From:	Andy Cumming
To:	"Arie and Willemiek Muilwijk"
Subject:	Concrete and Soil Investigation Guides
Date:	Thursday, July 16, 2020 9:23:18 AM
Attachments:	TG_096-93_Concrete_Liners.pdf Agdex_096-62_subsoil-investigations-for-manure-storage-facilities-manure-collection-areas_April_2020.pdf

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Hi Arie,

Further to our conversation yesterday, attached please find technical guides for subsoil investigations and concrete liners you requested I send.

As discussed you need to provide information to show how the proposed liners for your manure storage and collection facilities will meet the groundwater and surface water protection requirements set out in the Agricultural Operation Practices Act.

Regards

Andy

Non-Engineered Concrete Liners for Manure Collection and Storage Areas

Purpose

- Provide guidance for the design and construction of non-engineered concrete liners used for manure collection and storage areas
- Protect groundwater from contamination

Audience

- Operators, consultants, and contractors constructing concrete liners for manure collection and storage areas at confined feeding operations

Relevant Legislation

- *Agricultural Operation Practices Act* and Standards and Administration Regulation

Introduction

Concrete is a practical, cost-effective and long-lasting material to use as a liner for manure collection and storage areas at confined feeding operations (CFOs). This technical guideline describes specifications for concrete liners that can be used to satisfy the requirements of the *Agricultural Operation Practices Act* (AOPA) and its regulations.

This guideline does not apply to manure collection and storage areas that use a natural protective layer, a compacted clay liner or a synthetic liner under the proposed concrete liner, provided that the layer or liner meets AOPA requirements.

Professionally engineered designs may differ from the specifications outlined in this guideline and may provide greater protection than AOPA requires.

This guideline also identifies when an operator must consult an engineer for a site specific design. If a site specific engineered design is not required, the operator has the option of having their concrete liner designed by an engineer.

Concrete liners must be constructed to ensure that groundwater is protected from manure constituents.

Concrete as a Liner

Section 9 of AOPA's Standards and Administration Regulation requires constructed concrete liners to provide equal or greater protection to groundwater resources than compacted soil. Section 9(6) sets out the thicknesses and hydraulic conductivity values of compacted soil that must be met or exceeded.

The concrete liner should be constructed to the minimum thickness required to maintain the structural integrity of the concrete liner and to prevent cracking and ensure durability.

Concrete Categories and Facility Construction

The concrete required for manure collection and storage areas is categorized by the complexity of the facility and the moisture content of the manure contained in the facility (see Table 1).

Alberta Government

NRCB Natural Resources Conservation Board

Table 1. Manure Collection and Storage Facility Types.

Category	Manure Facility	Examples
A	Complex storage (liquid or solid manure) **MUST BE ENGINEERED**	• Circular and rectangular tanks—steel or concrete walls and concrete floor • Concrete pit floor or slab within 1 m (3.3 feet) of the water table • Concrete pit walls >2.4 m (8 feet) on large scale under barn
B	Liquid manure (shallow pits)	• Pits 2.4 m (8 feet) deep or less • Concrete pit walls >2.4 m (8 feet) on small scale under barn (i.e., small transfer pits and pump pits)
C	Solid manure (wet)	• Scrape alleys • Outdoor solid manure storage • Pen floors in a partially slatted barn
D	Solid manure (dry)	• Indoor or covered solid manure storage

Category A Concrete Liners

Category A concrete liners are complex storage systems. A complex manure collection or storage area may contain liquid or solid manure. Examples include above ground liquid storage tanks, deep liquid pits and pit floors or slabs within one metre of the water table.

Category A concrete liners must be designed by a professional engineer and constructed under their supervision. An engineer must verify how the liner meets AOPA specifications.

To allow for maximum flexibility of engineering design, professional engineers are not required to follow the specifications outlined in Table 2.

Category B, C, D Concrete Liners

Category B, C and D liners are simpler manure storage systems used for lower risk sites that do not require a complex design.

The design and construction options for category B, C and D liners are:

1) Engineered by a professional engineer,

or

2) If not engineered by a professional engineer, the design and construction must be in accordance with the specifications set out in Table 2.

