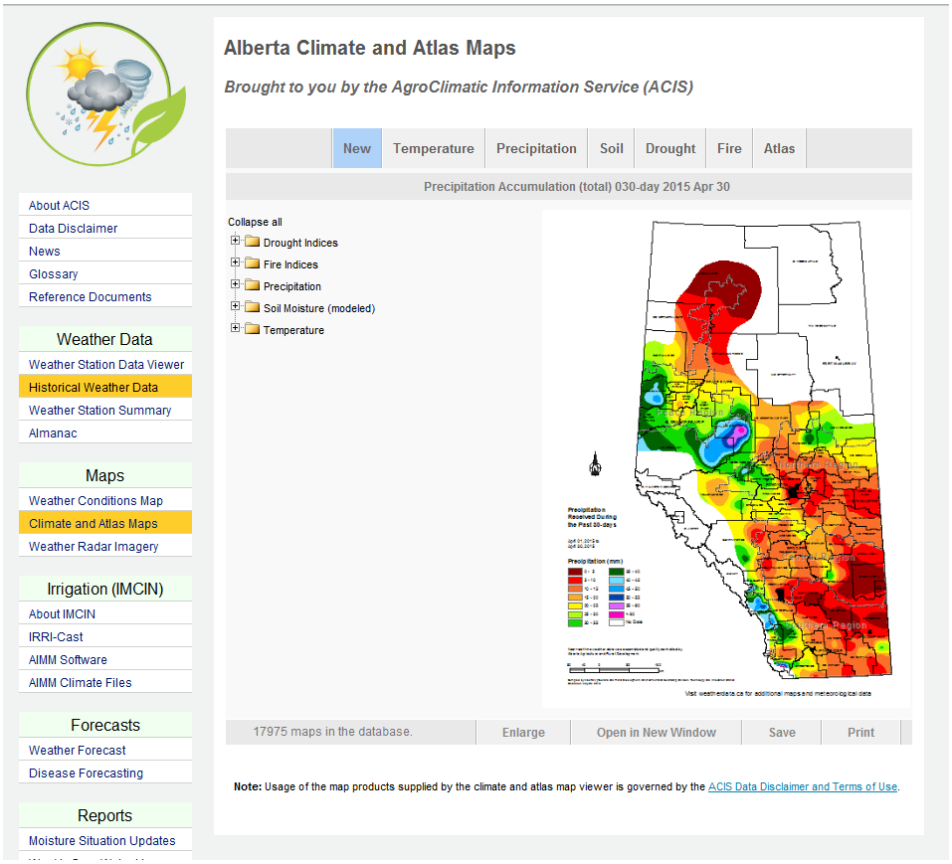


Figure 4. Image capture of the web interface showing Alberta Agriculture and Rural Development's AgroClimatic Information Service (ACIS) website.

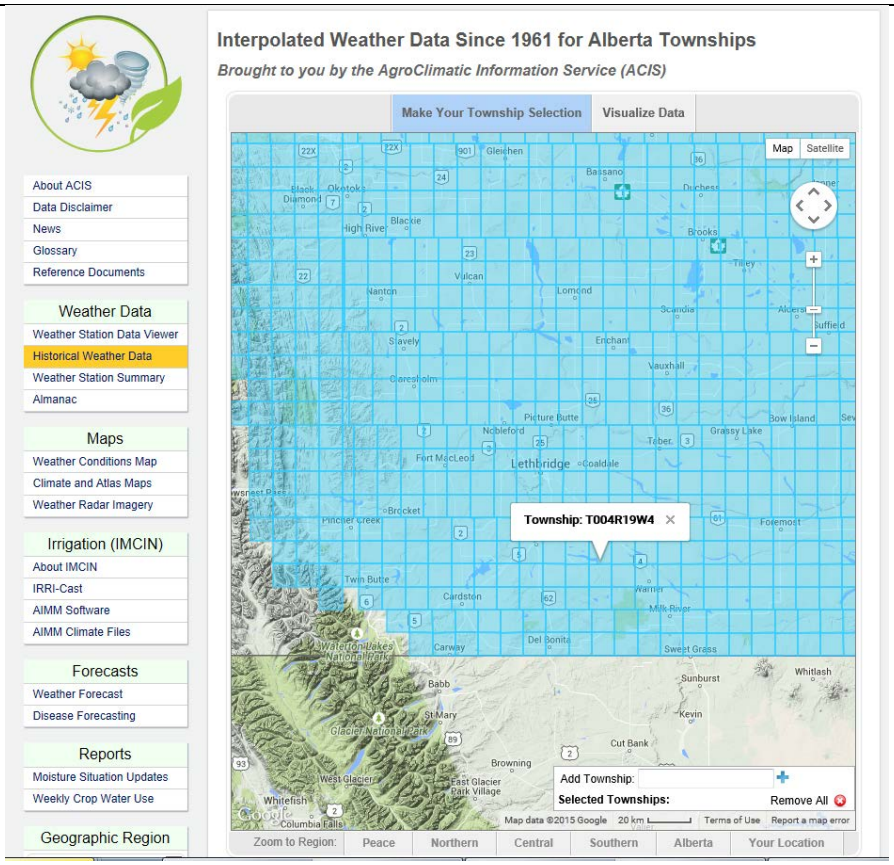


Figure 5. Image capture of the web interface highlighting the township selection feature for weather data. Clicking on a township will yield data for that township.

2. Once the specific township has been selected, the data can be viewed by clicking on the "visualize data" tab at the top of the map (Figure 6).

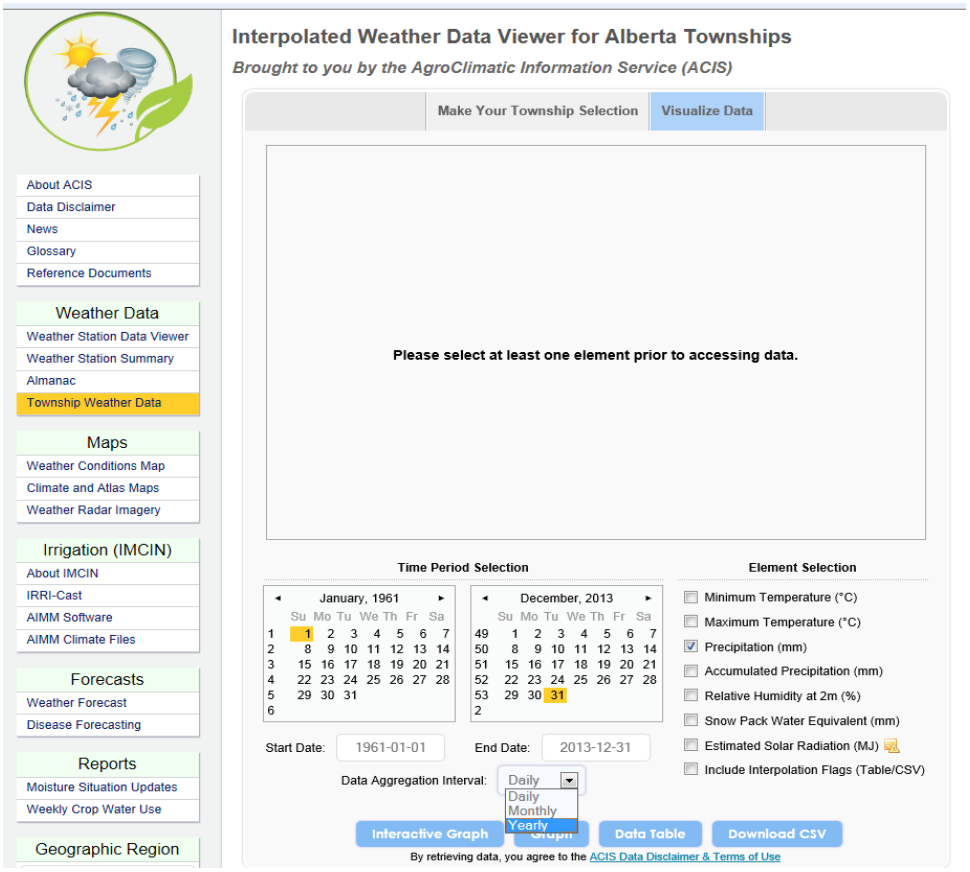


Figure 6. Image capture of the web interface showing the Township Weather Data viewer.

3. Select precipitation using the toggle boxes on the right, then select the time period (data range) and time interval (daily, monthly or yearly). Using the tabs at the bottom to graph, select to view or download the data (Figure 6 and Figure 7).

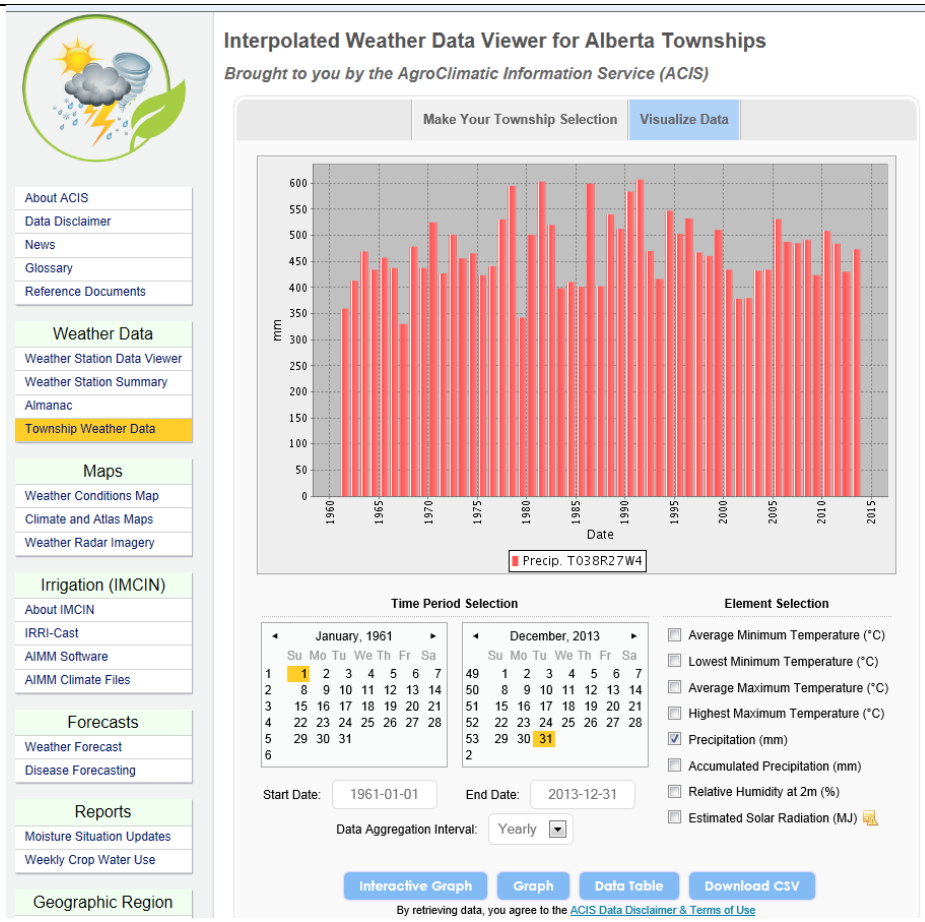


Figure 7. Image capture of yearly precipitation in township T038, range R27, meridian W4 between January 1, 1961 and December 31, 2013.

4. Download yearly data from the earliest available date to present. Calculate the Average, Maximum and Minimum precipitation levels for later use in interpretation (Figure 8).

