Information Bulletin – Design Objectives For Liquid Manure Storage Facilities

Manitoba Sustainable Development

The Livestock Manure and Mortalities Management Regulation (Manitoba Regulation 42/98) regulates livestock liquid manure storage facilities. The regulation is available at http://web2.gov.mb.ca/laws/regs/current/_pdf-regs.php?reg=42/98.

Under the regulation, permits are required to construct, expand or modify storage facilities. The designs of facilities are undertaken by engineering consultants on behalf of the facility owners. These design objectives outline considerations for the design of the facilities based on Manitoba experience. The required considerations must be incorporated into the design to address matters of environmental significance. The optional considerations address the efficacy of the design and its serviceability as well as the environmental performance of the facility.

These design objectives provide a practical approach to facility design. Manitoba Sustainable Development (MSD) is responsible for environmental protection, and engineering consultants are responsible for the engineering performance of the facility.

Where design objectives are indicated as 'must' or 'required', other approaches are major deviations from the design objectives and require approval by MSD. The person proposing the approaches will provide supporting information and explanation to support the proposal to MSD. Where design objectives are indicated as 'should', 'typically' or 'normally', other approaches may be used if in the professional judgment of the design engineer they will accomplish the desired objective.

These design objectives will be updated as needed to reflect any future changes in the regulation or to provide clarification. Engineering consultants and facility owners/operators are encouraged to contact the Environmental Approvals Branch of Manitoba Sustainable Development directly if they have questions or concerns regarding these design objectives.

Scope

Liquid and semi-solid manure storage facilities store manure until it can be applied to agricultural land. They are normally designed for a facility life of at least 20 years. These design objectives address earthen manure storage facilities that may be lined with clay (either in-situ or reworked) or with synthetic material, as well as manure storage facilities constructed using concrete or steel.

These guidelines do not address the storage of solid manure.

These guidelines also do not apply to situations where treatment of manure is contemplated so that liquid effluent can be discharged directly or indirectly to a surface water body, or the treatment involves energy production, airborne particulate release, etc. For these situations, approval is

required through a licence under The Environment Act, and not through a permit under the Livestock Manure and Mortalities Management Regulation.

Design Objectives

These guidelines apply to manure storage facilities being constructed, expanded or modified.

1. **General** The facility design must be compatible with the municipal approval pertinent to the facility. For new or expanding operations, one of four possible municipal approval documents must be provided with the permit application package:
   - **i.** For operations which require no municipal approval, a letter or a copy of a letter from the Municipality indicating that no approval is required; or
   - **ii.** For operations below the municipality's threshold for a conditional use approval, a copy of the development permit; or
   - **iii.** For operations at or above the municipality's threshold for a conditional use approval, a copy of the conditional use approval; or
   - **iv.** Where the municipality chooses to provide its development permit or conditional use approval after the manure storage facility permit is issued, a letter from the municipality indicating this choice.

   The purpose of this requirement is to ensure that the municipality is aware of the owner's intention to build or expand a manure storage facility, and that the municipality and the owner know the type and timing of any needed municipal approval. This avoids unexpected requirements and delays later in the planning and construction process.

   Existing operations not intending to expand the size of the operation beyond the current number of animal units are not required to provide any of the above municipal approval documents when proposing to construct a new or expand an existing manure storage facility. However, it is recommended that the owner advise the municipality of the intent to construct or expand a manure storage facility. This provides an opportunity for the owner and the municipality to address any potential concerns and avoid unexpected delays following issuance of the permit.

   a) Drawings: Engineering drawings for manure storage facilities must be submitted with the application. All engineering drawings provided with the design of a manure storage facility must be of a scale that is readable, including when printed. Design features noted as requirements in these guidelines ("must" or "required") are required to be shown on the drawings. Construction notes may be included on the drawings, or appended on separate sheets. Construction notes must include information on construction supervision by the design engineer.

   In particular, the drawings must show the location of the facility relative to surrounding buildings, natural features and property boundaries, sizing details, manure containment details and notes on how construction will be carried out and supervised.

b) Alterations: Alterations or amendments to the original design relevant to environmental significance must be approved prior to incorporation into the construction and must be reflected in record drawings. Notification should be provided for alterations related to the efficacy and serviceability of the facility and the alterations must be reflected in record drawings.

