Province of Ontario
Ministry of Agriculture and Food

DRAFT PROTOCOLS
for Construction and Siting
November 29, 2002

Table of Contents

NSTS-01 ENGINEERING AND INSPECTION

SECTION 1 - PURPOSE AND SCOPE

1.1 This document outlines the role and responsibilities of the Engineer for the design, inspection, and general review of construction for a permanent nutrient storage facility.

1.2 In this document, “engineer” means a person who hold holds a licence or a temporary licence under the *Professional Engineers Act* but does not include a person who holds a limited licence under that Act.

“permanent nutrient storage facility” includes a structure that is intended to hold liquid or solid nutrients but does not include a temporary in-field nutrient storage facility.

SECTION 2 – GENERAL REQUIREMENTS

2.1 No person shall commence a new livestock operation or expand an existing livestock operation that generates **liquid** manure that does not include as part of the farm unit a permanent nutrient storage facility or facilities that is or are capable of containing at least all of the nutrient produced on or received at the operation for a period of 240 days with the following exceptions:

(a) a farmer who sends some of the nutrient generated on the farmer’s agricultural operation to a broker and that broker require an aggregate storage capacity of 240 days between the farmer and the broker; or

(b) where the period of use of a permanent livestock confinement area is less than 240 days the storage capacity of the permanent nutrient storage facility associated with the area must be adequate for the period of confinement.

2.2 No person shall commence a new livestock operation or expand an existing livestock operation that generates **solid** manure that does not include as part of the farm unit a permanent nutrient storage facility or facilities that is or are capable of containing at least all of the nutrient produced on or received at the operation for a period of 240 days with the following exceptions:

(a) a farmer who sends some of the nutrient generated on the farmer’s agricultural operation to a broker and that broker require an aggregate storage capacity of 240 days between the farmer and the broker; or

(b) the farmer’s nutrient management strategy provides for the disposal of the nutrient generated for the agricultural operation by means that eliminate the need for 240 days of nutrient storage on the operation; or

(c) where the period of use of a permanent livestock confinement area is less than 240 days the storage capacity of the permanent nutrient storage facility associated with the area must be adequate for the period of confinement;

2.3 Except as noted in subsection 2.4, the design and construction of a new permanent nutrient storage facility or an expansion, or alteration of an existing permanent nutrient storage facility or part thereof shall be carried out by or under the supervision of an Engineer.

2.4 The design and construction of a permanent solid nutrient storage facility having a floor area of 600 m^2 or less with nutrient supporting retaining walls not exceeding 1200 mm in height above the floor may be carried out by a person who is not an engineer.

2.5 In Ontario, an engineer who designs a permanent nutrient storage facility must adhere to all applicable Regulations and Nutrient Storage Technical Standards (MSTS) Protocols under the *Nutrient Management Act*, *2002*, the Ontario Building Code (OBC), the National Farm Building Code of Canada (NFBC) and all other applicable standards.

SECTION 3 – INFORMATION REQUIREMENTS

3.1. Submission Requirements– In conjunction with each design, the engineer shall submit the following information to the appropriate regulatory agency for each project that involves the construction of a new permanent nutrient storage facility or the enlargement, or alteration of an existing facility:

a. A site plan showing the location of the proposed new permanent nutrient storage facility or the existing permanent nutrient storage facility and the proposed addition or alteration thereto and spatial separation distances as outlined in NSTS-02;
b. A geotechnical investigation report showing relevant sub-surface information pertaining to the site characterization as outlined in NSTS-03, where applicable;
c. Detailed construction drawings for steel or concrete permanent nutrient storage facilities in accordance with NSTS-04 , where applicable;
d. Detailed construction drawings for earthen permanent nutrient storage in accordance with NSTS-06, where applicable;
e. Detailed construction drawings for synthetic or clay liners in accordance with NSTS-07, where applicable;
f. Details for seepage monitoring and leak detection in accordance with NSTS-09, where applicable; and
g. Detailed construction drawings of all transfer systems for liquid nutrients in accordance with NSTS-10, where applicable.

3.2 Design Provisions - The design of a permanent nutrient storage facility prepared by an Engineer shall contain:

a. The projected nutrient produced and received, as determined by NMAN/MSTOR software, taking into account the projected total amount of nutrient to be produced, precipitation over the storage period, accumulation of solids, other materials to be stored (such as wash water) and a freeboard allowance;
b. Provisions for loading the facility, agitating the contents, and emptying the facility, where applicable;
c. A recommendation for regular inspection and maintenance, where applicable;
d. Details for the ventilation system for elimination of corrosive gases, where applicable;
e. Details for safety fences or guards in accordance with NFBC Section 4.1.1.4. where applicable; and
f. Signage that clearly describes the risk of manure gas in accordance with NFBC Section 4.2.4.1.

SECTION 4 - QUALITY ASSURANCE

4.1. General Review – A person who intends to construct or have constructed a permanent nutrient storage facility that is required to be designed by an engineer shall ensure that an engineer is retained to undertake the general review of construction in accordance with the performance standards (see notes in Form B of this protocol) of the Professional Engineers Ontario (PEO).