Township	Date	Precip. (mm)
T037R24W4	1975	469.12
T037R24W4	1976	474.38
T037R24W4	1977	503.95
T037R24W4	1978	621.75
T037R24W4	1979	342.84
T037R24W4	1980	533.88
T037R24W4	1981	504.14
T037R24W4	1982	482.44
T037R24W4	1983	366.99
T037R24W4	1984	472.36
T037R24W4	1985	416.84
T037R24W4	1986	562.76
T037R24W4	1987	345.5
T037R24W4	1988	487.2
T037R24W4	1989	493.45
T037R24W4	1990	600.94
T037R24W4	1991	638.75
T037R24W4	1992	456.39
T037R24W4	1993	454.33
T037R24W4	1994	548.01

Township	Date	Precip. (mm)
T037R24W4	1995	471.6
T037R24W4	1996	523.22
T037R24W4	1997	430.41
T037R24W4	1998	454.66
T037R24W4	1999	571.11
T037R24W4	2000	438.47
T037R24W4	2001	333.67
T037R24W4	2002	382.03
T037R24W4	2003	447.17
T037R24W4	2004	441
T037R24W4	2005	485.72
T037R24W4	2006	490.27
T037R24W4	2007	454.63
T037R24W4	2008	350.59
T037R24W4	2009	329.72
T037R24W4	2010	549.66
T037R24W4	2011	388.27
T037R24W4	2012	451.6
T037R24W4	2013	434.42

AVG	466.7754
MIN	329.72
MAX	638.75

Figure 8. Example of yearly precipitation tables downloaded as csv files.

5. Similarly, download the monthly and daily data for further interpretation (Figure 8).

   By correlating meteorological data to imagery, one can make better decisions for choosing appropriate images for interpretation. Note that the correlation between the date the image was captured and daily, seasonal or yearly precipitation data does not guarantee accurate representation of contemporaneous water levels in the wetland of interest. It is highly recommended to consider precipitation levels in the two or three years and the trend preceding and following the exact date of the available image of interest. Vegetation often has a time lag associated with response to changing water levels.

6. Using the search tools available from the imagery provider, determine what imagery is available for the land location of interest. Note when the image was taken and correlate this date to the plotted precipitation record. This will provide an indication as to whether the image is representative of a dry, moderate or wet year in the precipitation record. Part of the review should include an analysis of the climatic conditions preceding the date of photo capture to determine if any significant dry periods are likely to influence the characterization of the wetland. For example, if the image date is July 14, 1987, examine the precipitation for the year, and the

preceding few years. Prior to the photo, was the climate in previous years drier or wetter? Then, to ensure the data interpretation is not skewed, look at the monthly data from July, 1987 to determine whether or not any monthly precipitation occurred after the photo was taken, and finally, examine precipitation data around the day the image was taken (if available) and document whether the image is reflective of "normal", "dry" or "wet" conditions.

Caution! Do not rely on photos representing drought or overly wet conditions. Choose appropriate photos using years and seasons that are most appropriate for the wetland class you are examining.

7. **Request imagery from the service provider**. Select the photographs or images of the most recent spring imagery taken in a reasonably wet year, as well as a reasonable time series of air photos that represent the climate-driven trends of wetland hydrology and vegetation in wetter, moderate, and drier conditions. See Appendix 2 and Appendix 4 for guidance on selection and analysis of imagery.

8. Identify and draw or digitize a boundary around all wetlands at the site of interest that may potentially be impacted by the proposed activity on the base reference photographs or images. Using a variety of sources of information over a greater length of time will better support due diligence and regulatory applications. For avoidance purposes, and to ensure that water inundation does not adversely affect the activity over its lifetime, the greatest boundary extent should be used. Examples of boundary delineation using only desktop methods are also in Appendix 5. Use this to aid the field verification/delineation in the next section and/or for creation of a digital shapefile as required for regulatory applications and/or ABWRET-A support.

9. Use the table template below to document the date (day, month and year), and climate conditions of each image. Imagery used to interpret the presence and ecological boundary of wetlands will need to be provided in the report to the regulatory body for review, and where an application is not required, retained as documentation of due diligence.

Table 1. Table of images used in interpretation of wetland delineation that is included in a Wetland Assessment and Impact Report (WAIR) for an individual wetland.

Legal Description (Sec. Twp. Rge. Meridian):									
Photo Date (MM/DD/YY)	**Photo ID (Roll AS# Photo#)**	**Season***	**AWCS Wetland Class**	**Precipitation Year****	**Precipitation Month Analysis****	**Precipitation Day Analysis**	**Open Water Visible or Consistent Wetland Vegetation Signature*****	**Assessment of Permanence**	**Photo Notes**
5/16/1974	1455-022	S		Normal	preceded by very wet month	None (but 20mm in 2 weeks prior)	W	N	Lake levels above average
8/13/1966	944-162	Sum		Normal	Wet	None (but 10mm in 2 weeks prior)	DV	N	
9/29/1949	0146-016	Fall		Not available	Not available	Not available	DV	N	
				Years Dry Over Photo Record (# Years)	#				
*	S=Spring (April to June); Sum=Mid-Late Summer (June to Sept); F=Fall (Sept-Nov): Seasonality based on ae								
**	D=Dryer; N=Normal; W=Wetter N/A=Not available								
***	W=Water present/inundated; D=Dry; DV=Dry, vegetated (consistent with wetland class); DVI=Dry, vegetated (indistinguishable from surrounding uplands)								
****	Y=Yes (Reasonably Permanent, a Sec 3 *Public Lands Act* body of water); N=No (Not Permanent, a wetland regulated under *Water Act*)								

Table 2. Table of images used in interpretation of wetland delineation that is included in a Wetland Assessment and Impact Report (WAIR) for multiple wetlands.

Legal Description (Sec. Twp. Rge. Meridian):															
Wetland ID	Qtr	Sec	Twp	Rg	M	Photo Date (MM/DD/YY)	Photo ID (Roll AS# Photo#)	Season*	AWCS Wetland Class	Precipitation Year**	Precipitation Month Analysis**	Precipitation Day Analysis	Open Water Visible or Consistent Wetland Vegetation Signature***	Assessment of Permanence	Photo Notes
001						5/16/1974	1455-022	S		Normal	preceded by very wet month	None (but 20mm in 2 weeks prior)	W	N	Lake levels above average
						8/13/1966	944-162	Sum		Normal	Wet	None (but 10mm in 2 weeks prior)	DV	N	
						9/29/1949	0146-016	Fall		Not available	Not available	Not available	DV	N	
002						8/13/1966	944-162	Sum		Normal	Wet	None (but 10mm in 2 weeks prior)	DVI	N	
										Years Dry Over Photo Record (# Years)	#				
						* S=Spring (April to June); Sum=Mid-Late Summer (June to Sept); F=Fall (Sept-Nov): Sea									
						** D=Dryer; N=Normal; W=Wetter N/A=Not available									
						*** W=Water present/inundated; D=Dry; DV=Dry, vegetated (consistent with wetland class); DVI=Dry, vegetated (indistinguishable from surrounding uplands									
						**** Y=Yes (Reasonably Permanent, a Sec 3 *Public Lands Act* body of water); N=No (Not Permanent, a wetland regulated under *Water Act*)									

5. Field methods for wetland delineation

Field verification is a mandatory component of wetland delineation when access to the wetland is possible. Pathways 3 and 5 require wetland boundaries that are digitized from desktop delineation methods to be field verified. Pathway 4 requires delineation of the full extent of the wetland using a handheld GPS unit. Although wetlands can sometimes be identified and delineated fairly accurately using photo interpretation, a field visit to the site can confirm, clarify and reveal new information on the wetland. Marking the wetland boundary in the field is especially important for projects where wetland avoidance or minimization is planned. Staking out the wetland boundary will help land users and construction crews avoid impacts to wetland and ensure they are in compliance.

For wetlands that have high topographic relief or obvious transitions in vegetation from wetland to upland, vegetation alone can be used to verify the photo-interpreted wetland boundary. In contrast, wetlands with gentle relief and shallow shorelines often have transitional plant communities containing a mix of both wetland and upland species, especially towards the outer extent of the wetland. A combination of soil and vegetation indicators may be required to find the true wetland extent. In other problematic situations, for instance, when sampling during a period of extensive drought, soil indicators will remain the most reliable.

5.1. Wetland field indicators

The Alberta wetland delineation protocol uses a different approach based on the Primary Indicators Method, called PRIMET (Tiner, The Primary Indicators Method--A Practical Approach to Wetland Recognition and Delineation in the United States, 1993). In Alberta, the boundary of a wetland is identified by the lack of any primary indicators, which are vegetation or soil characteristics that can be reliably used

to indicate the presence of wetland. This method recognizes that certain vegetation and soil characteristics are a visible expression of wetness due to prolonged periods of water in or on top of the soil, and can thus be used to determine wetland from non-wetland. Table 3 provides a list of vegetation and soil indicators whose presence and absence can be used to delineate the boundary of a wetland.

Vegetation is the most commonly used primary indicator, and can be used alone in Pathway 3, without evidence of soil indicators. Using vegetation alone can be deceptive, however, since the life cycle of water-tolerant plants are linked to temporal fluctuations in water levels. If vegetation indicators are unclear or inconclusive, soils are the most reliable wetland indicators and should be used. For Pathways 4 and 5, vegetation indicators should be used more frequently and occasionally supplemented with soil indicators. Soil indicators can be used to aid in identification of the boundary and correlate it to topography. Where delineation is problematic, continue to occasionally check soil indicators to verify you are on the right path.

Hydrology should only be used as a wetland indicator to draw a line at the interface between wetland and deepwater or true aquatic habitat (i.e. ~ two meter mark at midsummer). This interface might occur at the edge of a wetland connected to a river, lake, or other water body.

5.1.1. Vegetation

Repeated flooding or soil saturation can promote anaerobic conditions within a day or two and provide favourable conditions for the establishment of wetland plants. Wetland plants are water tolerant, or hydrophytic, and are adapted to the stressful conditions of saturated, anaerobic soils and periodic inundation. Wetland species may exhibit morphological, physiological and/or reproductive adaptations to survive in hydric soils (emergent species), bottom sediments (submersed aquatic vegetation) or the water column (free-floating vegetation). Different species have varying tolerances to water levels and permanence, and often are organized into intermediate plant communities or zones along a moisture gradient.

The wetland boundary can usually be delineated as the point at which the abundant species in the outermost plant community are made up of less than 50% facultative wetland or obligate wetland species. Facultative wetland species are species that occur in wetlands 67% to 99% of the time and obligate wetland species occur in wetlands >99% of the time. An abundant species is a plant species with 20 percent of more areal cover in the plot or quadrat.

Some wetlands will be easily recognizable by well-known wetland species, such as cattails. Other wetlands or portion of a wetland will be more problematic, especially if there is no definitive vegetative “break” or if facultative communities dominate two adjacent units (Sipple, 1988). The delineator must first be able to determine the outermost wetland community or ecotone community before delineating the wetland boundary. Although vegetation is usually appropriate to delimit the landward extent of a wetland in areas of abrupt topographic relief, many wetlands in Alberta have relatively flat slopes and will require soil indicators for more accurate delineation. Wetlands or wetland areas dominated by facultative wetland species (Tiner, The Primary Indicators Method--A Practical Approach to Wetland Recognition and Delineation in the United States, 1993) require further investigation (i.e. soil samples) before determining whether the area is wetland or non-wetland. Note that even facultative upland species may possess certain morphological traits that developed in response to wetland hydrology. Other indirect vegetation indicators that may help recognize wetland area are surface encrustations of algae observed in drier wetlands or after drawdown, and dominant groundcover of peat mosses (*Sphagnum* spp.) in the boreal region (Table 2). The latter indicator is

particularly important for determining peatlands. The presence of floating-leafed and submersed aquatic plants can be used to distinguish shallow open water wetland from deepwater habitat.