2. Location Manure storage facilities are located on land controlled by the facility owner and/or operator. They are typically located near the manure source or spread lands.

a) Setbacks: Manure storage facilities must be located a minimum of 100 metres away from surface watercourse, sinkhole, spring, well and boundaries of agricultural operations, unless a variance is obtained. The setback distances are to be measured from the outer toe of the nearest dyke for earthen storage facilities or the closest part of the tank for above ground concrete and steel facilities.

b) Surface Runoff: The siting of manure storage facilities in locations receiving significant amounts of runoff water is discouraged unless adequate provisions are made to divert storm water and snowmelt around the cells and otherwise protect dykes. Areas which are habitually inundated shall be avoided. If the facility is to be situated in an area requiring a designated flood protection level (Red River valley or other flood-prone locations), the level specified in the designated flood area permit must be noted and top elevations for the manure storage facility must not be below this level or must be protected by dykes appropriately.

c) Groundwater Pollution: Proximity of manure storage facilities to water supplies and other facilities subject to contamination and location in areas of porous soils and fissured rock formations must be critically evaluated to avoid creation of health hazards or other undesirable conditions. Where soils are unsuitable to provide adequate containment, artificial liners or concrete or steel tank storage facilities must be used. The design of the facility must provide a rationale for the final selection of the type of storage facility. The regulation requires that manure storage facilities be designed, constructed and operated so that pollution to surface water, groundwater or soil does not occur. In the design of a facility, sufficient engineering investigation is required to ensure that groundwater presence is identified and that pollution will not occur. Typically, groundwater presence is verified by checking with at least three boreholes to a depth of 10 metres below the ground surface at a site.

3. Sizing and Configuration

a) Hydraulic Loading: Provision shall be made for winter storage based on holding manure for a minimum of 400 days for earthen facilities and 250 days for concrete and steel facilities. One year of storage or more is commonly provided because of

operational considerations – owners may wish to apply manure only after harvesting a crop, and not in the spring and fall. The regulation prohibits storage over 750 days. Assumptions made in the design for loading and the storage period must be clearly outlined.

b) Multiple Cells or Tanks: Where more than one cell or tank is provided, the designer may consider both series and/or parallel operation.

c) Shape of Cells: Cell shapes should not be narrow or elongated. Round, square, or rectangular cells are desirable. Dykes should be rounded at corners to minimize accumulation of floating materials.

d) Size of Cells: Erosion due to agitation and wave action should be considered in cell sizing.

4. Safety Considerations Safety features for operators and the general public should be noted in the design. These may include signage, fencing around facilities that may be accessed by the public, restricted access for ladders, and safe walkways with appropriate handrails at and above ground level for operators performing normal daily activities, as necessary.

5. Pipelines Buried pipelines used under freezing conditions must be designed to provide protection from freezing. For pipelines between barns and manure storage facilities, cleanouts are normally provided at distances not more than 400 m apart, based on Manitoba experience. Pipe entrances into storage facilities are designed to be resistant to freezing and plugging. Pressure testing for pipelines typically references Manitoba Water Services Board specifications.

6. Earthen (Clay Lined) Manure Storage Facilities Facilities may be designed with a clay liner where soil at the site or nearby is or can be compacted to provide a hydraulic conductivity of 1 x10^{-7} cm/second or less. Clay liners must have a minimum thickness of 1 metre perpendicular to any surface. These requirements are consistent with requirements for all other clay lined liquid containment facilities in Manitoba. The hydraulic conductivity and thickness will be verified by testing upon completion of the liner construction. The amount of testing required for construction of a new facility is dependent on site conditions such as the size of the facility, the uniformity of soil conditions and the quality of construction. The requirement for testing and the amount of testing required for modification of an existing facility is dependent on the nature of the modification work and the extent to which it affects the integrity of the liner. Hydraulic conductivity testing is described in Manitoba Sustainable Development's Information Bulletin – Hydraulic Conductivity Testing for Manure Storage Facilities.

a) General Cut and Fill: When the material available at the chosen location is suitable (hydraulic conductivity of 1x10^{-7} cm/second or less without recompaction) a cut and fill cell may be the desired design. Areas of lesser quality materials must be removed, but the

earthwork required is greatly reduced if suitable material is available in-situ. Fill areas must be compacted to meet the required hydraulic conductivity criterion.