CRITICAL FACTORS FOR CONCRETE PERFORMANCE

Owners and operators are responsible for the following critical factors for concrete construction and maintenance:

- Design and construct each facility using high quality material (including low permeability concrete and proper aggregate), with appropriate reinforcement and placement.
- Ensure water tightness and proper finishing. Water stops and control joints help prevent leakage.
- Properly place and cure the concrete, and protect it from extremes of cold and hot weather during the curing.
- Ensure the concrete meets the requirements for its intended use, for example, loader traffic.
- Monitor cracking, and repair cracks as soon as they occur.

Table 2. Minimum Requirements for Non-Engineered Concrete Liners.

	Category B	Category C	Category D
Depth from bottom of liner to water table	Must be greater than one metre at the time of construction		
Cement type	• High Sulphate Resistant (HS) or High Sulphate Resistant blend (HSb) (formerly known as Type 50) **OR** • General Use blend (GUb) that meets sulphate resistance requirements (formerly known as Type 10 with fly ash) Air entrainment is required		
Concrete Strength	Maximum water to cement ratio (W/CM) of 0.45 (Strength of 32 MPa at 28 days (A-2); or 32 MPa at 56 days (S-2))[1]	Maximum W/CM of 0.50 (Strength of 30 MPa at 28 days (A-3); or 30 MPa at 56 days (S-3))[1]	Maximum W/CM of 0.55 (Strength of 25 MPa at 28 days (A-4))[1]
Crack Control	Pit floor:[2] • Adequate rebar and cover (approximately three times the floor thickness for rebar spacing) • Minimum 40 mm cover with a minimum total thickness of 100 mm Pit walls[2] • Adequate rebar and cover	• Adequate rebar and cover (approximately three times the floor thickness for rebar spacing) • Minimum 40 mm cover with a minimum total thickness of 100 mm	• Adequate rebar and cover (approximately three times the floor thickness for rebar spacing), or concrete reinforcing mesh (for example, fibre mesh) in appropriate amounts (with no rebar) • Minimum 40 mm cover with a minimum total thickness of 100 mm
Leak control	Must be compatible with manure and sulphates: External pit walls and pit floor • Water stop, caulked joint, expanding caulked joint Piping and other extrusions • Expanding caulked joints, piping boots, cast in place (by design) Cold joints or precast where the seal type is to be covered by poured-in-place concrete • Water stop, caulked joint, expanding caulked joint	n/a	n/a

[1]Canadian Standards Association, A23.1 Concrete materials and methods of concrete construction, Tables 1, 2 and 3.
[2]Canadian Standards Association, A23.3 Design of Concrete Structures.

Reporting and Documentation

The Natural Resources Conservation Board (NRCB) typically requires reports and documentation for the four categories of concrete, as described below. NRCB approval officers have discretion to determine which reports and documents are required. However, approval officers may require more or less reporting and documentation for an individual permit condition, depending on the particular file.

Category A Concrete Liners

Approval officers may include a condition or conditions in the permit to require the applicant to provide an engineer's completion report. As-built drawings from the engineer may also be required. The engineer may be required to report on the methods used to place and cure the concrete. In extreme cases, supervision could be required to ensure placement and curing is done according to the standards established by the Canadian Standards Association (CSA).

Category B and C Concrete Liners

To determine whether there are specific risks to groundwater associated with an application that will use a category B or C concrete liner, approval officers use the Environmental Risk Screening Tool (ERST) to determine the level of risk. The results determine which reports and documentation will be required.

The approval officer may require the specifications listed in Table 2 and in the application to be proven to their satisfaction. For example, the approval officer may require ready-mix concrete delivery tickets or invoices, or evidence of water stops and rebar size, spacing and placement. For higher risk sites, the approval officer has discretion to require the contractor to provide this information in a completion report, and may also require as-built drawings. If self-mixed concrete is used, independent third party tests of the concrete quality may be required.

In addition, documentation may be required to confirm that the concrete meets sulphate resistance specifications or is equivalent to those specifications.

Category D Concrete Liners

Normally, minimal follow up is required. The approval officer may require the applicant to confirm that the concrete has been placed inside the facility. The approval officer also has discretion to require independent third party testing of the concrete quality if self mixed concrete is used. Tickets and invoices, evidence of rebar and completion reports are generally not required.

Documentation may be required to confirm that the concrete meets sulphate resistance specifications or is equivalent to those specifications.