5.1.2. Soils

Indicators of hydric soils include soil characteristics associated with anaerobic and reducing conditions that form during periods of prolonged saturation of flooding. They provide evidence of seasonally saturated condition and better reflect the long-term hydrology of a site than vegetation (Tiner, The Primary Indicators Method--A Practical Approach to Wetland Recognition and Delineation in the United States, 1993). Soil indicators can be identified to confirm the boundary estimated by vegetation indicators or to identify the boundary where vegetation indicators are unclear or inconclusive. Soil indicators include the presence of Organic soils (except Folisols), Of, Om or Oh horizons, mottling and gleying, oxidized rhizopheres, mineral accretions, sulphuric odors, or the accumulation of peat (Table 2). However, even soil indicators can be problematic, misleading and have exceptions. See Tiner (1999) for a discussion on problematic soils and plant communities in Chapter 7 of Wetland Indicators: A Guide to Wetland Identification, Delineation, Classification, and Mapping. Note that new constructed and restored wetlands will often take years to form soils altered by wet conditions.

Table 3. Examples of indicators of wetlands, adapted from Tiner (1993).

Vegetation indicators of wetland
V1. Facultative wetland or obligate species cover more than 50 percent of the abundant plant species in the community or plot
V2. Surface encrustations of algae are present
V3. The presence of a dominant groundcover of peat mosses (*Sphagnum* spp.)
V4. Diminished rigor and productivity of upland species in disturbed areas
V5. Evidence of morphological adaptations of plants to saturated conditions (e.g. floating leaves, inflated stems, adventitious roots)
Soil indicators of wetland
S1. Organic soils (except Folisols) present
S2. Presence of peat accumulation determined by von Post test
S3. Of, Om or Oh horizons (organic surface layer 20-40 cm thick) present
S4. Sulfidic material (H_2S, odor of "rotten eggs") present within 30 cm of the soil surface
S5. Gleying (chroma of 2 or less formed by excessive soil wetness) or mottling (blotches or spots of different colour) present immediately below the surface layer (A- or Ae- horizon) and within 30 cm
S6. Native prairie soils with a low chroma matrix (chroma of 2 or less) within 30 cm of the soil surface *and* one of the following present: a. Thin surface layer (at least 0.5 cm) of peat or muck; or b. Accumulation of iron (high chroma mottles, especially oxidized rhizospheres) within 30 cm of the surface; or c. Iron and manganese concretions within the surface layer (Chernozemic A-horizon); or d. Low chroma (gray-coloured) matrix or mottles present immediately below the surface layer (Chernozemic A-horizon) and the crushed color is chroma 2 or less
S7. Nonsandy soils (e.g. clay, loam, silt) with a low chroma matrix (chroma of 2 or less) within 30 cm of the soil surface *and* one of the following present within 30 cm of the surface: a. Iron and manganese concretions or nodules; or b. Distinct or prominent oxidized rhizospheres along several living roots; or c. Low chroma mottles
S8. Sandy soils with one of the following present: a. Thin surface layer (at least 2.5 cm) of peat of muck where a leaf litter surface mat is present; or b. Surface layer of peat or muck of any thickness where a leaf litter surface mat is absent; or c. A surface layer (A-horizon) having a low chroma matrix (chroma 1 or less and value of 3 or less) greater than 10 cm thick; or d. Vertical organic streaking or blotchiness with 30 cm of the surface; or e. Easily recognized high chroma mottles occupy at least 2 percent of the low chroma subsoil matrix within 30 cm of the surface; or f. Organic concretions within 30 cm of the surface; or g. Easily recognized oxidized rhizospheres along living roots within 30 cm of the surface; or h. A cemented layer (ortstein) within 30 cm of the soil surface
S9. Remains of aquatic invertebrates are present within 30 cm of the soil surface in nontidal pothole-like depressions
S10. Other regionally applicable, field-verifiable soil properties associated with prolonged seasonal high water tables

5.1.3. Hydrology

A water depth of 2 m, taken from the Cowardin *et al*. (1979) is used as the cut-off to define the interface between a wetland and true aquatic habitat (e.g. river, lake, pond, stormwater pond). Otherwise, hydrology is not used as a primary indicator in the PRIMET method.

Although it is common practice to fall back on hydrology as a primary variable that distinguishes wetlands from other ecosystems, it is generally an unreliable indicator to use in the field. Land that appears dry at first glance may in fact be wetland that simply doesn't have obvious indicators at the time of the visit. Temporary or seasonal swamps, for example, may resemble upland spruce forests until they are identified to have hydric soils and plants morphologically adapted to a wet environment. In contrast, land that may appear wet during a flood year may in fact be ephemeral in nature and not meet the definition of a wetland. Wetland hydrology is dynamic, varying annually, seasonally, and daily from wetland to wetland and from region to region (Tiner, Wetland Indicators: A Guide to Wetland Identification, Delineation, Classification, and Mapping, 1999). In Alberta, where precipitation is less than potential evapotranspiration, frequency of flooding or ponding can be influenced by annual water-deficits and frequent long-term droughts. Temporary and seasonal Prairie Pothole wetlands in the Grassland Region are often difficult to identify and delineate because they fluctuate along a hydrologic continuum and exhibit resultant shifts between wetland and upland species (Van der Valk, 1978). In Alberta, the majority of wetlands in the southern half of the province are small temporary or seasonal wetlands and reliance on hydrology will result in overly conservative identification of wetlands and the failure to identify numerous, smaller wetlands. Wetland assessments done during a prolonged drought, for example, cannot use hydrology to determine with confidence the presence of wetlands and their extents. Hydrology, although it is the driving force behind wetland formation and maintenance, is widely considered to be the least useful parameter for wetland identification and impracticable for delineating wetland boundaries (Tiner, The Primary Indicators Method--A Practical Approach to Wetland Recognition and Delineation in the United States, 1993) and is not recommended for use in identifying wetlands in Alberta.

5.1.4. Disturbances

In addition to the inherent challenges of wetland identification and delineation under normal circumstances and natural disturbances, human activities such as farming can further complicate wetland identification and delineation. Hydrologic alteration may include berms, dams, beaver dams, drainage systems or storm- or waste-water inputs that have significantly altered the area's hydrology. Soil alterations include evidence of tillage, soil compaction, infilling or stockpiling in wetland. Vegetation alterations include vegetation removal or planting. Areas where hydrology has been altered can be problematic and will require additional investigation.

Wetlands that have undergone hydrologic modification by human activity should be immediately reported and must be considered on a case by case basis. Often, the wetland needs to be brought into compliance before any further evaluation or decision can proceed. Indications of hydrologic modification can be detected by searching for evidence of dugouts, drainage ditches, tile drainage, dams, berms, farming activity, roads, stormwater outlets, dewatering systems, or any other impacts in the imagery and on the ground.

Important. Changes in land use are not always reliable markers of a wetland boundary. Farming activities, for example, often encroach into wetlands in drier years, leading to subsequent changes in

vegetation from wetland species to crop, ruderal or upland species. When tilling ceases and wetter conditions ensue, wetland vegetation may return. Soil indicators can be less reliable if soil has been repetitively turned over. If a wetland is cultivated, crops may be stunted and less productive than the surrounding upland due to stressed physiological conditions.

5.2. Sampling intensity

Sampling intensity of plots and soil cores should increase according to the complexity of the site, or in problematic areas such as where a disturbance has occurred. It does not have to increase with size of the wetland unless size is correlated with heterogeneity. Note that if you are delineating a forested wetland, satellite signals may be obscured by tree canopy and lead to unreliable boundaries. In forested wetlands, desktop delineation alone may suffice, while visitation is used to ground truth the site's characteristics in the absence of accurate GPS verification points.

5.3. rapidPS unit standards

Delineation of non-forested wetlands can be conducted using a modern GPS unit that has a maximum range of error of ≤ +/- 5m functional accuracy or WAAS enabled GPS if one is available. For wetland delineation, track collection should be set to use a time interval of 10 seconds or 10 meters. Otherwise, take several waypoints using a GPS unit and compare it to the desktop delineated boundary. The GPS should be set up as follows:

1. Datum: World Geodetic System 1984 (WGS84)
2. Projection: None or Geographic Coordinate System (GCS)
3. Track collection should be set to use a time interval of 10 seconds or 10 meters

As part of the *Water Act* application, the proponent must submit a shapefile outlining the wetland boundary. The following are the shapefile requirements:

1. Geodetic Data Standard
2. *Horizontal Datum Name:* North American Datum of 1983
3. *Ellipsoid Name:* Geodetic Reference System 80
4. Semi-major Axis: 6378137.000000
5. Denominator of Flattening Ratio: 298.257222
6. Geographic Coordinate System Name: GCS_North_American_1983
7. Projected Coordinate System Name: NAD_1983_10TM_AEP_Forest

5.4. Timing of field visit

Wetlands in Alberta often alter in appearance between years, seasonally, and wetland indicators are not present or visible at all times of the year. In winter, wetlands throughout the province are covered by ice and snow and often are not visible at all. Winter is not an appropriate time to assess wetlands in Alberta. It is advisable, depending on the water source and landscape position of a wetland, to avoid wetland delineation assessments directly after spring freshet or a major storm. In fall, the delineator must be competent relying on plant residue or standing dead vegetation with fewer and more difficult indicators. If vegetation indicators are no longer apparent, use soils. The best time to conduct a wetland assessment is

during the peak biomass when the majority of plants are flowering. Peak biomass usually occurs in midsummer in Alberta.

5.5. Steps for Wetland Delineation

1. Permission to access the land must be obtaining before trespassing on any land except Alberta Crown land not under a disposition. The following procedure should be followed to obtain ownership information: a) list legal description to quarter section level and coordinates of area; b) contact the appropriate county office to request the names and addresses of the landowners or disposition holders; c) contact the landowners and request permission to access their land.

2. The delineator should begin by walking the site of interest and identifying the various plant communities as well as other important features, including surface water connections, disturbances, surrounding land cover, and landscape position. Note obvious wetland communities dominated by hydrophytic vegetation.

3. If any hydrologic disturbances are present, report it to the province by calling 1-800-222-6514 or by emailing erc.environment@gov.ab.ca.

4. Walk to points along the boundary digitized by the desktop delineation (printed copy or transposed onto a GPS or smart device). Check whether this boundary closely reflects what is observed at the wetland. If it does, walk towards this boundary until you reach the outermost plant community that you are sure is still wetland. Often, vegetation community characteristics such as changes in colour, vegetation height, and density can help distinguish probable locations to begin the assessment.

5. Locate the point at which the boundary of the wetland is likely to be. Sample each stratum—ground cover, shrub layer, and tree layer—separately. When additional or more rigorous investigation is necessary, establish sampling plots in the centre of the plant community. 1 x 1 meter quadrats or 1 m circular plots for communities dominated by herbaceous species and 10 m meter circular plots for shrubby or treed plant communities are recommended. Measure relative cover of ground layer species and species density for shrub and tree stratums. GPS all vegetation plot locations and mark them on a base map. If any primary vegetation indicator is present, the area is wetland and go to Step 9. If the plant community does not meet the criteria any vegetation indicator, go to Step 6. Use the field form in Appendix 7 to fill out the field indicators for each delineation point.