b) ***Clay Liners at the Surface:*** When the material available at the selected site can achieve the required hydraulic conductivity when recompacted, a clay liner with a minimum thickness of 1 metre may be selected for the containment structure. In this situation, the storage facility is over-excavated and the excavated material is recompacted. This technique can also be used with suitable nearby borrow material if the excavated material cannot be compacted sufficiently.

c) ***Cut off Walls:*** In the event of a site with suitable underlying clay materials at a reasonable depth, and more porous material at the surface, a cut off wall may be selected. The compacted clay cut off wall is designed to penetrate through the lesser quality material close to the surface to the depth of the underlying clay to create a barrier. The cut off wall is usually located near the centre of the dykes of the cell or cells it surrounds.

d) ***Dykes***

i. ***Material:*** Dykes shall be constructed of relatively impervious materials and compacted sufficiently to form a stable structure. Vegetation and topsoil should be removed from the area upon which the dyke is to be placed.

ii. ***Top Width of Dyke:*** The minimum dyke top width should be three metres to permit access of maintenance vehicles.

iii. ***Maximum Slopes:*** Dyke slopes should not be steeper than:

Inner — three horizontal to one vertical. (typically, inner slopes are 4:1)

Outer — four horizontal to one vertical. (typically, outer slopes are 5:1)

Excessively steep inner slopes are prone to erosion damage, so inner slopes steeper than 4:1 are normally selected only where soil texture and resistance to erosion allow. Dyke slopes must be shown on the engineering drawings for the facility.

iv. ***Freeboard:*** A minimum freeboard of 0.5 m is required for all facilities.

v. ***Seeding:*** Earth dykes shall be seeded above the water line. Perennial type, low growing, spreading grass that withstands erosion, occasional submergence and drought and can be kept mowed is most satisfactory. In general, alfalfa and other long rooted crops should not be used in seeding, since the roots of this type of plant may impair the water-holding efficiency of the dykes.

e) ***Bottom***

i. ***Uniformity:*** The cell bottoms should be as level as possible at all points. Finished elevations should not be more than ten centimetres from the average elevation of

the bottom. Shallow or feathering fringe areas usually result in locally unsatisfactory conditions.

ii. ***Vegetation:*** The cell bottoms should be cleared of vegetation and debris. Organic material thus removed should not be used in the dyke core construction. However, suitable topsoil relatively free of debris may be used as cover material on the outer slopes of the dykes.

iii. ***Soil Formation and Percolation:*** The soil formation or structure of the cell bottoms must be relatively tight to avoid excessive liquid loss due to percolation or seepage. The minimum hydraulic conductivity for use of in-situ or recompacted soils is $1x10^{-7}$ cm/second. Soil borings and tests to determine the characteristics of surface soil and subsoil must be made a part of preliminary surveys to select facility sites. Gravel and limestone areas and areas with high water tables will require additional design considerations. Typically, unsuitable material is removed and replaced with suitable material during construction, or it is covered with a minimum thickness of 1 metre of suitable material. Synthetic liner material may also be used to cover unsuitable material.

7. Synthetic Liners When suitable in-situ or recompacted clay is not available, synthetic liners are usually utilized to line the cells of earthen manure storage facilities. Synthetic liners use materials such as high density polyethylene (HDPE). Special care, design and operational requirements may be necessary depending upon the type of synthetic liner installed.

Note: Polyvinyl chloride (PVC) liners are no longer used for new construction applications. While repairs may be made to PVC liners, these liners are generally replaced with HDPE liners when modifications are necessary.

Gas collection systems are required under synthetic liners, and consideration should be given to hydrostatic pressure on the underside of the liner.

Pipe penetrations through the liner must be sealed between the pipe and the liner by the liner installer at the time of liner construction or alteration.