For more information

Contact your nearest NRCB field office or an AF CFO extension specialist (dial 310-0000 to be connected toll free)

Alberta Agriculture and Forestry
www.agric.gov.ab.ca/aopa

Morinville	(780) 939-1218
Red Deer	(403) 755-1475
Lethbridge	(403) 381-5885

Natural Resources Conservation Board
www.nrcb.ca

Fairview	(780) 835-7111
Morinville	(780) 939-1212
Red Deer	(403) 340-5241
Lethbridge	(403) 381-5166

This guideline was developed by the Technical Advisory Group, a partnership between Agriculture and Forestry, the Natural Resources Conservation Board and the agricultural industry.

Subsoil Investigations for Manure Storage Facilities and Manure Collection Areas

Purpose

Provide consistent processes and methodologies for determining the depth to the water table and the uppermost groundwater resource when conducting a subsoil investigation for a proposed manure storage facility or manure collection area

Relevant Legislation

Agricultural Operation Practices Act

- Standards and Administration Regulation
- Administrative Procedures Regulation

Related Technical Guidelines

Agdex 096-50	Reclamation of Groundwater Monitoring Wells
Agdex 096-51	Monitoring Well Construction Installation and Development
Agdex 096-60	Subsoil Investigation Information for Applicants
Agdex 096-61	Determining Equivalent Protective Layers and Constructed Liners
Agdex 096-63	Subsoil Investigations for Naturally Occurring Protective Layers
Agdex 096-64	Subsoil Investigations for Compacted Soil Liners

1. Introduction

This guideline is for consultants conducting subsoil investigations to determine depth to the water table and the uppermost groundwater resource (UGR) at a site for a proposed manure storage facility or manure collection area. The investigation is dependent on subsoil and groundwater conditions of the site, and the types of groundwater protection and facilities proposed. This guideline refers to both manure storage facilities and manure collection areas as "facilities".

For the purpose of this guideline, "subsoil investigation" is equivalent to the term "soils investigation" as found in the Administrative Procedures Regulation of the *Agricultural Operation Practices Act* (AOPA).

Subsoil investigations must be completed by members of the Association of Professional Engineers and Geoscientists of Alberta (APEGA) or the Alberta Institute of Agrologists (AIA). Questions about the use of this guideline for specific permit applications should be discussed with an approval officer with the Natural Resources Conservation Board (NRCB).

2. Subsoil Investigations

Naturally occurring protective layers, compacted soil liners and other types of groundwater protection all require information on the depth to the water table and to the UGR. Regardless of the type of groundwater protection being proposed, the initial steps in a subsoil investigation will be the same.

This guideline assumes the proposed facility will use a naturally occurring protective layer for groundwater protection. As the subsoil investigation gathers information, the proposed method of groundwater protection may need to change to a compacted soil liner. For this reason, the consultant should collect enough subsoil samples while on site for laboratory tests supporting a compacted soil liner.

3. Test Holes

Test holes may include both drilled boreholes and dug test pits. The number, location, and depth of test holes for a subsoil investigation is dependent on the type of groundwater protection, the size of the proposed facility, and the consistency of subsoil and geologic materials at the site. More test holes are required for larger facilities and for sites with less consistent subsoil and geologic materials. The number of test holes may need to increase or decrease based on results found over the course of the investigation.

More information on the number of test holes, location and depth can be found in **Agdex 096-63 Subsoil Investigations for Naturally Occurring Protective Layers and Agdex 096-64 Subsoil Investigations for Compacted Soil Liners** (currently under development).

3.1 Soil Logging Methods

Soil descriptions should be continuously logged as the test hole is advanced. Soil logs should include a description of the soil texture and bedrock encountered using either the Canadian Soil Classification System (NRC, 1988), D2487-06 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System, ASTM International, 2006), or the Wentworth Scale (Wentworth, 1922). The system used must be specified on the test hole logs and must be used consistently throughout the site. More information can be found in **Agdex 096-51 Monitoring Well Construction, Installation and Development**.

Representative samples of soils encountered in test holes must be collected at least every 1.5 metres of test hole depth and where soil changes are suspected or observed. The following characteristics should be recorded:

- Soil texture
- Lithology (e.g. sandstone, siltstone, claystone, coal)
- Grain size
- Colour
- Moisture content
- Consistency
- Plasticity
- Hardness
- Secondary features such as staining, mottling, carbonates, gypsum, degree of cementation, degree of weathering, degree of visible fractures, surface staining and odour

3.2 Completing Boreholes as Monitoring Wells

Boreholes can be completed and used as monitoring wells to determine water table depth, depth to groundwater, groundwater sampling and to conduct hydraulic conductivity tests.