4.2 A person who constructs or has constructed a permanent nutrient storage facility that is required to be designed by an engineer shall complete the Engineer's General Review / Commitment Certificate (Form A) and General Review (Form B) and submit them to the appropriate regulatory authority.

4.3. Inspection and Testing - During construction, the Engineer may request inspection and testing be performed by an independent agency or professional engineer. All inspection and testing shall conform to applicable codes and standards.

4.4. Written Reports - where applicable, the Engineer shall provide the appropriate regulatory agency with copies of written reports arising out of the general review. Where required, a final letter confirming that the proposed structure has been constructed in general conformity with the approved drawings, specifications, and other documents shall be forwarded to the regulatory agency and provided to the client.

Nutrient Storage Technical Standard – 01
Form A

ENGINEER'S COMMITMENT CERTIFICATE

Project: ____

____

Name / Location

This is to Certify that: _____________________ _____________________ ____________________

Engineer

Signature Date

has been retained to undertake the overall coordination of design for the permanent nutrient storage facility in accordance with NSTS-01 (Engineering and Inspection).

_____________________ _____________________ ____________________

Owner

Signature Date

Components of the design shall be performed by the Engineer or allocated to other engineering disciplines according to the following checklist:

Submission Requirements - (To the Regulatory Agency where applicable)	NSTS – Standard	Design Required
Site Plan – Location of manure storage structure relevant to spatial separations.	NSTS-02	
Geotechnical Investigation - Sub-surface information relevant to site characterization	NSTS-03	
Liquid Storage Structures - Drawings and details for liquid storage construction.	NSTS-04	
Solid Storage Structures – Drawings and details for solid storage construction.	NSTS-05	
Earthen Storage Structures - Drawings and details for earthen storage construction	NSTS-06	
Synthetic or Natural Liner - Drawings and details for liner construction.	NSTS-07	
Monitoring System – Details for seepage and monitoring and leak detection.	NSTS-09	
Transfer Systems – Drawings and details for transfer systems construction.	NSTS-10	

In accordance with NSTS-01 Section 4.3, the design of a permanent nutrient storage facility prepared by an Engineer shall contain:

a. The anticipated nutrient produced and received, as determined by NMAN/MSTOR software, taking into account the total projected amount of nutrient to be produced, precipitation over the storage period, accumulation of solids and other materials to be stored (such as wash water), and a freeboard allowance;

b. Provisions for loading the facility, agitating the contents and emptying the facility;
c. A recommendation for regular inspection and maintenance, where applicable;
d. Details for the ventilation system for elimination of corrosive gases, if applicable.
e. Details for safety fences or guards in accordance with NFBC Section 4.1.1.4. where applicable; and
f. Signage that clearly describes the risk of manure gas in accordance with NFBC Section 4.2.4.1.

Nutrient Storage Technical Standard – 01
Form B

GENERAL REVIEW / COMMITMENT CERTIFICATE

Project: ____
____

Name / Location

This is to Certify that: ____ ______
____________ ___________________

Engineer
Signature Date

has been retained to undertake the general review of the construction of the permanent nutrient storage structure in accordance with the NSTS-01 (Engineering and Inspection) and Section 78, Regulation 941, RRO 1990, as amended, and the Professional Engineers Act.

____
_______________________________ ____________________

Owner
Signature Date

Components of the review shall be performed by the Engineer or allocated to other engineering disciplines according to the following table:

Function	Engineer / Address	Name / Signature
Site Plan		
Geotechnical*		
Storage Structure		
Monitoring System		
Transfer Systems		

* Member of the Association of Geoscientists of Ontario

The Professional Engineers Act

The following are prescribed as performance standards with respect to the general review of the construction, enlargement or alteration of a building by a professional engineer as provided for in the building code made under the Building Code Act:

1. The professional engineer, with respect to the matters that are governed by the building code, shall,

i) Make periodic visits to the site to determine whether the work is in general conformity with the plans and specifications;

ii) Record deficiencies found during site visits and provide the client, the contractor and the owner with written reports of the deficiencies and the actions that must be taken to rectify the deficiencies. Review the reports of independent inspection and testing companies called for in the plans and specifications and which pertain directly to the work being reviewed;

iv) Interpret plans and specifications when requested to do so by their client, contractor or owner; and

v) Review shop drawings and samples submitted by the contractor for consistency with the intent of the plans and specifications.

2. The professional engineer shall not review work in disciplines in which the professional engineer is not qualified.

3. The professional engineer may delegate one or more of the functions described in paragraph 1 to another person where it is consistent with prudent engineering practice to do so and the functions are performed under the supervision of the professional engineer.

NSTS-02 SPATIAL SEPARATION

Siting:

1. No person shall construct a permanent nutrient storage facility or expand an existing permanent nutrient storage facility except in accordance with the requirements of the Minimum Distance Separation II document and any associated amendments or clarifications published by the Ministry of Agriculture and Food and any set back distances established by the Nutrient Management Act regulations, unless the municipality or the Director approves a variance from the requirements of MDS II or the Director approves a variance from the requirements of the regulations to mitigate an effect on the natural environment resulting from such construction.