Construction notes typically detail procedures to be followed to prevent traffic damage to synthetic liners during construction.

a) Liner test requirements: The liner installer must complete a report after the liner has been installed and tested, and the approval of the assigned Environment Officer must be received prior to the use of the lined cell. The installation report must include a location plan showing all panels of the liner, and, typically in tabular form, the dates of panel installation, a description of each panel including its size and origin, the names of persons seaming and testing each panel, a reference to the testing method, a list of liner penetrations for inlet and outlet pipes, and a list of repairs, including type, location, reason, and repair technician. The installation report also includes a statement that the

completed liner meets the permit requirements. The Environment Officer may inspect the liner during the construction process.

b) High density polyethylene (HDPE) liner: The liner thickness must not be less than 60 mils (60/1000 inches) for HDPE liner. Since no cover material is used on dyke side slopes for manure storage facilities, fencing requirements may be imposed to prevent access to the cells by people and animals, since uncovered synthetic liner material may be slippery and prevent escape. Where a continuous liner is proposed without cover material over an intercell dyke and operator access to an intercell pipe valve is needed, operator safety should be considered and slipping hazards should be prevented.

8. Erosion Protection For all earthen manure storage facilities, several design requirements are followed to protect bottoms and dykes from erosion and dyke damage while the facilities are being filled and emptied.

a) Pumping Ramps: A minimum of two ramps and pump pads are required in the first cell of a storage facility. A minimum of one ramp and pump pad is required in other cells. Ramps must be at least 4.0 m (13 ft) in width and curbs on the sides of ramps must be 0.3 m in height to facilitate the entry and exit of pumps. These requirements may be varied for very small facilities or where the facility owner has a known access to floating pumping and agitation equipment or an alternative acceptable method of solids removal.

b) Pipes and Overflows: All pipes entering the storage facility must be anchored to prevent movement. Typically, inlet pipes are anchored to a concrete pad which incorporates 20 cm curbs. Similar provision of a concrete pad with 20 cm curbs is made under manure return pipes connecting adjacent cells. Where overflow pipes or overflow channels are provided at the top of cells, freeboard requirements must be maintained, and overflow pipes must be anchored.

9. Monitoring For all earthen manure storage facilities except those constructed with the cut and fill technique, leak detection systems and corresponding monitoring programs are required. Typically monitoring wells or a network of perforated pipes linked to sumps are used as leak detection systems. The location and installation details of the leak detection systems are needed on the engineering drawings for the facility.

10. Concrete Manure Storage Facilities Concrete facilities should be designed in accordance with Canadian Standards Association specification CSA A23.3 for the design of concrete structures. Any deviations from the specification should be noted and rationale provided.

a) Geotechnical Investigation: Due to the nature of the structure, a geotechnical investigation is required by a qualified professional engineer so that an appropriate foundation design is provided. The foundation design should include under-drainage

provisions if appropriate. Highlights and conclusions of this investigation must be provided, and the full geotechnical report may be appended to the permit application if available.

b) ***Freeboard:*** The freeboard requirement for a concrete facility is 0.3 m. A freeboard marker is recommended to facilitate the checking of freeboard from the ground during operation.

c) ***Cold Weather:*** Cold weather construction and operation protocols are recommended. These may be detailed in the construction drawings or in supplementary material in the permit application package.

d) ***Construction Joints and Floor-to-Wall Joint:*** For concrete joints in the facility waterstops and epoxy rebars must be used to maintain watertight joints and to prevent the potential corrosion of rebar.

e) ***Wall Form Ties:*** Wall Form Ties must be cone shaped and grouted after the forms are removed to prevent corrosion damage.

f) ***Ports, Piping and Valves:*** It is recommended that adequate loading/agitation ports be provided for a concrete facility. Waterstops are recommended on piping hardware, and valves should be corrosion resistant and lockable.

g) ***Leaks:*** A leak detection system for below ground components is required. The system must include a sump for leakage collection. A check valve is required on any pipe entering the facility below the ground so that backflow cannot occur in the event of a pipe leak or burst.

11. Steel Manure Storage Facilities Steel facilities should be designed in accordance with Canadian Standards Association specifications CSA S16.1 and CSA G40.21 for the design of steel structures. Any deviations from the specification should be noted and rationale provided.

Geotechnical and floor design requirements are the same as for concrete structures in Section 10 of these design objectives. Freeboard requirements and leak prevention requirements are also the same as for concrete structures. Recommendations for ports, piping and valves are also the same.

Cathodic protection from corrosion is required in accordance with standard NACE RPO196-96.