All monitoring wells must:

- Penetrate the water table or the zone intended to be monitored
- Be installed in similar lithology
- Be constructed and developed properly

For more information on the construction of a monitoring well, see **Agdex 096-51 Monitoring Well Construction, Installation and Development**.

Strategic placement of these monitoring wells may also make them suitable for ongoing groundwater monitoring or leakage detection.

3.3 Reclaiming Test Holes

Boreholes within the footprint of a liquid manure storage facility or catch basin must be properly reclaimed by filling them with bentonite, and topping off with 0.5 metres of compacted clay to the ground surface.

Boreholes and monitoring wells used as part of the investigation, but no longer needed, must be properly reclaimed as outlined in **Agdex 096-50 Reclamation of Groundwater Monitoring Wells**.

Test pits completed within the footprint of a facility or that penetrate the water table must be backfilled with excavated material or with material of similar characteristics. Backfilling should replace the subsoil in the reverse order from which it was removed.

4. Depth of Subsoil Investigation

A subsoil investigation must be deep enough to identify the stratigraphy beneath the proposed facility and verify the presence or absence of shallow groundwater resources or permeable units throughout. The subsoil investigation should extend to a depth of 1.0 to 2.0 metres below the bottom elevation of the proposed protective layer or compacted soil liner. Possible elevation changes due to construction excavation should be considered when determining the depth of the subsoil investigation.

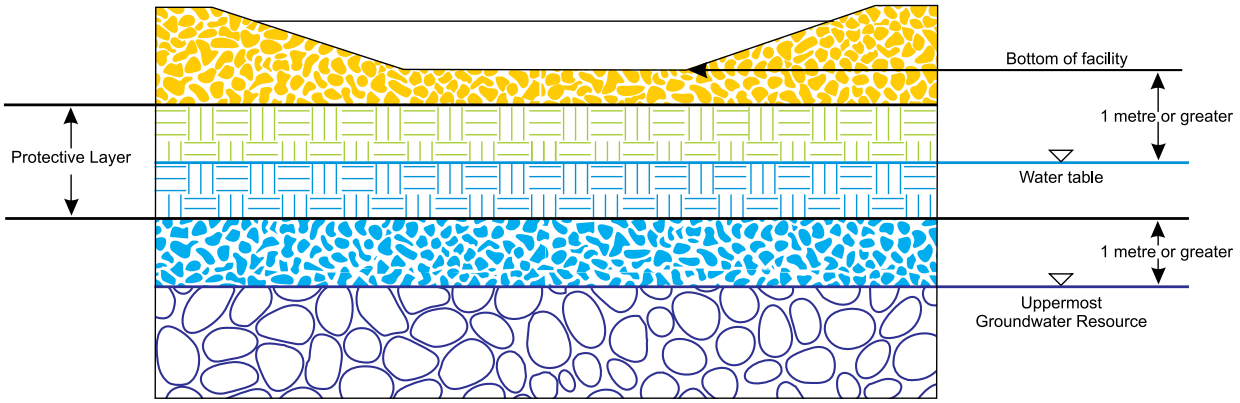

Figure 1 - Water Table and Uppermost Groundwater Resource (UGR) Depth Requirement for Naturally Occuring Protective Layer