6. Examine the soil properties by digging a soil pit or taking a soil core to look for evidence of primary soil indicators. GPS all soil core or pit locations to include them on a base map. If any soil indicators of a wetland are present, the area is wetland. If neither vegetation nor soil indicators are present, the area is not a wetland. Use the field form in Appendix 8 to fill out the field indicators for each delineation point.

7. Repeat steps 4 to 6 for each remaining plant community and determine whether the area is wetland or non-wetland. Use the field form in Appendix 8 to fill out the field indicators for each delineation point.

8. Occasionally check soil indicators along your path for wetlands where vegetation indicators are unclear or inconclusive. Corroborate the approximate contours with vegetation and soil indicators can help guide your path.

9. If the wetland is connected to deepwater habitat, approximate the wetland extent at which the water is 2 m deep at midsummer.

10. Perform a routine GPS survey by traversing around the wetland use the track or waypoint function on a GPS. Waypoints should be taken every 10 meters or less or set to a tracking rate of every 10 seconds. Check that waypoints from desktop delineation are similar to the field delineation.

11. (If necessary or applicable). Mark the boundary of the wetland with prominent flagging tape at regular intervals when planning avoidance or minimization of impacts to the wetland. Obvious markers of the wetland area will help developers and construction crews circumvent impacts to wetland area while reducing their own risk and liability.

12. Upload the GPS waypoints or tracks to GIS and overlay the boundary on the base reference image. Using the waypoints, draw a polygon around wetland boundaries.

Important. In the event that the wetland extends into adjacent landowner's property, contact the landowner and ask for permission to conduct the survey. If access is denied, collect a waypoint as close to where the edge meets the fence. The remainder of the wetland will then have to be delineated using photo-interpretation.

5.6. Steps for Wetland Verification

1. Follow steps 1-8 for wetland delineation. Use the field form in Appendix 8 to fill out the field indicators for each delineation point.

2. If the field delineation is within + or – 5 meters of the preliminary boundary delimited by the photo-interpreter, the desktop delineation is verified. If the observed boundary in the field differs by greater than this, continue checking more points and carefully compare the two and investigate why this has occurred. If delineation results continue to deviate from the desktop delineation, it may be wise to delineate the entire wetland or a representative portion of the wetland to compare, analyze and adjust back in the office. If necessary, adjust, and/or re-draw boundaries.

3. Follow steps 10 and 11 for wetland delineation if necessary.

Important if you are delineating a forested wetland, satellite signals may be obscured by tree canopy and lead to unreliable boundaries. In forested wetlands, desktop delineation alone may be have to be relied on, while visitation is used to ground truth the site's characteristics (vegetation species) and examine it for evidence of disturbance. Office delineation can then be QA/QC'd against characteristics found at the site visit.

6. Submission standards of a Digital Shapefile of Delineated Wetland

Below are instructions for providing a digital shapefile of delineated wetland boundaries as part of a regulatory application and/or where a request is made by the user in support of their ABWRET-A assessment.

1. Add the template shapefile to ArcMap using the Add Data button.
2. Right click on the file in the Table of Contents window and select Edit Features -> Start Editing (Figure 9).

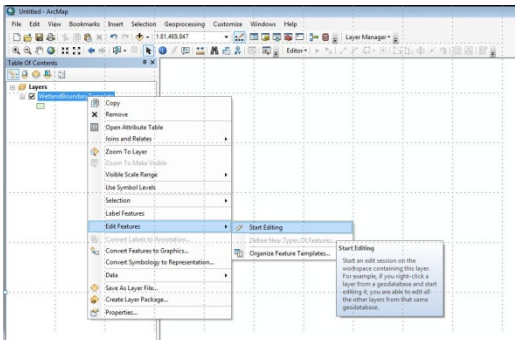


Figure 9. Screen capture of start editing.

3. On the Editor Toolbar select the Create Features button (Figure 10).

Figure 10. Screen capture of create features button.

4. In the Create Features form, select the template shapefile and then in the Construction Tools area select Polygon (Figure 11).

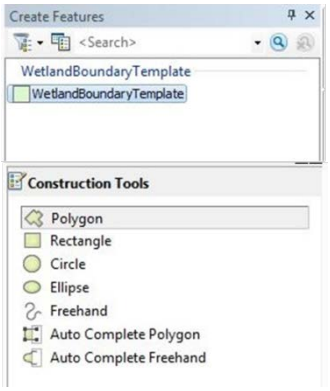


Figure 11. Screen capture of polygon tool in Create Features form.

5. Digitize the wetland polygon using the Polygon Construction Tool (Figure 12).

Figure 12. Screen capture of digitized wetland polygon.

6. Click on the Measure tool and select the Area button. Make sure the Area calculation units are in square meters. Using the Measure -> Area tool digitize the extent of Open Water and record the value (0 decimals) as shown in Figure 13.

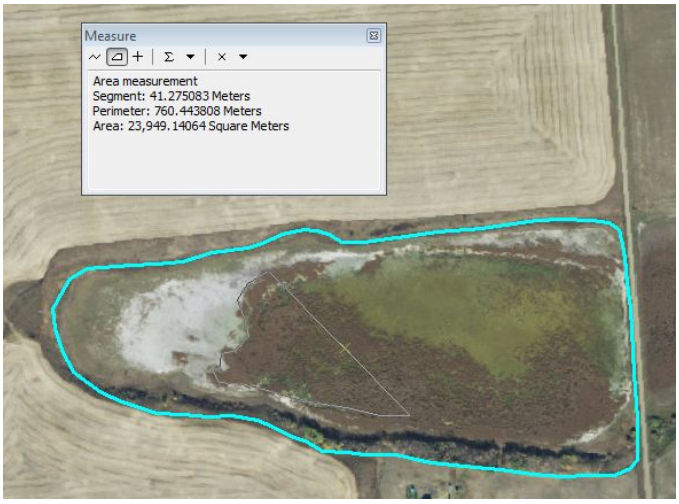


Figure 13. Screen capture of Measure tool.

7. Right click on the Wetland Boundary Template layer in the Table of Contents window and select Open Attribute Table. In the Attribute Table the ID, Open Water Area and Wetland Class Area can be input. Left-click on the desired field and type in the ID and Open Water Area in the appropriate fields (Figure 14).

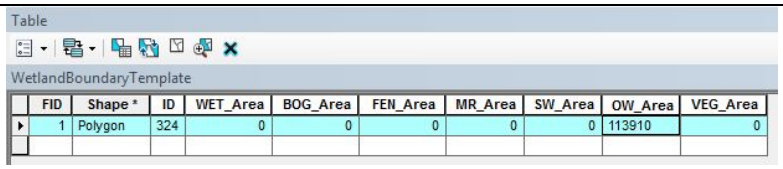


Figure 14. Screen capture of attribute table that needs to be populated.

8. Right-click on the WET_Area field and select Calculate Geometry. In the dialog box select Area, ensuring that the units are in square meters and that the coordinate system is set to NAD 1983 10TM AEP Forest (Figure 15).

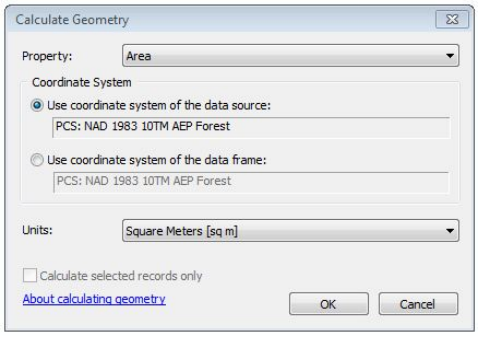


Figure 15. Screen capture of Calculate Geometry form.

9. Now that there is an Open Water Area and a total Wet Area the Vegetation area can be determined by subtracting the Open Water Area from the Wet Area. Right-click on the VEG_Area column and select Field Calculator and, using the expression show in Figure 16, calculate the area.

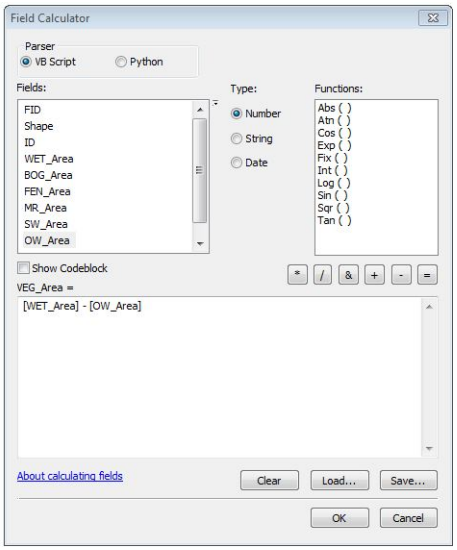
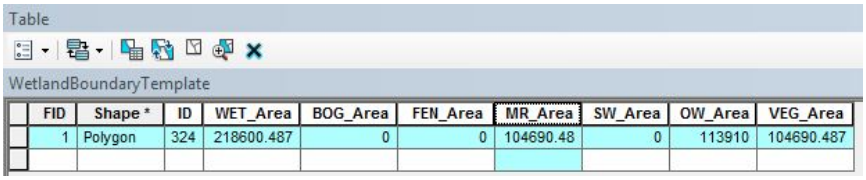


Figure 16. Screen capture of Field Calculator and expression for calculating the vegetation area.

10. Given the VEG_Area, the appropriate Wetland Area field can be calculated. Classify the wetland being digitized as Bog, Fen, Marsh or Swamp (Figure 17). Right-click on the appropriate Wetland Class field and select Field Calculator. In the Field Calculator double-click on the VEG_Area field and press OK.



Table

WetlandBoundaryTemplate

FID	Shape *	ID	WET_Area	BOG_Area	FEN_Area	MR_Area	SW_Area	OW_Area	VEG_Area
1	Polygon	324	218600.487	0	0	104690.48	0	113910	104690.487

Figure 17. Screen capture of wetland attribute table with areas of each wetland class and vegetation area.

6.1. Shapefile Specification for delineating the Wetland Boundary

The shapefile format is the native format of Environmental Systems Research Institute's (ESRI) Arc View product. Shape records store both geometry and attributes for features. Shape records consists of six files, however only four are required to support the Office Form Tool (OFT) in ABWRET-A. The files required are:

1. Shape records (geometry) are stored in the .shp file. This is the main file.
2. Attribute records are stored in the .dbf file. This is a dBase file.
3. An index to each shape is stored in the .shx file.
4. A projection .prj file that contains the map projection and datum information.
5. These extensions are added to the basename of the file (e.g. test.shp, test.dbf, test.shx, etc.).

**Please note the following:

For OFT, the shapefile can only contain polygon features.

The shapefile extension must be in lowercase (i.e. .shp, .dbf, .shx, .prj)

6.2. File Naming

There are no standards with respect to the naming convention for the basename, as long as it is supported by the ESRI shapefile format.

6.3. Map Projection and Datum

All shapefiles must be in 10TM_AEP_FOREST projection. The following .prj file parameters are required.

Table 4. Parameters for shapefiles submitted to the regulatory body for wetland applications or ABWRET-A assessments.