Separation distance between groundwater sources and agricultural structures capable of generating, storing and handling potential groundwater contaminates:

2. No person shall establish or construct a permanent nutrient storage facility or expand an existing permanent nutrient storage facility:

(a) within 15 metres of a well that has a continuous steel casing that extends at least 6 metres below the surface of the ground;
(b) within 100 metres of a well that supplies water to a municipal water system; or
(c) within 30 metres of any other well.

3. Subject to section 6, no person shall construct a permanent nutrient storage facility or expand an existing permanent nutrient storage facility without:

a) locating all field drainage tiles or piped municipal drains within 15 metres of the perimeter of the facility;

b) removing all drainage tile within the 15 metre zone around the facility in accordance with the OMAF publication entitled “Nutrient Storage Facilities and Tile Drainage Systems”; and

c) redirecting the flow of the field drainage system or piped municipal drain away from the facility.

d) receiving approval for any modification affecting a municipal drain under the *Drainage Act*.

4. No person shall construct a permanent nutrient storage facility or expand an existing permanent nutrient storage facility that does not have a flow path that is at least 50 metres long to the top of the bank of the

nearest surface water unless the surface water is an artificial facility intended to collect, re-circulate or otherwise manage contaminated runoff from the facility.

5. No person shall construct a permanent nutrient storage facility or expand an existing permanent nutrient storage facility within the regional or 1 in 100 year flood lines established by the municipality or by the local Conservation Authority unless,

(a) the Director is satisfied that the location of the facility does not affect the control of flooding or pollution or the conservation of the land; or

(b) a permit for the facility is issued under section 28 of the *Conservation Authorities Act*.

6. (1) A person who constructs a drainage system, within 15 metres of a permanent nutrient storage facility, that is intended to collect or divert water away from the facility shall ensure that the system is constructed with non-perforated pipe and that all subsurface joints in the piping are properly sealed unless,

(a) water collected by the drainage system discharges into an approved treatment system; or

(b) the foundation drains of the permanent nutrient storage facility are equipped with an observation and shut-off station that has been installed in accordance with the OMAF publication entitled “Nutrient Storage Facilities and Tile Drainage Systems”.

- (2) No person shall permit liquid nutrients to enter a tile drainage system unless the system is equipped with a treatment system approved by the Director and designed to treat effluent containing such nutrients.

NSTS-03 SITE CHARACTERIZATION AND ASSESSMENT

PURPOSE AND SCOPE - All permanent nutrient storage facilities must meet the standards set in this protocol with the exception of: Solid Nutrient Storage Facilities as outlined in NSTS – 05, for Category 1 through 3 operations.

1.0 DEFINITIONS

1.1 In this document,

"*Professional geoscientist*" means a member of the Association of Geoscientists of Ontario.

"*Hydraulically Secure Soil*" means natural material such as soil below a nutrient storage structure that is consistent in nature and able to meet a specified maximum hydraulic conductivity of 1×10^{-8} metres per second. The criterion of homogeneity is established from the soil boring logs and sample analysis data from the site investigation. The criterion of hydraulic conductivity of the material may be established using either one of the following tests:

a) Standard in-situ or laboratory testing procedures according to American Society for Testing and Materials (ASTM) or Canadian Standards Association (CSA) standards; or
b) Particle size analysis and Atterberg test data. The materials shall meet the following minimum criteria:

Particle Size Analysis
- Percent Fines: = 50%
- Clay Content: = 20%
- Sand Content: $\leq$ 45%
- Gravel Content $\leq$ 50%

Atterberg Limits
- Plasticity Index (PI): $20\% \leq PI \leq 30\%$
- Liquid Limit (LL): $30\% \leq LL \leq 60\%$

Where the soil below a structure does not meet the maximum hydraulic conductivity criteria of 1×10^{-8} m/sec., the proponent is required to meet the equivalent standard either through engineering design or by the use of an accepted alternative technology, approved by the Director. For example, if the hydraulic conductivity of the material below the site were greater than the specified minimum, the presence of an additional depth of more permeable material could be shown to create an equivalent level of protection. Alternatively, if the natural site characteristics cannot meet the criteria set out in the protocol, an engineered liner system can be employed to create the equivalent level of protection. The Engineer must verify the hydraulic equivalency of the site characteristics or the engineered design through appropriate calculations or groundwater modeling exercises.

2.0 REQUIRED SUBSURFACE ASSESSMENTS

2.1 Where available, the professional engineer or professional geoscientist, shall obtain for the purpose of site characterization and assessment, the following information:

a) Topographic maps;
b) Quaternary geology maps;
c) Hydrogeological or septic suitability reports;
d) Provincial soils maps;
e) MOE Well Construction records;
f) MOE Hydrogeological files and/or maps;
g) Well water quality data

Data obtained from these sources will assist the professional engineer or professional geoscientist in identifying characteristics of the site requiring special consideration.

2.2 No person shall construct or expand a permanent liquid nutrient storage facility for agricultural source material unless the person retains the services of a professional engineer or professional geoscientist to carry out a stage one hydrogeologic or geotechnical investigation of the proposed site that,

(a) identifies the soil type or types to a depth of at least,
   (i) 1.5 metres below the lowest elevation of the excavation required for a structure made of concrete or steel; or
   (ii) 2.5 metres below the lowest elevation of the excavation required for an earthen structure; and
(b) establishes the depth of the aquifer and bedrock in relation to the lowest elevation of the excavation required for the facility.