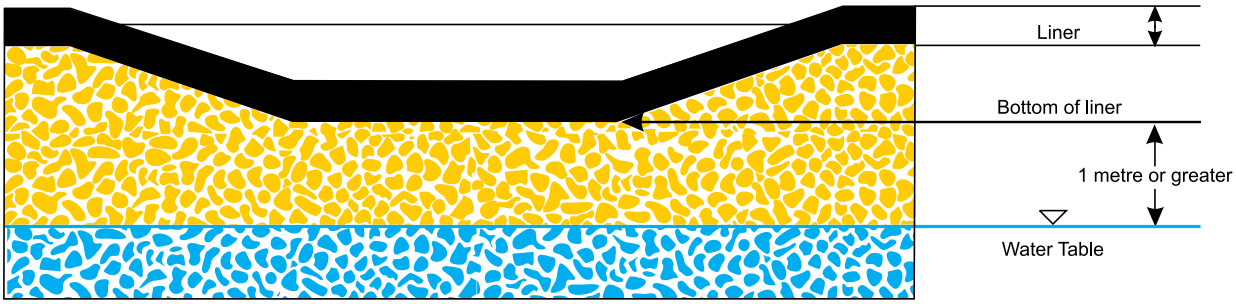

Figure 2 - Water Table Depth Requirement for Compacted Soil Liner

5. Water Table

A water table is defined in the *Agricultural Operation Practices Act* Standards and Administration Regulation as "the top of the zone of water saturation where water pressure equals atmospheric pressure regardless of whether the water is usable".

For protective layers, the bottom of the facility must be more than one metre above the water table at the time of construction (Figure 1). For compacted soil liners, the bottom of the liner must be more than one metre above the water table at the time of construction (Figure 2).

For information on concrete liners, see **Agdex 096-93 Non-Engineered Concrete Liner for Manure Collection and Storage Areas**.

If facilities already exist at a site, a mounded water table may be present. A mounded water table must be delineated. If in doubt, assume the water table is not mounded.

In rare instances a perched water table may be present. A perched water table must be delineated and characterized including calculations. If in doubt, assume the water table is not perched.

Where a proposed facility is to be constructed into, or within, one metre of a water table, the applicant must request a variance and include justification supporting it. The application must include additional design information on facility construction from an APEGA member and must ensure that the water table does not compromise the construction or performance of the proposed facility (e.g., cracking and heaving of a compacted clay liner).

The depth of the water table is typically measured by use of a monitoring well which has been screened across the zone containing the water table.

Multiple measurements over time is the only practical method of confirming the stabilized water table level. Following the initial well installation and development, groundwater levels must have stabilized prior to taking water level measurements. Groundwater levels can stabilize within minutes in coarse textured materials but may take several weeks in fine textured soils. The depth to the water table must be measured at the time of the subsoil investigation and confirmed prior to construction of the facility. Water tables can fluctuate throughout the season and from year to year.

For more information, see **Agdex 096-51 Monitoring Well Construction, Installation and Development**.

6. Groundwater Resources

The *Water Act* definition of aquifer, incorporated in the Standards and Administration Regulation under AOPA, is "an underground water bearing formation that is capable of yielding water".

According to the Standards and Administration Regulation:

(g.1) "groundwater resource" means "an aquifer below the site of a confined feeding operation or a manure storage facility"

(i) that is being used as a water supply for the purposes of domestic use; or

(ii) if no aquifer referred to in subclause (i) exists,

(A) an aquifer that has a sustained yield of 0.76 litres per minute or more and a total dissolved solids concentration of 4000 milligrams per litre or less as determined by well records, well drilling logs, hydrogeological maps, hydrogeological reports or other evidence satisfactory to an approval officer or the Board, and

(B) if there is more than one aquifer that meets the requirements of paragraph (A), the aquifer that an approval officer or the Board considers to be the best suited for development as a water supply for the purposes of domestic use;

6.1 Identifying Groundwater Resources from Well Logs

Groundwater resources are typically identified by their usage, such as a water well at or near the site. Often water well drilling reports contain sufficient information to indicate the depth of the groundwater resources at a site. If no water well information is available then neighbouring properties up to 1.6 kilometres from the property line or regional hydrogeology maps may provide the necessary information. The proper interpretation of a groundwater resource from drilling reports or other information is critical and must be done by a professional.

6.2 Determining Groundwater Resources from Test Holes

A groundwater resource or aquifer with a sustained yield of 0.76 litres per minute or more would typically have a geologic unit hydraulic conductivity of 1 x 10^{-6} m/s (1 x 10^{-4} cm/s) or greater and a geologic unit thickness of 0.5 metres or greater. Any water bearing subsoil formation encountered in the minimum depth of investigation that potentially meets these requirements should be tested to determine if it is a groundwater resource. The hydraulic conductivity is determined using slug or pump tests. Appropriate hydraulic conductivity tests are listed in the In-situ Hydraulic Conductivity Test Methods sections of **Agdex 096-63 Subsoil Investigations for Naturally Occurring Protective Layers** (currently under development).

The Farvolden Method (Appendix A) is to be used for yield calculations to identify a groundwater resource.

