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.

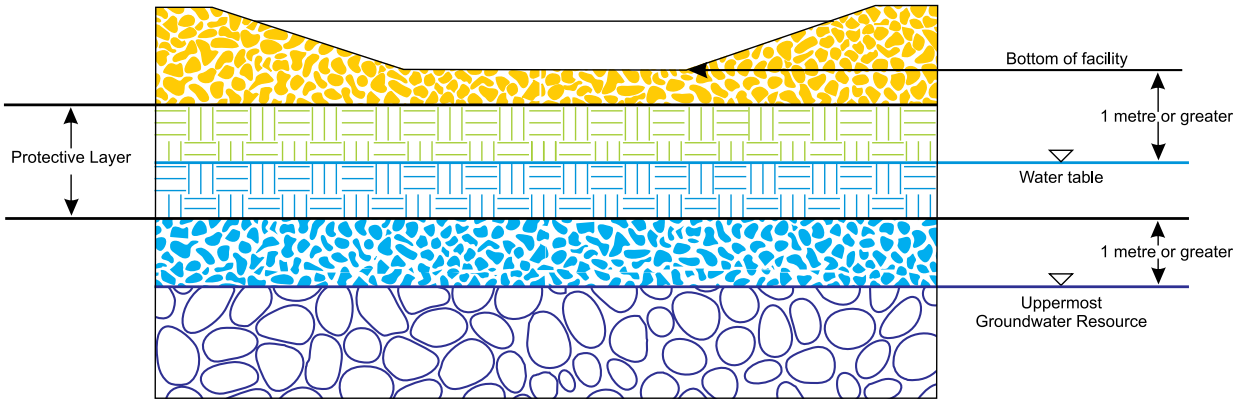

Figure 1 - Water Table and Uppermost Groundwater Resource (UGR) Depth Requirement for Naturally Occuring Protective Layer

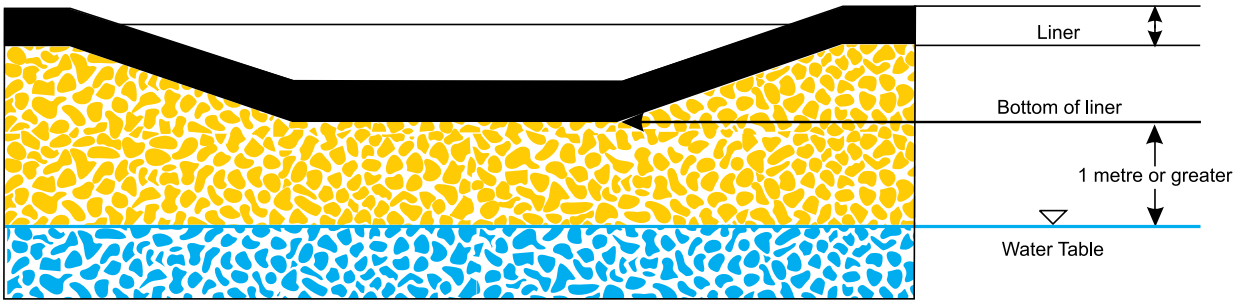

Figure 2 - Water Table Depth Requirement for Compacted Soil Liner

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

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