10TM AEP Forest	
Projection	Transverse Mercator
False Easting	500,000
False Northing	0.0
Central Meridian	-115.0
Scale Factor	0.9992
Latitude of Origin	0.0
Linear Unit	Meter (1.0)
Geographic Coordinate System	GCS North American 1983
Angular Unit	Degree (0.0174532925199433)
Prime Meridian	Greenwich (0.0)
Datum	North American 1983
Spheroid	GRS 1980
Semi-Major Axis	6,378,137.0
Semi-Minor Axis	6,356,752.314140356
Inverse Flattening	298.257222101

6.4. Shapefile Attributes and Attribute Values

The following Table contains a description of the required attributes and attribute values represented as fields within the shape .dbf file.

Table 5. ABWRET-A GIS Attributes Format.

Field Name	Type	Description	Mandatory
ID	String	Unique name identifying the wetland polygon. Can be numbers or text	Yes
WET_Area	Double	Total area (m^2) of the wetland polygon	Yes
BOG_Area	Double	Total area (m^2) of the vegetated portion of the wetland polygon identified as Bog	Yes
FEN_Area	Double	Total area (m^2) of the vegetated portion of the wetland polygon identified as Fen	Yes
MR_Area	Double	Total area (m^2) of the vegetated portion of the wetland polygon identified as Marsh	Yes
SW_Area	Double	Total area (m^2) of the vegetated portion of the wetland polygon identified as Swamp	Yes
OW_Area	Double	Total area (m^2) of the Open Water portion of the wetland polygon	Yes
VEG_Area	Double	Total area (m^2) of the vegetated portion of the wetland polygon (WET_Area – OW_Area)	Yes

7. Literature Cited

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Appendix 1 Additional guidance and information on imagery sources

Table 1-1. Comparison of various data layers or combination of data layers for delineating wetland boundaries (Source: Creed, Irena, pers. comm.).

Imagery	Available resolution(s)	Advantage(s)	Disadvantage(s)
Black and white air photos	1:5,000 to 1:80,000 (usually <= 1 meter)	- provincial coverage & ownership historic archives dating back to 1950s (and older in some cases) - delineation of wetlands assisted by relatively high visual contrast between features	- frequency of acquisition low in much of province (approximately decadal except in recent years) poorer chance of capturing range of climatic conditions - spectral confusion between water and shadows - older air photos typically provide lower visual contrast - may not detect wetlands under tree canopy - lack of colour for vegetation mapping - may not be georeferenced / orthorectified
Colour air photos	1:5,000 to 1:80,000 (usually <= 1 meter)	- addition of colour channels improves visual contrast and identification of wetland features	- not widely available - not historically available - may not detect wetlands under tree canopy - older colour air photos may not be georeferenced/orthorectified
Colour + infrared air photos	1:5,000 to 1:80,000 (usually <= 1 meter)	- addition of infrared channel in conjunction with colour channels (NDVI) allows mapping of vegetation	- not widely available (mostly White Area only) - poor temporal coverage from 2006/7 + - may not detect wetlands under tree canopy - less useful under drought conditions
SPOT multispectral satellite imagery	medium resolution (2.5 to 20 meter)	- Allows mapping of vegetation - provincial coverage and ownership - frequent satellite acquisition (several times a year back to 1992)	- coarser resolution than air photos - clouds may obstruct image - cannot necessarily distinguish between wetland and upland vegetation - cannot detect wetlands under tree canopy
LiDAR Bare Earth Digital Elevation Model DEM	< 1 to 15 meter (usually <= 1 meter)	- can detect depressions below tree canopy - detection of depressions not dependent on wetness conditions - can map non-apparent depressional parts of wetland - defined automatic methodology	- expensive - cannot map vegetation - ability to classify wetlands has not been tested or verified
Air photo + LiDAR DEM	< 1 to 15 meter (usually <= 1 meter)	- can characterize vegetated and non-vegetated parts of wetland - can use air photo to verify wetland boundary delineation from LiDAR DEM	- LiDAR imagery is expensive
SPOT satellite imagery + LiDAR DEM	< 1 to 15 meter	- can characterize vegetated and non-vegetated parts of wetland - can use SPOT image to verify boundary delineation from LiDAR DEM	- coarser resolution than air photos for wetland boundary verification - LiDAR imagery is expensive
SPOT satellite imagery + LiDAR DEM	< 1 to 15 meter	- can characterize vegetated and non-vegetated parts of wetland - can use image to verify boundary delineation from LiDAR DEM	- coarser resolution than air photos for wetland boundary verification - LiDAR imagery is expensive

Appendix 2 Photo-Interpretation Keys for Water and Wetland Vegetation Features From Aerial Photographs

Table 2-1. Ranking of various chromas of aerial photography for wetland identification and delineation, taken from Haekel (2010)**.**

Chroma					
	Saturated Soils	Water Penetration	ID of most wetland species	Tonal Range	Vegetation Vigour
Colour	**	***	**	**	**
Colour IR	***	*	***	***	***
Black and White	**	**	*	*	*
*** best choice for that feature; ** good alternative; * least valuable alternative					

Table 2-2. Ranking of seasons and vegetative states for identifying and delineating various wetland land cover features, taken from Haekel (2010)**.**

Season and Vegetative state							
	Extent of Water	Flooded Trees/ shrubs	Emergents	Wet Meadow	Open Water	Submerged and Floating	Soil Saturation
Spring Leaf Off	***	***	*	***	***	*	***
Summer	*	*	***	*	*	***	*
Fall Leaf Off	**	**	**	**	**	**	**
*** best choice for that feature; ** good alternative; * least valuable alternative							

Table 2-3. Air photograph notes for different air photography periods, taken from Haekel (2010)**.**

Photography Period	Notes
Spring	Freshet and precipitation runoff inundates wetlands in most years, except in drought. Non-woody vegetation in images often dead or senescent and may be difficult to interpret vegetation communities and their height.
Summer	Ephemeral, temporary wetlands dry out by late spring. Water in seasonal wetlands may be present into summer. Differentiating greens in summer vegetation may be challenging with colour photography or black and white photos. Colour IR is preferred.
Fall	Semi-permanent and permanent wetland classes remain inundated until late summer or later. Vegetation communities easily discernable in colour and colour IR photography. Use of interpretation keys is useful.

Table 2-4. Shade characteristics of water and wetland vegetation features from Black and White Panchromatic and Black and White Infrared aerial photos, taken from Haekel (2010)**.**

Objects	Black and White Panchromatic	Black and White Infrared
Snow	white	white
Clouds	white	white
Sky (high oblique)	medium gray	black
Clear water	dark gray	black
Silty water	light gray	medium gray
Deciduous foliage	dark gray	white
Coniferous foliage	dark gray	medium gray
Autumn foliage (yellow)	light gray	light gray
White sand (dry)	light gray	light gray
White sand (moist)	medium gray	dark gray
Red sandstone (dry)	medium gray	light gray
Red sandstone (moist)	medium gray	dark gray
Swamp	dark gray	black
Asphalt	dark gray	black
Concrete	light gray	medium gray

Table 2-5. Photo-interpretation characteristics of water, aquatic, wetland and adjacent vegetation features from True Colour Aerial Photos, taken from Haekel (2010)**.**

Feature	Colour/Tone	Texture	Comments
Deep water over 18 feet	Dark Blue	Uniform, smooth unless wind blown.	Indistinct boundaries. Sunlight and wave patterns sometimes noticeable.
Open water (non-vegetative)	Med brown-dark blue-green	Smooth	Depends on suspended material in water column such as silt or algae.
Clear Bottom, less than 10% submergents	Very light (tan - greenish): varies with depth of water	Large mottlings	
Dense, low-growing submergents (max. height - 2 ft.)	Light yellow-green to light blue-green, varies with depth of water	Uniform	*Chara*, *nitella* and naiad.
Stalked submergents, not reaching surface	Dark blue	Fairly uniform	Distinct boundaries with adjacent areas. Water milfoil common species.
Stalked aquatics reaching surface	Dark brown-purple	Mottled; rough	Distinct boundaries with adjacent areas. Water milfoil common species.
Scirpus (bulrush)	Dk. Brown-Dk. Green	Mottles, grainy, or speckled appearance.	Distinct boundary discernable with submerged aquatic areas.
Typha (cattail)	Lt brown-grey/brown, brownish orange	Distinct, smooth-grainy, filigree/popcorn.	Distinct boundary discernable with submerged aquatic areas.
Mixed aquatic emergents	Lt buff-tan (fall); blue-green (spring)	irregular	Edge of deep wetlands or throughout basin of shallow wetlands.
Wet meadow	Lt brown-brownish/orange (fall) Blue-green or tan (spring)	Smooth/grainy, indistinct	Distinct boundary present with robust emergents and upland grass areas. If an ephemeral wetland, often not distinguishable if basin is dry at time of photo. If sedge meadow, course leaved sedges covering part or all of basin. In stereo, differences in vegetation height from others are apparent.
Herbaceous-shrub	Lt brown-orangish/brown	Irregular	Willows and alder blue-green in Spring photos.
Shrub-tree	Dk brown-greenish/brown	Coarse	In stereo, vegetation height differences apparent.
Mud flat (mineral soils)	Various shades of brown, occasional white specks	Smooth, occasionally a grainy appearance	Natural draw-down areas; ephemeral lakes (dry); seepage areas.
Saline areas	Buff-white with brown/black speckles	Irregular, smooth/grainy, salt & pepper appearance	Often white band when evaporation lowers water in basin.
Adjacent fields	Green=growing crops; Bright Yellow=canola blooming; Tawny-yellow=swathed grains/straw; Summer fallow=tan/brown	Uniform	Regular, linear features following contours of land when crops cut and lying on ground. Irregular mottles of underlying ground depressions when straw removed from fields.

Table 2-6. Interpretation key of marsh vegetation signatures from colour infrared aerial photographs taken from Haekel (2010)**.**

Feature	Colour	Texture	Location/Comments
Open water	Distinct blue/black Light Blue/green White to green/white	Smooth, rippled in some areas from wave action	Clear open water is distinct and dark. Varying degrees of suspended sediment shift colour to greens; Shallow water or reflections off water will often appear white to green/white; duckweed is greyish-white
Submersed aquatic vegetation	Variable, pale green/blue	Smooth, smoky appearance	Algae and floating aquatics will appear in shades of dark purple to lavender.
Bare ground, sand (beaches, exposed), alkaline soils	White, usually quite bright	Smooth, flat appearance	Mostly devoid of vegetation, so appears bright white
Mudflat	White to blue/white (dry), to greeny black (moist)	Smooth, flat appearance, navy/ greeny black and white patches	Found bordering water, disturbed areas
Bulrush (Schoenoplectus or Scirpus)	Dark deep red, brick red to dark navy, to browny red	Blurry appearance and patchy; open water patches due to sparseness	Found in water, along water's edge, or deeper water areas; sparse patches appear as shadowed areas on open water
Cattail (*Typha*)	Medium to deep red (dense); Rust, reddish-olive (with decreasing density); light green to pale blue (dead)	Smooth to grainy; pock marked appearance from open water, and inter-mixed patches of deadfall	Found mainly bordering open water to low water-filled areas; also borders whitetop, giant reed grass as well as sedges/rushes
Giant reed grass (*Phragmites*)	Pink to dark pink	Grainy to lumpy, shadows along edges gives depth to these patches appearing almost three-dimensional on photos, & much higher than surrounding areas w/ stereoscopes	Found bordering water, upland areas, cattail and whitetop; often a thin ring of cattail between giant reeds and water; also borders sedges and rushes, grasses, grasses with forbs.
Sedges and rushes (*Carex*, *Eleocharis*, *Juncus*)	Dark red to dark pink	Appears flatter on photos, does not have three-dimensional appearance as cattail does; with stereoscope appears flat	Usually occurs around/near whitetop areas, as well as cattail and fen grasses; also borders reed canary grass, grasses, and forbs; found in wet, waterlogged areas
Wet meadows	Bright pink (if very wet)	Smooth	Often not distinguishable if basin is dry at time of photo
Whitetop (Scolochloa festucacea)	White, to pale/light pink to green (shallow water)	Fine mottled appearance, white or green patches from open water areas	Often found bordering cattail, wet meadows, and giant reed patches; also borders fen grasses, sedges/rushes, and grasses
Willows	Burgundy, maroon to dark red	Lumpy, gravelly, dotted patches	Uplands, dikes, along river channels; borders and surrounds sedge patches
Reed canary grass	Dark pink to browny red, a darker pink than Whitetop	Grainy lumpy appearance, to smooth	Usually occurs between whitetop and grasses/forb areas; also occurs next to cattail and giant reed; is a wet meadow grass, found where soils are moist to wet
Salt flat species (*Hordeum*, P*uccinellia*)	Cream, brown to browny red	Flat smooth texture, low flat appearance with use of stereoscopes	Occurs all over, but usually associated with mudflats, white-top, sedges/rushes and fen grasses; occurs in grass/forb areas as well
Grasses (> 75% cover)	Light pink, light brown, to cream	Flat smooth texture, often more light pink to cream and not as patchy as Grasses/forbs	Low prairie areas found bordering wet meadows of whitetop, reed canary grass and sedges/rushes; slightly moister areas than grass/forbs