6.3 Groundwater Resource Limitations

Peat deposits or muskeg, regardless of hydraulic conductivity and thickness, are not considered a groundwater resource.

There is no limit to the number of groundwater resources that may be present at a site and no guarantee that a groundwater resource will be present at a site.

The groundwater resource definition does not apply to shallow, large diameter bored wells (i.e. greater than 60 centimetres or 2 feet), unless the geologic unit in which the well is completed would otherwise meet the hydraulic conductivity or yield requirements of a groundwater resource.

6.4 Determining the Uppermost Groundwater Resource (UGR)

Once the groundwater resources have been identified at the site, the UGR can be determined. Part of the UGR determination would include identifying whether the groundwater resource is unconfined or confined.

More information on hydraulic conductivity testing for UGR's can be found in **Agdex 096-63 Subsoil Investigations for Naturally Occurring Protective Layers** (currently under development).

6.4.1 Unconfined UGR

Any facility that is proposed to extend into or within 1.0 metre of an unconfined UGR would require a variance. The criteria to justify a variance are beyond the scope of this guideline.

If an unconfined aquifer is the UGR at the site, then the top of the aquifer would be the water table.

6.4.2 Confined UGR

If a confined aquifer is the UGR at the site, the top of the aquifer may be at a different depth than a shallow water table. In this scenario, the regulatory requirements for the depth to the UGR and the depth to the water table at the time of construction would apply separately.

A variance is required for sites where proposed facilities are to be constructed into or within one metre of a water table located above a confined UGR. The application must include justification supporting the requested variance. This includes additional design information on facility construction from an APEGA member and must ensure that the water table does not compromise the construction or performance of the proposed facility (e.g., cracking and heaving of a compacted clay liner).

7. Reporting Requirements

A subsoil investigation report should include all relevant information that was used to determine the depth to the water table and the UGR. It should also include all naturally occurring protective layer or compacted soil liner designs for the proposed facility.

More information on the reporting of design details can be found in **Agdex 096-63 Subsoil Investigations for Naturally Occurring Protective Layers and Agdex 096-64 Subsoil Investigations for Compacted Soil Liners** (currently under development).

The following information should be included regarding the determination of the water table and UGR depths.

1. *Site information*
   - Client, location, and purpose of the investigation
2. *Description of the investigation*
   - Site map of test hole locations, dimensioned or to scale
   - Location and depth of samples taken
3. *Observations*
   - Logs of observed soil characteristics for all test holes
   - Total depth of test holes and auger refusal if any
   - Depth to water table, relative to elevations, including when it was observed
   - Monitoring well completion details, and elevations surveyed to a common datum
   - Borehole and monitoring well reclamation details
4. *Results*
   - Field hydraulic conductivity results of potential UGR formations, including:
     - methodology,
     - water level measurements over time,
     - formulas used,
     - sample or example calculations, and
     - any graphs or tables produced.
   - Farvolden method calculations and supporting data
   - Recommendations on groundwater protection options
5. *Conclusions*

Appendix 1 – Farvolden Method

For a geologic unit to meet the definition of a groundwater resource, it must have a bulk hydraulic conductivity of 1 x 10^{-6} m/s or greater and sufficient thickness to support a sustained yield of 0.76 l/min (1.2667 x 10^{-5} m^3/s) or greater.

The long-term theoretical sustained yield is calculated using the **Farvolden Method**

$$Q_{20} = 0.68 * T * H_a * 0.7$$

$$T = K * b$$

Where:

Q_{20} = the 20 year sustained yield (m^3/s)
T = transmissivity of the geologic unit (m^2/s)
K = bulk hydraulic conductivity (m/s)
b = thickness of the geologic unit (m)
H_a = available head (m)

For confined aquifers, the available head (H_a) is equal to the distance between the non-pumping water level in the well prior to the pumping test and the top of the aquifer.

For unconfined aquifers, the available head (H_a) is chosen to be 2/3 of the difference between the base of the aquifer and the non-pumping water level in the well (or 2/3 the saturated thickness).

For more information

Contact your nearest NRCB field office or AF AOPA staff

Alberta Agriculture and Forestry
www.agriculture.alberta.ca/aopa
Ag Info Centre 310 FARM (3276)
Publications (780) 427-0391
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Morinville (780) 939-1212
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