2.3 Subject to section 2.12, no person shall construct or expand a permanent liquid nutrient storage facility for agricultural source material on a site that does not meet or exceed the following requirements:

a) unlined concrete or steel storage facilities, with reinforced concrete floors (Figure 1) require a minimum of 0.5 metre of hydraulically secure soil between the bottom of the storage facility and the upper most identified bedrock layer or aquifer;
b) lined concrete or steel storage facilities with reinforced concrete floors (Figure 2) require a minimum of 0.5 metre of native undisturbed material or compacted granular material between the bottom of the storage facility and uppermost identified bedrock layer or aquifer;
c) unlined concrete or steel storage facilities with unreinforced concrete floors (Figure 3) require a minimum of 1.0 metre of hydraulically secure soil between the bottom and sides of the storage facility and the upper most identified bedrock layer or aquifer;
d) lined concrete or steel storage facilities with unreinforced concrete floors (Figure 4) require a minimum of 1.0 metre of native undisturbed material or compacted granular material between the bottom of the storage facility and the uppermost identified bedrock layer or aquifer;
e) lined earthen nutrient storage facilities (Figure 6) require a minimum of 2.0 metres of hydraulically secure soil between the bottom and sides of the lined storage facility and the upper most identified bedrock layer or aquifer; and

f) nutrient storage facilities that are designed to incorporate a combined system such as a facility that has earthen walls and a concrete floor shall satisfy the most restrictive criteria for the types of material used in the construction of the facility.

2.4 Subject to section 2.12, no person shall construct a permanent solid nutrient storage facility or expand such a facility on a category 4 agricultural operation that does not contain a concrete floor unless, the person retains the services of a professional engineer or professional geoscientist to complete a stage one hydrogeologic or geotechnical investigation of the proposed site that establishes,

(a) the soil type or types to a depth of 1.5 m below the lowest elevation of the excavation required for the facility; and
(b) that there is at least 0.5 metre of hydraulically secure soil between the bottom of the facility and the uppermost identified bedrock or aquifer.

2.5 An unlined permanent earthen nutrient storage facility (Figure 5), with a maximum storage depth of 3.0 metres and a maximum storage volume of 2500 m^3, can be used to store liquid agricultural source materials listed in paragraphs 2 through 6 of section 1.6 (1) of the Nutrient Management Act regulations if;

a) the facility has at least 2.0 metres of hydraulically secure material between the bottom and sides of the facility and the upper most identified bedrock layer or unconfined aquifer;
b) the soil materials that form the interior surface of the proposed facility are disked to a depth of at least 150 millimetres and compacted with an approved compaction device as specified in NSTS – 07b; and
c) any soil anomalies that are discovered during construction, such as course material lenses, large rocks or soil fractures shall be excavated and filled with hydraulically secure soil to a depth of one metre;
d) topsoil shall be stripped to the subsoil layer from the area where any berm is to be constructed and stockpiled for use in the outside slopes of the structure; and
e) any above ground berms shall be constructed of a material that is suitable for compaction to meet a maximum saturated hydraulic conductivity of 1×10^{-9} metres per second and be compacted to at least 95% modified Proctor according to accepted engineering test criteria (according to ASTM D0698)

2.6 The professional engineer or professional geoscientist responsible for the investigation referred to in sections 2.2 and 2.4 shall analyze the data collected for the site characterization study to determine the suitability of the proposed site for a permanent liquid manure storage facility or a permanent solid manure storage facility with an earthen floor located on a category 4 agricultural operation.

2.7 If the results of the stage one hydrogeologic or geotechnical investigation confirm that appropriate site conditions, as listed in sections 2.3 through 2.5 exist beneath and adjacent to the proposed site then the proponent may proceed with construction of the facility. Section 2.13 provides additional requirements for the site investigation.

2.8 If the results of the stage one hydrogeologic or geotechnical investigation do not confirm the suitability of the proposed site for the construction and operation of a permanent liquid manure storage facility the owner of the proposed facility may,

(a) look for another site;
(b) construct a facility that is suitable for the site in accordance with sections 2.3 through 2.5; or

(c) carry out a stage two investigation of the proposed site in accordance with the applicable Ministry protocol.

2.9 If the results of the stage two hydrogeologic or geotechnical investigation confirm that appropriate site conditions as listed in sections 2.3 through 2.5 exist beneath and adjacent to the proposed site then the owner may proceed with construction or the nutrient storage facility. Section 2.13 provides additional requirements for the site investigation.

2.10 If the results of the stage two hydrogeologic or geotechnical investigation fail to confirm that the proposed site is a suitable location for the proposed facility the owner may,

a) look for another site;
b) construct a facility that is suitable for the site in accordance with sections 2.3 through 2.5; or
c) conduct a stage-three investigation of the proposed site.

2.11 If the proponent elects to conduct a stage-three hydrogeologic or geotechnical investigation of the proposed site the terms of reference for the stage three investigation shall be developed by the ~~proponent's~~ professional engineer or professional geoscientist to determine what measures could be used to provide adequate protection for the ground water and approved by the Director.

