Information Bulletin – Hydraulic Conductivity Testing for Manure Storage Facilities

Manitoba
Environment and Climate Change

Manure storage facilities using clay containment are required to provide a minimum clay thickness of 1 metre with a hydraulic conductivity less than or equal to 1 x 10^{-7} cm/sec for liquid manure storage and 1 x 10^{-6} cm/sec for solid manure storage. These requirements are consistent with requirements for other clay lined containment facilities in Manitoba. The thickness is verified by drilling boreholes that penetrate through the liner material and into underlying material in a number of locations on the bottom and side slopes of the facility, where applicable. This also provides a good indication of the uniformity of the clay liner, and allows the inspector to choose an appropriate location(s) for the verification of the hydraulic conductivity requirement.

This information bulletin discusses acceptable methods of testing the hydraulic conductivity of a clay liner for liquid and solid manure storage facilities. It applies to in-situ clay lined (cut and fill) facilities, facilities with excavated and re-compacted clay liner, a liner constructed of borrowed clay material at the surface, and to facilities using cut off walls tied into sound underlying material. Engineering consultants and facility owners/operators are encouraged to contact the Environmental Approvals Branch of Manitoba Environment and Climate Change directly if they have questions or concerns regarding this information bulletin.

Types of Clay Liners

In-situ clay lined (cut and fill) facilities are constructed in locations where the in-situ hydraulic conductivity of the clay below the topsoil level is less than or equal to the required hydraulic conductivity value. In this situation, where applicable, excavated material at the site is used to construct compacted clay dykes to confine the upper portion of the facility.

Where the in-situ hydraulic conductivity is greater than the required hydraulic conductivity value, but the clay at the site can be excavated and re-compacted to reduce the hydraulic conductivity to this value or below, a re-compacted clay liner can be used. This results in a facility with a clay liner starting at the surface of both the bottom and the side slopes.

Where the in-situ hydraulic conductivity is greater than the required hydraulic conductivity value, and the clay cannot be excavated and re-compacted to reduce the hydraulic conductivity to this value, a clay liner may be constructed using re-compacted clay borrowed from another nearby location. This results in a facility with a clay liner starting at the surface of both the bottom and the side slopes.

Where the in-situ hydraulic conductivity is greater than the required hydraulic conductivity value in an upper clay layer, and less than this value in an underlying layer, cut off walls may be constructed using the lower permeability clay that extend from the top of the dyke down into the underlying low permeability clay. Cut off walls have a minimum thickness of 1 m, and are typically either constructed vertically in the centre of the dykes, or following the side slopes of the dykes. The bottom liner may be some distance below the floor surface of the facility, and the dyke liners, if vertical, may have a substantial depth.

Hydraulic Conductivity Testing

Required hydraulic conductivity must be verified upon the completion of construction of the liner. Since manure storage facility permit requirements specify both a minimum liner thickness and a maximum allowable hydraulic conductivity, the post-construction verification examines both parameters. The inspector from the Environmental Approvals Branch selects one or more locations for hydraulic conductivity testing based on the drilling conducted for liner thickness verification. To meet permit requirements for hydraulic conductivity, the liner must not exceed the allowable hydraulic conductivity at any point within the liner. Hydraulic conductivity is measured by conducting triaxial tests on soil samples obtained with Shelby tubes. Methods for sampling and testing are detailed in the American Society for Testing and Materials (ASTM) standards.

Where facilities are being expanded or modified, the extent of liner testing depends on the extent of the new or modified liner material.

Sampling Procedure

(a) Samples shall be obtained using a drilling rig with a solid stem auger with the capability of drilling a minimum hole diameter of 5 inches (12.5 cm). The rig shall be capable of pressing a sampling tube into the liner in a straight line motion along the centre axis line of the sample tube and without sideways movement.

(b) Soil samples shall be collected and shipped in accordance with ASTM D1587 (Standard Practice for Thin-Walled Tube Sampling of Soils), D 4220 (Standard Practice for Preserving and Transporting Soil Samples) and D3550 (Standard Practice for Ring-Lines Barrel Sampling of Soils). Thin-walled tubes shall meet the stated requirements including length, inside clearance ratio and corrosion protection. An adequate venting area shall be provided through the sampling head.

(c) All drill and sample holes shall be sealed with bentonite pellets after the field drilling and sampling has been completed.

Triaxial Testing

(a) The soil samples shall be tested for hydraulic conductivity using ASTM D5084 (Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter).

(b) Soil specimens shall have a minimum diameter of 70 mm (2.75 inches) and a minimum height of 70 mm (2.75 inches). The soil specimens shall be selected from a section of the soil sample that contains the most porous material based on a visual inspection. The hydraulic gradient shall not exceed 30 during sample preparation and testing. Swelling of the soil specimen should be controlled to adjust for the amount of compaction measured during sample collection and extraction from the tube and the depth or elevation of the sample. The effective stress used during saturation or consolidation of the sample shall not exceed 40 kPa (5.7 psi) or the specific stress level, that is expected in the field location where the sample was taken, whichever is greater.

(c) A complete laboratory report, as outlined in ASTM D5084, shall be supplied to the Environmental Approvals Branch for each soil sample collected in the field.

Other Methods

For other or new hydraulic conductivity test methods, the written approval of the Director is required prior to testing. Other methods will be considered for approval only if they follow ASTM standards and maintain the integrity of the clay liner at the conclusion of the sampling process.

Timelines

Sampling on site following construction normally requires less than three hours. The major constraint is the availability of a drilling rig needed to obtain auger samples and press the Shelby tubes in a manner that allows undisturbed samples to be obtained within the tubes. Especially in the late fall at the end of the construction season, available drilling contractors are frequently busy. Once Shelby tube samples have been recovered, they are extruded from the tubes in a geotechnical laboratory and undergo triaxial testing in the lab. This generally requires two – four weeks depending on the availability of testing equipment and the ultimate hydraulic conductivity. (The more impermeable the sample, the longer the test takes).

Time savings are possible. Where the cells of a multi-cell facility are not ready for testing at the same time, the owner may choose to test cells separately to facilitate the earlier use of one cell that is ready for testing. Although this speeds up the approval, additional costs are incurred since the drill rig must come to the site at least twice. Where drilling to confirm the liner thickness indicates that good quality clay is present at all locations and is highly likely to meet the hydraulic conductivity requirements, the inspector may provide an interim approval to use the facility subject to later confirmation by the laboratory results. Note that interim approval is not provided when there is doubt about the material, due to the operational complications arising if the samples do not meet permit requirements.

When timelines are critical, owners or consultants should discuss in advance with Environmental Approvals Branch staff to minimize delays.

After Testing

When hydraulic conductivity testing demonstrates that permit requirements have been met, the inspector approves the use of the facility, usually by letter or email to the owner.

When permit requirements are not met, re-working of the liner is needed. During sampling, if there is doubt about the quality of the liner in any location, it is usual to take advantage of the drilling rig to auger additional holes to define the area likely to be deficient. Re-testing of the liner normally focusses on this deficient area, with some holes checked beyond the deficient area to confirm that the re-worked area is adequate. In cases where the hydraulic conductivity testing indicates that the hydraulic conductivity is marginally acceptable in some areas and has been deficient in other areas, additional testing in other areas may be conducted when re-testing deficient areas.