Feature	Colour	Texture	Location/Comments
Grasses and forbs (< 50% forb cover)	Pink, light brown, gray and cream	Flat smooth texture, often patchy and mixed light pink, brown, gray to cream	Low prairie areas near wet meadows of whitetop, fen grasses and sedges/rushes; transition to upland areas of prairie grasses; presence of forbs cause mixed patches of browns and grays
Prairie (> 50% forb cover)	Medium pink to dark pink	Smooth to grainy	Upland areas, borders grasses and forbs, woodlands, cultivated fields and hayfields
Hayed grasses and forbs	White-light green, to light pink	Lined, pinstriped, and patchy; can see hay bales as large dots if already cut; hayed, fallen dead grasses and forbs appear white to light green	Low prairie areas which are hayed; often intermixed with grasses/forbs, as well as prairie; borders wet meadows and low prairie areas alike; many sedge/rush meadows are hayed as well
Grazed (prairie and shrubs)	Dark pink, cream, brown and gray	Smooth texture, patchy mixed dark pink, cream, brown and gray	Occur near and intermixed with woodlands while bordering cultivated areas and hayfields; patchy cream colours and browns from grazing
Cultivated	Variable, see comments	Lined, pinstriped, patchy or smooth to grainy; can see rows of crops	Very distinct; found upland on higher ground; Deep red=healthy crop; Pink=stressed or immature crop; Dk. Green=black organic soil or high soil moisture; Lt. Green=light soil or shallow topsoil; white= sand, clay or canola in bloom
Trees (trees and shrubs)	Burgundy, maroon to dark red	Lumpy, patchy, gravelly with shadows; cauliflower appearance; tall, three-dimensional appearance with stereoscope	High upland areas, borders next to prairie, grass/forbs, and cultivated fields; willow bluffs appear as smaller, lumpy, dotted areas surrounding small cattail and fen grass marshes
Disturbed	Browny-gray, gray to white; light green	Smooth to grainy appearance; freshly disturbed bare soils and deadfall appear white to light green	Disturbed areas very distinct; usually found in grass/forb areas, or near trees

Appendix 3 Tips and recommendations for photo interpretation, adapted from Tiner (1999)

1. Avoid photographs that have emulsified or are over- or under-exposed
2. Do not use photographs with any significant snow coverage
3. Stereoscopic interpretation of topography can help separate upland plant communities from wetland plant communities, especially if species are transitional or grow in both upland and wetland areas (e.g. wetlands and uplands dominated by alder, cottonwood, black spruce), or plant communities/associations within a wetland
4. Imagery tied to season can help determine wetland permanence and classification. Imagery taken in early spring during seasonally high water tables will help detect all wetlands and other wet features including ephemeral water bodies. By early to mid-summer imagery surface water in ephemerals and temporary wetlands will have disappeared. Imagery taken in late summer to fall should depict seasonal wetland without surface water, leaving only semi-permanent and permanent wetlands remaining wet throughout the growing season
5. Evidence of beaver dams/lodges can help identify marshes
6. LiDAR or leaf-off imagery (image captured in early spring or late fall) can help detect and delineate potential wetland basins under tree canopy, such as bogs and fens
7. Spring leaf-off is best for identifying deciduous forested wetlands, when the water table is highest and saturated soils can be seen beneath the canopy, although fall leaf-off imagery will facilitate identification of certain forested wetland communities, such as larch (*Larix laricina*) and fen wetlands
8. Colour IR photography is most useful for distinguishing forested peatlands and swamps from forested upland. It can be used to identify saturated soils, and wetland species, including ericaceous shrubs in bogs, true shrubs and tree saplings
9. Colour IR is usually preferred to True Colour for differentiating vegetation communities and species, except when identifying aquatic beds and submersed aquatic vegetation. Mid-summer imagery is needed to detect submersed aquatic vegetation at a fairly high resolution depending on water turbidity.
10. Interpretation of evergreen or coniferous forests can be aided by looking for evidence of saturated soils or characteristic understory vegetation where the canopy is open (LiDAR and Wet Areas Mapping)
11. Wetlands often have a denser understory than uplands with similar species

Appendix 4 Sources of additional information that may be useful for wetland identification and delineation:

1. Wet Areas Mapping (WAM) - provides depth to water below soil and shows water flow paths derived from the bare group digital elevation model of LiDAR surface images of 1 metre resolution. Where it is available, Wet Areas Mapping (WAM) can be ordered from the Department website.

2. Local landowners and residents - Landowners usually have an intimate knowledge of their land and can be invaluable sources of information. Landowner information can be obtained from the appropriate County office by providing them with the legal land description.

3. Contoured topographic maps, both current and historical.

4. Hydrological gauges such as staff gauges or electronic water depth meters. Where available, Miscellaneous Lake Level Data can be obtained from the local Alberta government office through the hydrogeologist.

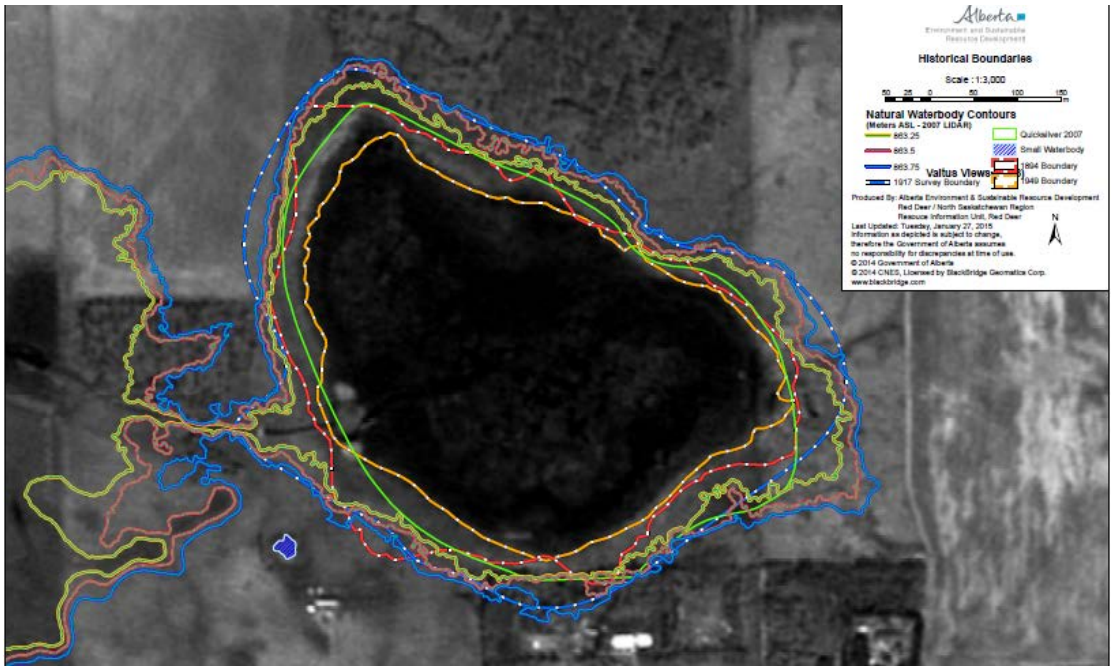
5. Soil and/or plant classification maps and databases.

6. Master drainage plans (municipal).

7. Survey plans and engineering designs on adjacent properties.

8. Maps and inventories from local governments, such as Environmentally Sensitive Areas mapping.

Appendix 5 Examples of Desktop Delineation of Wetland Boundaries



Figureapx 5-1. Boundaries of a water body identified through geo-referenced imagery from 1949 overlaid on a SPOT 2005 image. 1894 and 1917 Survey information used to create 1894 and 1917 boundaries. LiDAR contours are used to show topography and may be helpful to identify connectivity, basins, and inlets and outlets.

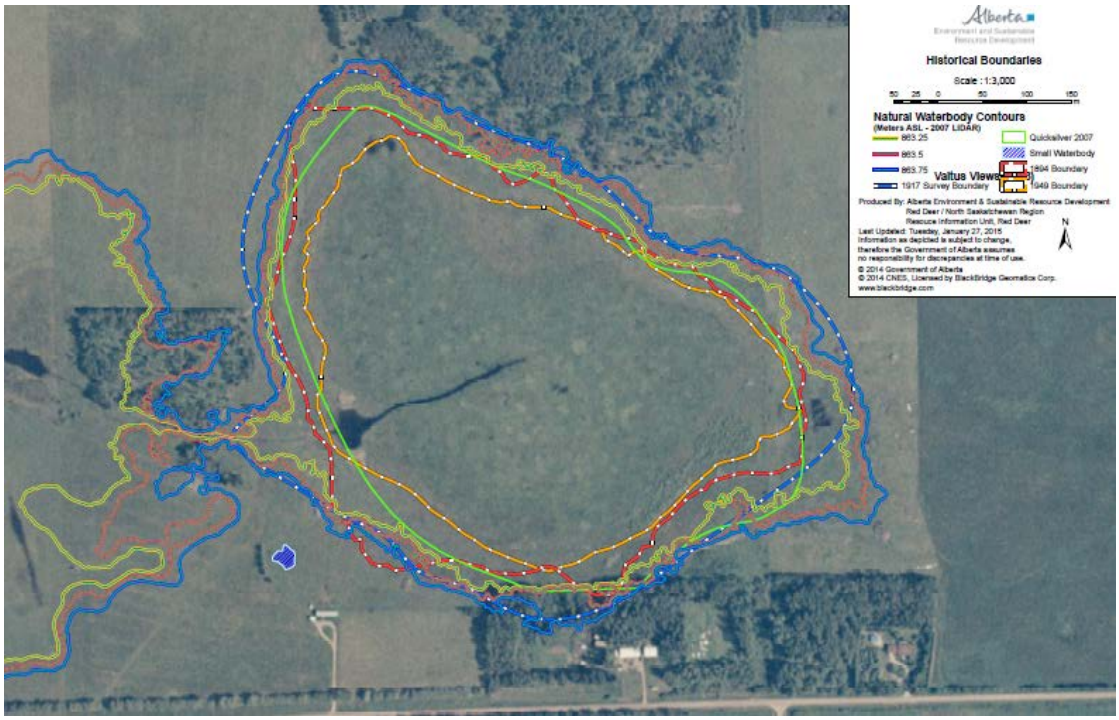


Figure 5-2. The same wetland as 6-A after alteration shown on 2013 imagery.