2.12 If the results of the stage three hydrogeologic or geotechnical investigation fails to confirm that the proposed site is a suitable location for the proposed facility the owner may,

a) look for another site;
b) construct a facility that is suitable for the site in accordance with sections 2.3 through 2.5; or
c) have a qualified professional develop an appropriate design, specific to the site, which will provide a level of protection for the groundwater which is the equivalent of the structures listed in sections 2.3 through 2.5.

2.13 Stage one of the hydrogeologic or geotechnical investigation shall have a minimum of one borehole per 1000 m^2 of facility's ground floor area. Stage two of the hydrogeologic or geotechnical investigation shall have a minimum if one borehole per 500 m^2 of the proposed facility's footprint area. Boreholes must be sealed according to the methodologies described in the OMAF, Agriculture and Agri-Food Canada, Best Management Practices; *Water Wells* publication when they are abandoned after use.

References:

ASTM D0698 *Standard Test Method for Laboratory Compaction Characteristics of Soil using Standard Effort*

OMAF, Agriculture and Agri-Food Canada, Best Management Practices; *Water Wells*, ISBN 0-7778-6149-6

Nutrient Storage Types:

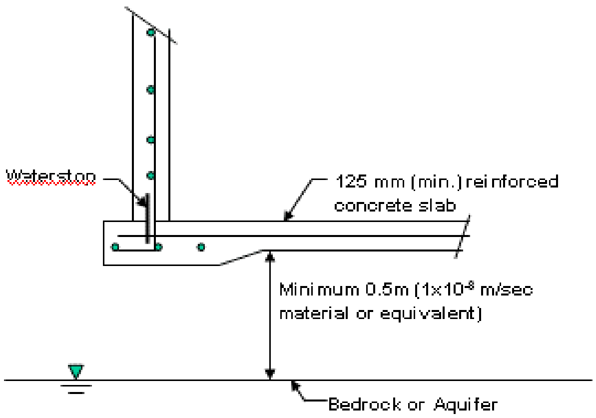

Figure 1 - Unlined, Reinforced Floor

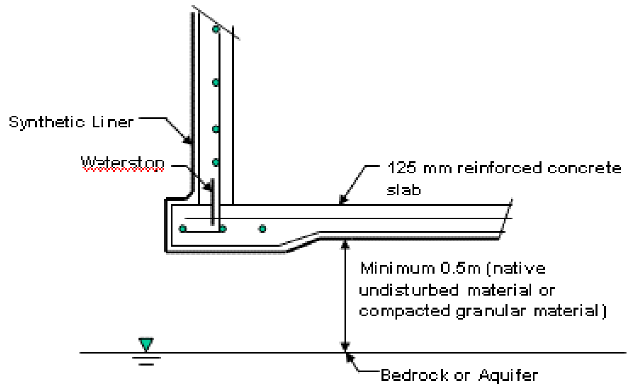

Figure 2 - Lined, Reinforced Floor

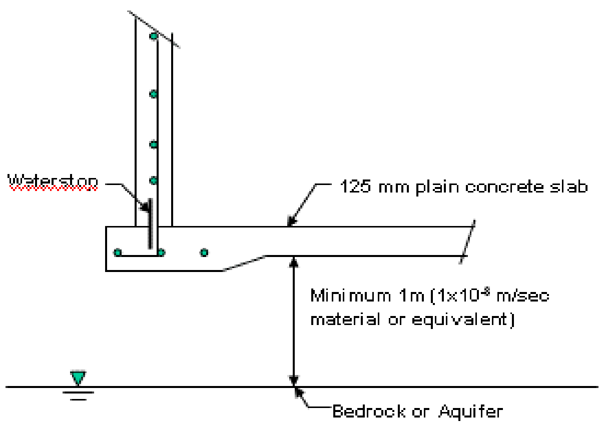

Figure 3 - Unlined, Unreinforced Floor

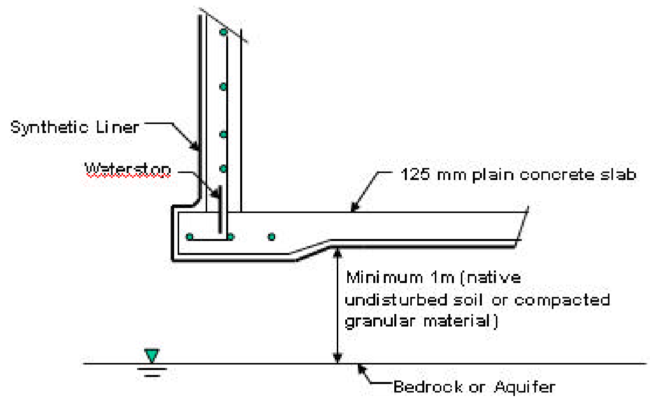

Figure 4 - Lined, Unreinforced Floor

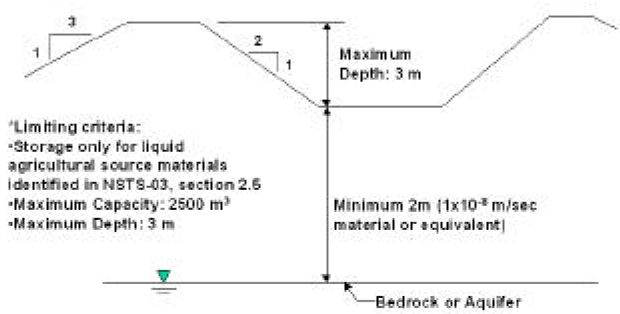

Figure 5 - Earthen Runoff Storage

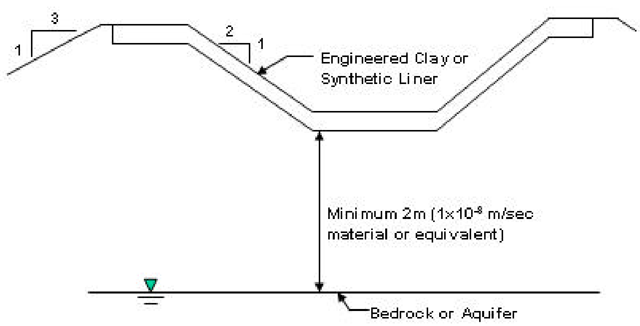

Figure 6 - Lined, Earthen Nutrient Storage Structure

NSTS-04 CONCRETE AND STEEL (OR EQUIVALENT) STORAGE STRUCTURES

SECTION 1 - PURPOSE AND SCOPE

1.1. Purpose of the Protocol – This protocol defines the engineering requirements for the design of steel and concrete structures (or equivalent - see section 2, EQUIVALENTS) used for the storage of liquid nutrient in agricultural applications. The information that is required for the structural analysis and approval of a liquid nutrient storage structure is specified or referenced herein. For earthen nutrient storage structures, refer to NSTS-06.

1.2. Objective of the Design –The primary objective for the design of a liquid nutrient storage structure is the economical construction of a watertight structure that is designed to provide public and environmental protection. A professional engineer in accordance with NSTS-01 shall design the structure to be watertight, corrosion resistant and structurally safe and sound.

1.3. Watertight Design – The ability of the structure to be watertight and minimize leakage will be reasonably assured if:

a. Adequate structural resistance is provided for the intended design loads and serviceability;
b. Joints are properly spaced, sized, and constructed for the application;
c. Joints and penetrations are made watertight with the appropriate use of water-stops, caulking, gaskets, or sealants;
d. Exposure conditions are clearly identified;
e. Crack widths in concrete are minimized as described in section 6.2 of this protocol; and
f. Impervious protective coatings or barriers are used where required;

1.4. Leakage – New, properly engineered structures may contain small cracks that will allow minimal quantities of leakage to occur. It is anticipated that these cracks will seal after a relatively short period of exposure to manure and other nutrients. The engineer shall provide an estimate of the expected leakage rate. If leakage is found to be occurring at a rate higher than outlined by the engineer, the local district office of the Ministry of the Environment shall be notified. At no time shall leakage from a nutrient storage facility cause adverse effect under the Environmental Protection Act, Section 14.

1.5. Durability – The materials used in the construction of a liquid nutrient storage structure shall be resistant to the effects of its environment. In particular,

a. Cathodic protection in combination with coatings or liners shall be used to protect the steel tanks from the corrosive action of liquid manure and manure gases, or other corrosive actions that may occur as a result of other nutrients stored at the facility;
b. Concrete should be resistant to the action of liquid manure, alternate wetting and drying, freezing and thawing cycles, exposure to the elements, and exposure to manure gases where appropriate. The durability requirements of concrete shall conform to CSA A23.1 Section 15.

SECTION 2 - EQUIVALENTS

2.1. General - The provisions in this protocol are not intended to limit the appropriate use of materials, systems, equipment, and procedures not specifically described herein.

2.2. Alternatives – Alternatives not specifically described herein, or which may vary from specific requirements of this Protocol, or for which no specified test procedure has been established, are permitted to be used:

a. If it can be shown that these alternatives are based on sound engineering principles and are equivalent on the basis of tests, evaluation or past performance; and
b. If the Director is satisfied that these alternatives provide a level of public and environmental protection that is equivalent to the performance required by this protocol.

SECTION 3 – SECONDARY CONTAINMENT

3.1. General – Except as provided in NSTS-03, section 2.5, all liquid nutrient storage structures shall have provision for two levels of containment to control leakage.

3.2. Below Ground Tanks – The soil conditions described in NSTS-03 (site characterization) for nutrient storage structures is intended to provide the second level of containment for the floor and below ground portion of the walls.

3.2.1. In some soil types and situations, as defined in NSTS-03, an engineered synthetic or natural liner, constructed in accordance with NSTS-07a and NSTS-07b could be required.

3.2.2. Membranes, where required, shall be continuous under the floor and footings and shall extend up the wall to a level equal with the top of the ground surface or as specified by the project engineer.

3.3. Above Ground Tanks – Except as permitted in Section 3.4, the above grade portion of a liquid nutrient storage structure shall have a secondary containment system with a capacity equivalent to 110% of the above ground portion of the storage tank.