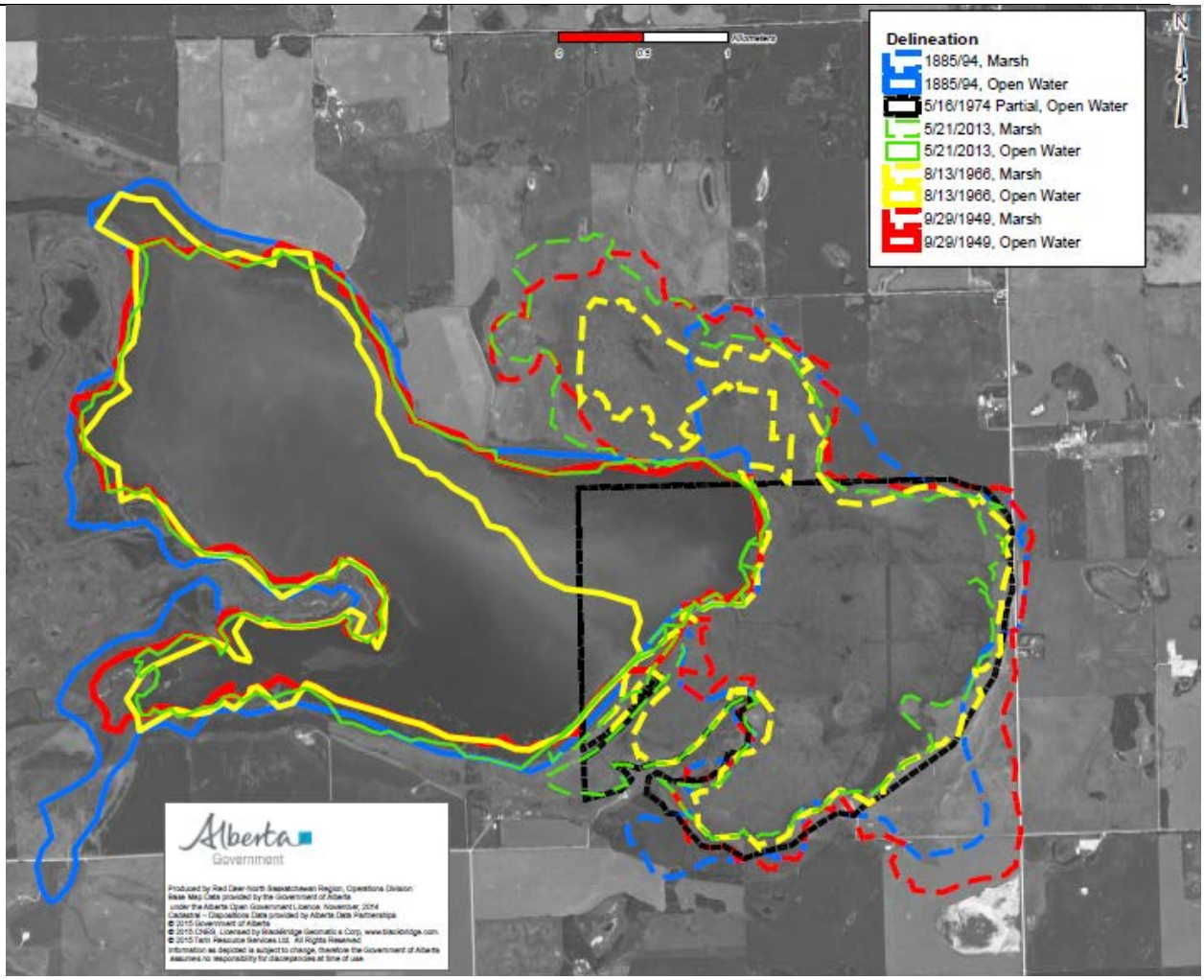


Figure 5-3. Boundary of a Shallow Open Water (solid lines) and Marsh (dotted lines) delineated using desktop methods on a geo-referenced hard copy black and white aerial photography. Desktop delineation boundaries overlaid on 2011 SPOT5 aerial photo. Field verification would be needed to help locate the best ecological boundary for the marsh. Analysis information for precipitation, photos, surveys and lake levels are provided below.

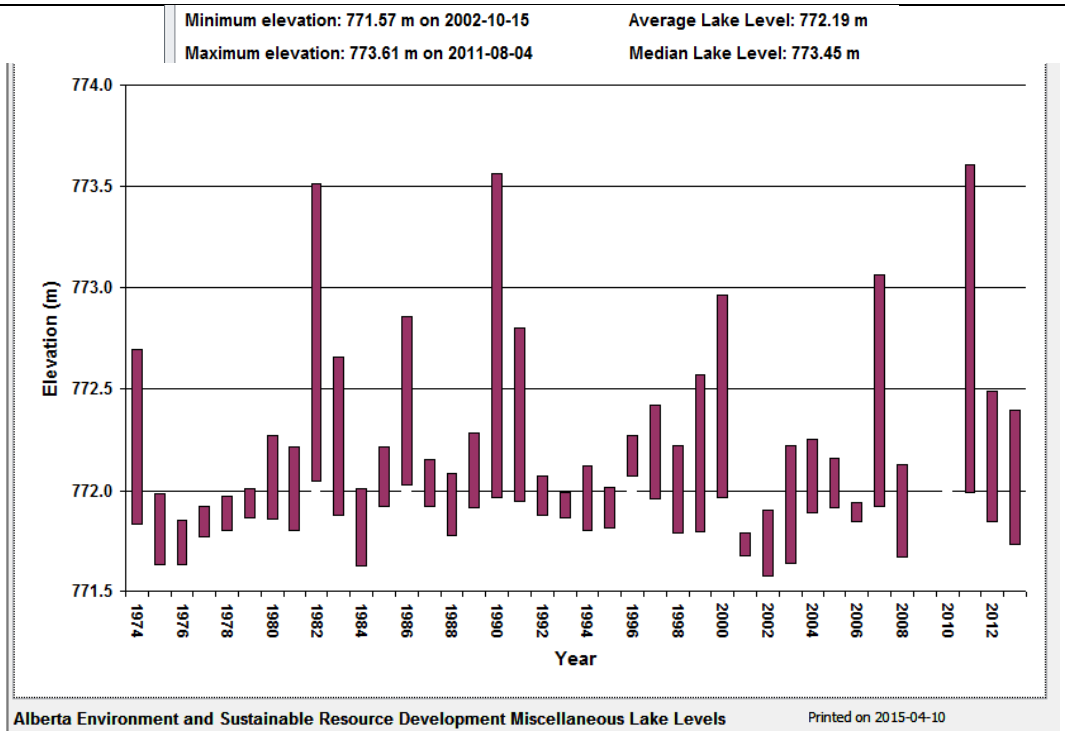


Figure 5-4. Lake Levels for water body shown above in Figure 6-4. Contact a local hydrogeologist with the Department, municipality or County to determine where data may be available.

Legal Description (Sec. Twp. Rge. Meridian): Section 30

Photo Date (MM/DD/YY)	Photo ID (Roll AS# Photo#)	Image Source	Resolution	Season*	AWCS Wetland Class	Precipitation Year**	Precipitation Month Analysis**	Precipitation Day Analysis	Open Water Visible or Consistent Wetland Vegetation Signature***	Assessment of Permanence	Photo Notes
5/21/2013		SPOT6	150cm	S	Marsh	Normal	Wet	only 5mm rain in that month prior to image	DV	N	
5/16/1974	1455-022	Aerial hard copy	1:12000	S	Marsh	Normal	preceded by very wet month	None (but 20mm in 2 weeks prior)	W	N	Lake levels above average
8/13/1966	944-162	Aerial hard copy	1:30000	Sum	Marsh	Normal	Wet	None (but 10mm in 2 weeks prior)	DV	N	
9/29/1949	0146-016	Aerial hard copy	1:36800	Fall	Marsh	Not available	Not available	Not available	DV	N	

Years Dry Over Photo Record (# Years)	3 of 4

* S=Spring (April to June); Sum=Mid-Late Summer (June to Sept); F=Fall (Sept-Nov): Seasonality bas
** D=Dryer; N=Normal; W=Wetter N/A=Not available
*** W=Water present/inundated; D=Dry; DV=Dry, vegetated (consistent with wetland class); DVI=Dry, vegetated (indistinguishable from surrounding uplands)
**** Y=Yes (Reasonably Permanent, a Sec 3 *Public Lands Act* body of water); N=No (Not Permanent, a wetland regulated under *Water Act*)

Figure 5-5. Template showing imagery and precipitation data descriptions collected using the steps in Section 4.2.

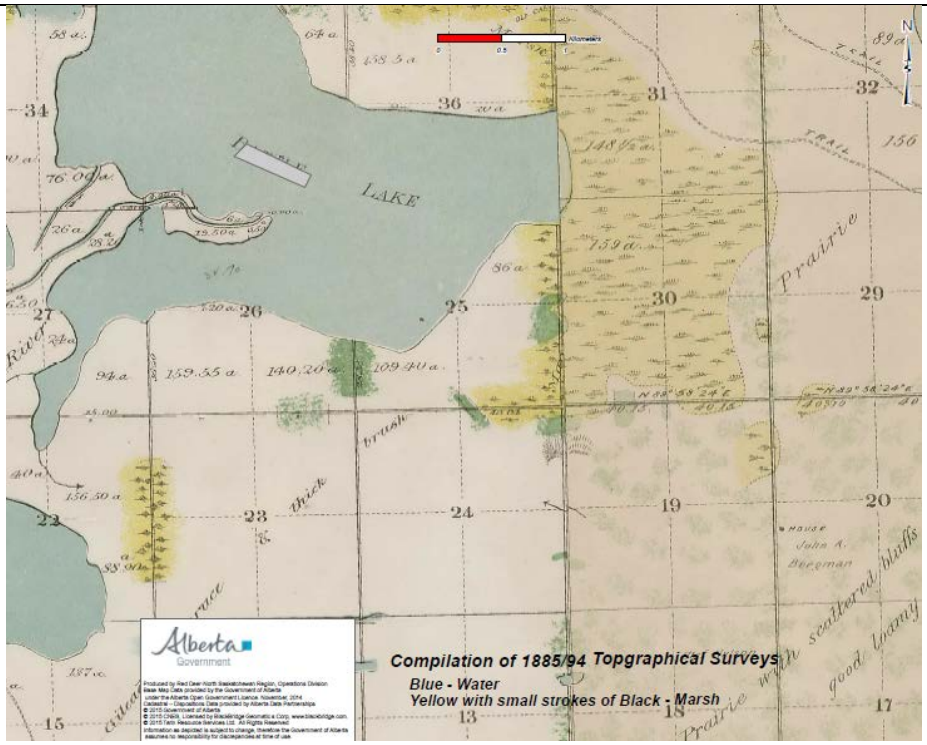


Figure 5-6. Historical Survey Information identifying and depicting areas of open water and marsh areas.

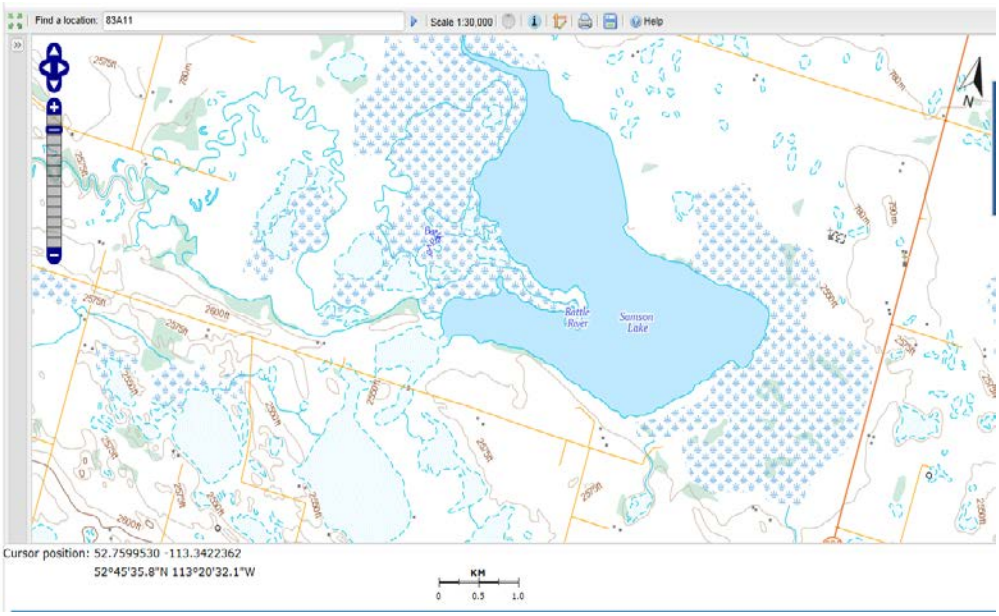


Figure 5-7. Current topographical information obtained online from Natural Resources Canada.

Figure 5-8. **Consequences of planning activities using boundaries that were field delineated under dry and/or frozen conditions. Other considerations such as fluctuating wetland extents or lake levels, vegetative cover and soils were also not adequately investigated. Additional information and historical imagery was not appropriately identified or utilized to plan and avoid risks to infrastructure prior to undertaking the activity. Water levels were at a historic high when these photos were taken in 2011.**

Appendix 6 List of field materials and equipment recommended for wetland delineation

1. Device able to check for wetland indicator status on U.S. Plants Database or on the national wetland plant list from U.S. Army Corps of Engineers (Great Plains and Western Mountains, Valleys, and Coast regions), measuring slope (clinometer), and taking site and delineation photographs

    - Natural Resources Conservation Service - U.S. Plants Database

2. A GPS unit
3. Field sheets from Appendix 7
4. Writing implement
5. Measuring tape
6. A quadrat or flags for marking transects and plots
7. A copy of the Alberta Wetland Classification System (2015)
8. A wetland plant field guide. Some suggestions include:

    - Common Mineral Wetland Plants of Alberta: A Field Guide for Wetland Classification in the Prairie Pothole Region (Aquality)
    - Water and Wetland Plants of the Prairie Provinces (Heinjo Lahring, University of Regina Press)
    - Plants of the Western Boreal Forest and Aspen Parkland (Johnson, Kershaw, MacKinnon, Lone Pine Publishing)
    - Plants of Alberta (Royer and Dickinson, Lone Pine Publishing)

9. A shovel or soil corer
10. Munsell colour Chart
11. Boat, paddles, lifejackets, bail and measuring stick (if wetland has deepwater interface)
12. Flagging tape for marking the outer boundary of wetland

Appendix 7 Field form for wetland delineation procedures in Alberta, based on Tiner (1993).

Instructions: Complete this form for the plant community at the boundary between wetland and non-wetland.

QWSP Investigator (Name and Company Name): _____

Date: _____ Project Name: _____

Legal land description of wetland: SEC TWP RNG MER

PRIMARY INDICATOR OBSERVED (Circle and describe below)

Vegetative Indicators of Wetland

V1. Hydrophytic species cover more than 50 percent of the abundant plant species in the community or plot (An abundant species is a plant species with 20 percent or more areal cover in the community or plot). List all abundant species below **Yes / No**

Plot #	Wetland class codes	Stratum (ground, shrub, tree)	Plot technique (1 x 1, 10 x 10, none)	Plot location (UTM)	Common name of species	*Latin* name of species	Facultative Wetland or Obligate Wetland spp. (Y/N)	Percent Relative Cover of abundant species (round to nearest 5)

V2. Surface encrustations of algae are present? **Yes / No**

V3. The presence of a dominant groundcover of peat mosses (Sphagnum spp.) **Yes / No**

V4. Diminished rigor and productivity of upland species in disturbed areas **Yes / No**

V5. Evidence of morphological adaptations of plants to saturated conditions (e.g. floating leaves, inflated stems, adventitious roots) **Yes / No**

Other comments: _____

_____

Soil Indicators of Wetland

S1. Organic soils (except Folists) present **Yes / No**

S2. Presence of peat accumulation determined by Von Post test **Yes / No**

S3. Of, Om or Oh horizons (organic surface layer 20-40 cm thick) present **Yes / No**

S4. Sulfidic material (odor of "rotten eggs") present **Yes / No**

S5. Gleying (chroma of 2 or less formed by excessive soil wetness) or mottling (blotches or spots of different colour) present immediately below the surface layer (A- or Ae- horizon) and within 30 cm**Yes / No**

S6. Native prairie soils with a low chroma matrix (chroma of 2 or less) within 30 cm of the soil surface and one of the following present: **Yes / No**

a. Thin surface layer (at least 0.5 cm) of peat or muck; or

b. Presence of iron (high chroma mottles, oxidized rhizospheres) within 30 cm of surface; or

c. Iron and manganese concretions within the surface layer (A-horizon); or

d. Low chroma (gray-coloured) matrix or mottles present immediately below the surface layer (A-horizon) and the crushed color is chroma 2 or less

S7. Nonsandy soils (e.g. clay, loam, silt) with a low chroma matrix (chroma of 2 or less) within 40 cm of the soil surface and one of the following present within 30 cm of the surface:

Yes / No

a. Iron and manganese concretions or nodules; or

b. Distinct or prominent oxidized rhizospheres along several living roots; or

c. Low chroma mottles

S8. Sandy soils with one of the following present: **Yes / No**

a. Thin surface layer (at least 2.5 cm) of peat or muck where leaf litter is present; or

b. Surface layer of peat or muck of any thickness where a leaf litter is absent; or

c. A surface layer (A-horizon) having a low chroma matrix (chroma 1 or less and value of 3 or less) greater than 10 cm thick; or

d. Vertical organic streaking or blotchiness with 30 cm of the surface; or

e. Easily recognized high chroma mottles occupy at least 2 percent of the low chroma subsoil matrix within 30 cm of the surface; or

f. Organic concretions with 30 cm of the surface; or

g. Oxidized rhizospheres along living roots within 30 cm of the surface; or

h. A cemented layer (ortstein) within 30 cm of the soil surface

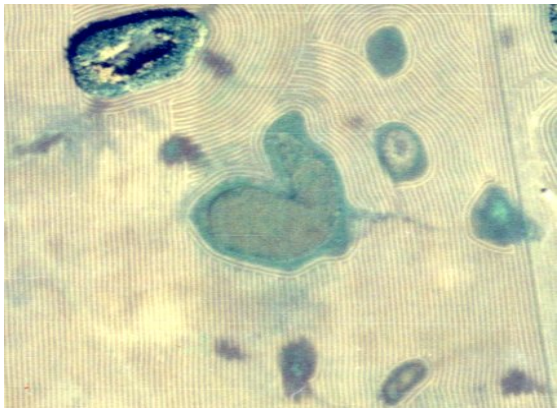
S9. Remains of aquatic invertebrates are present within 30 cm of the soil surface in pothole-like depressions

S10. Other regionally applicable, field-verificable soil properties associated with prolonged seasonal high water tables

Surface water present	**Yes / No**
Free water in soil pit	**Yes / No**
Saturated soil	**Yes / No**
Oxidized rhizospheres	**Yes / No**
Water-stained leaves	**Yes / No**
Sediment deposits	**Yes / No**
Water marks	**Yes / No**
Drift lines	**Yes / No**
Scoured/bare areas	**Yes / No**
Drained patterns	**Yes / No**
Beaver lodges or muskrat mounds	**Yes / No**

Appendix 8 Examples of aerial and field photographs of wetlands

a. Ephemeral Water Bodies
Low-lying areas where water is briefly ponded in early spring before soils are thawed or after a storm event. Central basin of the wetted area typically has the same vegetation and soils as the surrounding land. In agricultural areas these low-lying areas are typically cultivated. *These features are not recognized as wetlands in Alberta.*



b. Temporary Marshes (M-G-II)
Surface water exists for a few weeks only after snow melt and only several days after heavy rain/storm events. Vegetation in the centre of the basin consists of low-stature wet meadow plants composed of fine-textured grasses, rushes, and sedges.

Figure 8-A. Examples of air photography and field photos of mineral marsh and shallow open water wetlands in Alberta.

c. Seasonal Marshes (M-G-III) or Shallow Open Waters (W-SAV-III)
Basins are typically inundated by water for more than three weeks, but dry out by midsummer in most years. The central part of basin is represented by shallow marsh vegetation (moderately coarse grasses and sedges with associated forbs).

d. Semi-Permanent Marshes (M-G-IV) and Shallow Open Waters (W-SAV-IV)
Water persists into autumn in 7 of 10 years. The central basin is represented by deep marsh vegetation (relatively coarse marsh emergents or associated submerged aquatics).

e. Permanent Shallow Open Waters (W-SAV/B-V)
The central portion of the water body is permanently inundated with water throughout the year. The open water may be surrounded by deep wetland, shallow wetland, or wet meadow vegetation zones.

Figure 8-B. Examples of air photography and field photos of mineral marsh and shallow open water wetlands in Alberta (con't).

f. Intermittent Saline Shallow Open Waters (W-SAV-s-V)
Shallow wetlands with highly variable water levels. Basin is typically devoid of emergent vegetation. The vegetation is adapted to highly saline environments and is generally limited to periphery. Frequently bounded by exposed soils forming a dry alkali ring.

Figure 8-C. Examples of air photography and field photos of mineral marsh and shallow open water wetlands in Alberta.

a. Early summer

b. Late summer

c. Early autumn

d. Late autumn

Figure 8-D. Example of vegetative zones taken at different time of the season of a permanent shallow open water wetland in Alberta. The ecological boundary of this wetland extends to the willow in the far right of the frame.

a. Shrubby Swamp

b. Treed Swamp

Along the eastern slopes and in the transition zone between the Parkland and Boreal ecoregions, many wetlands consist of shrubby and treed swamps. They are difficult to recognize as wetlands without specialized expertise or tools (e.g. GIS inventory data). Swamps often occur between other wetland classes and uplands.

Figure 8-E. Ground of a shrubby swamp (a) and overhead view of a treed swamp (b).

a. Bog surrounded by patterned fen

b. Patterned fen surrounded by well sites

c. Bog

d. Fen

In the boreal ecoregions of Alberta, wetlands are primarily composed of bogs and fens. Fens are often easier to delineate as they frequently have more distinct boundaries and display flow patterns (patterned fens).

Figure 8-F. Overhead and ground views of peatlands commonly found in Alberta, including bogs (a AND c) and fens (a, b AND d).

Contact Information

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Authorities

Original signed by: _____ Date: Jun1, 2015

Andy Ridge, Director Water Policy Branch
Alberta Environment and Parks