3.4. Exclusion – An engineer may specify that a secondary containment system is not required for above ground tanks where:

a. The load factor a_L defined in the Ontario Building Code, Section 4.1.3.2. (4) for liquid loads provided in Clause 4.4 (a) is increased to 1.5; and
b. Cracks in concrete are required to be filled with appropriate construction material that prevents leakage of stored nutrient from the storage facility.; and
c. The engineer specifies that the storage and landscape features around the storage facility are adequate to ensure that a secondary containment system is not required.

3.5. Containment Berms – The secondary containment system shall consist of a bermed area with a low permeability barrier that conforms to the following performance specifications:

a. Concrete barriers shall:
   i. be designed and installed according to engineering standards;
   ii. be a minimum of 100 mm thick;
   iii. be constructed on native undisturbed soil or compacted granular material; and
   iv. have expansion joints located at least every 6 m sealed with a sealant that is compatible with the product being stored.
b. Clay barriers shall:

i. be designed and installed according to engineering standards;
ii. be a minimum of 300 mm thick;
iii. be chemically compatible with the native soil and cover material; and
iv. be covered with a minimum of 300 mm of material to prevent drying of the clay barrier.

3.6. Surface Water – Surface water, including rainwater, shall not be permitted to accumulate around the tank or in the containment area. The grade around tanks and within berms shall have a positive slope away from the tank toward a sump where liquids and surface water can be collected and removed.

3.7. Ground Level – The ground level shall be defined as the lowest surface grade within a 2 m perimeter of the tank. The slope of the grade away from the structure, beyond the 2 m perimeter shall not exceed a 3:1 horizontal to vertical ratio.

SECTION 4 - DESIGN CRITERIA

4.1. General – Liquid nutrient storage structures shall be designed to withstand all loads and load combinations reasonably anticipated during construction and operation in accordance with the most recent version of the Ontario Building Code (OBC), the National Farm Building Code of Canada (NFBC), and applicable CSA Standards.

4.2. Limit States Design – The structural design of liquid nutrient storage structures shall comply with all CSA Limit States Design Standards, which require that the specified strength of all components shall equal or exceed all factored loads.

4.3. Importance Factor – The NFBC allows the use of an importance factor of 0.8 for farm structures with low human occupancy. However, an importance factor of 1.0 shall be used for the design of liquid nutrient storage structures.

4.4. Liquid Loads –The walls and floor of a liquid nutrient storage structure shall be designed for liquid loads with:

a. Except as noted in section 3.4, the load factor a_L as defined in the Ontario Building Code, Section 4.1.3.2. (4) of 1.25, similar to dead loads, since the liquid load can be accurately calculated;
b. An equivalent fluid density of 10 kN/m^3;
c. A liquid head equal to the maximum height of liquid that the structure can contain; and
d. An allowance for unequal liquid levels on each side of an interior partition. A minimum pressure differential of 0.5 kPa is recommended for all walls even if equal liquid levels can be maintained on each side of the wall.

4.5. Ice Loads – Walls and other structural components shall be designed for ice loads in accordance with the NFBC. Based on testing, horizontal ice pressures of 50 kPa acting over a height of 0.5 m at the surface level of the liquid are recommended. The thickness of ice can be reduced proportionally to the number of degree days below 18 C as listed in OBC, Table 2.5.1.1., Column 6.

4.6. Soil and Backfill Loads – Recommended design values for earth loads on underground structures are provided in NFBC Section 2.2.1.13.

4.6.1. Where backfill in excess of 1.5 m is to be part of the design, investigative soil testing is required.

4.6.2. Where horizontal soil pressures are used to offset the pressure exerted by the nutrient storage contents, the engineer shall specify the backfill material and the required compaction.

4.6.3. The backfill shall be placed evenly around the nutrient storage structure. The surface of the backfill shall be sloped to ensure positive drainage away from the walls before and after settlement.

4.6.4. The design shall allow for increased loads due to uneven grades or ramps where required.
.
4.6.5. Exterior walls below grade shall be designed for surcharge loading from anticipated wheel traffic such as manure tankers and tractors. Design values for vehicle traffic are provided in the NFBC and OBC.

4.6.6. Backfill shall be installed around the foundation of a nutrient storage structure to provide adequate soil cover for frost protection unless the engineer uses an alternate design method.

4.7. Frost Loads – Adequate protection from frost action shall be provided to footings, floors, and walls. Under normal operation, damage to internal components such as floors from frost action is not a concern because the storage contains unfrozen nutrient of sufficient depth to prevent freezing. However, if the storage is left unused over the winter, special precautions to prevent frost heaving and damage (such as covering the floor with straw or liquids) are required.

4.8. Temperature Stress – The design of a concrete nutrient storage structure shall account for temperature-induced stresses, during both summer and winter seasons, resulting from:

a. Temperature variations between the above and below ground portions of the wall; and
b. Temperature differences between the inside and outside faces of the wall.

4.9. Wind Loads - The specified external pressure or suction due to wind on part or all of a surface of a wall shall be calculated according to Part 4 of the OBC.

4.10. Other Loads - When applicable, other loads such as dead loads, creep and shrinkage of the concrete or steel, floor loads, machinery loads, and snow loads shall be considered in the design of structural components.

SECTION 5 - FOUNDATIONS AND FLOORS

5.1. Soil Bearing Capacity and Uniformity of Base – The engineer shall ensure that the allowable bearing capacity and uniformity of base materials is appropriate for the foundation loads and method of construction.

5.2. Sub-Grade Preparation – The existing sub grade shall be cleared of all stones, topsoil, wood, mud and other deleterious material. Soft areas shall be over-excavated and replaced with engineer approved fill placed in 150 mm lifts and compacted to 98% Standard Proctor Density. The sub-grade shall be free of frost before concrete placement begins.

5.3. Ground Water – When designing concrete floors for liquid nutrient storage structures, high water table conditions shall be avoided or prevented. This shall be predetermined in a study of the site characterization as per NSTS-03.

5.3.1. A concrete nutrient storage structure shall not be built in such a manner or location that the water table may rise above the floor unless a properly designed drainage system is installed.

5.3.2. Drain tiles shall be installed at the discretion of the engineer around the perimeter of nutrient storage structures below the level of the floor. The drain tiles shall be connected to a controlled outlet or sump. Sump pumps shall be adequately sized for each installation, taking into account the permeability of the local soils and size of collection area. For additional information, see OMAF publication, "Nutrient Storage Facilities and Tile Drainage Systems"

5.4. Structural Design – The design of concrete footings and floor slabs on grade in liquid nutrient storage structures shall conform to the requirements of CSA A23.3 "Design of Concrete Structures for Building".

5.4.1. The minimum thickness of all slabs on grade in liquid nutrient storage structures shall be 125 mm or as required to satisfy concrete cover requirements.

5.4.2. Except as noted in Sentence 5.4.3., floor slabs on grade shall be designed as reinforced concrete slabs and shall support the intended loads and meet serviceability requirements where:

a. Reinforcement is provided in both directions and spaced no further apart than 5 times the slab thickness nor 500 mm; and
b. The minimum ratio of reinforcement steel area to gross concrete area is 0.0002.

5.4.3. Plain concrete footings or slabs on grade are permitted where:

a. There is a minimum of 1.0 m of natural, uniform material with a hydraulic conductivity of no more than 1×10^{-8} m/s directly below the slab as permitted in NSTS-03; and
b. The strength of plain concrete can resist the design loads applied in accordance with CSA A23.3 Section 22.

5.4.4. The design method shall provide for adequate structural strength and serviceability.

5.4.4.1. Cracking shall be controlled by the proper use and construction of control joints, expansion joints, and isolation joints as specified by the engineer.

5.4.4.2. Alternatively, an acceptable method of construction is an appropriately designed, joint-free floor slab with enough reinforcing to limit shrinkage or stress cracks. Such a design, however, may be limited by the floor area and loading criteria.

5.4.4.3. Effective vibratory equipment during concrete placement shall be used to achieve the concrete density and uniformity necessary for impermeability.

SECTION 6 – CONCRETE WALLS

6.1. General – The design of concrete walls in liquid nutrient storage structures shall conform to the requirements of CSA A23.3 "Design of Concrete Structures for Building".

6.2. Reinforced Concrete – Walls designed to prevent the leakage of the contents shall be reinforced to support the intended loads with:

a. A minimum ratio of vertical reinforcement area to gross concrete area of 0.0015;

b. A minimum ratio of horizontal reinforcement area to gross concrete of 0.0002;
c. Vertical and horizontal reinforcement spaced no further apart than 500 mm or 3 times the wall thickness.

6.2. Crack Widths – Except as noted in section 3.4.(b), the steel reinforcing in walls subjected to bending or direct tension shall be so proportioned to limit crack width of 0.33 mm as required for an exterior exposure.

6.3. Unreinforced concrete walls are permitted only where the wall is non-structural and not intended to prevent the leakage of the contents and shall be constructed in accordance with CSA A23.3 Section 22.

6.4. Joints in Walls – Leakage through tank walls occur mostly at joints, so these require special attention. Horizontal joints in walls should be avoided. PVC or other reliable waterstops are required along the joint between the wall and the concrete base and other locations as specified by the engineer.

SECTION 7 – STEEL WALLS

7.1. General – The most common type of steel nutrient storage tank is a pre-engineered, bolted assembly that is made from corrosion resistant glass fused to steel panels. Other non-typical tanks include plastic lined steel tanks.

7.2. Structural Design – Liquid nutrient storage structures made of structural steel shall conform to CSA S16.1, "Limit States Design of Steel Structures". Other design criteria for steel structures can be taken from the AISC "Specification for Structural Steel Buildings" and AWWA Standard D103.

7.3. Steel Grades – Seven acceptable grades of structural steel are covered in CSA A16.1 and CSA G40.21.

7.4. Corrosion Protection – Steel panels shall be protected from corrosion with a permanent lining, coating, or treatment on both the inside and outside, combined with cathodic protection. The preferred lining is one that is factory installed such as glass fused to steel, however other spray on *or plastic sheet liners* may be acceptable if they are properly designed, installed and monitored for leaks. *Plastic sheet liners must be properly secured to the steel walls to prevent wind damage.*

7.5. Cathodic Protection – Cathodic protection shall be used as a backup protection system to reduce the rate of corrosion where the lining fails or becomes damaged. Cathodic protection is addressed by Underwriters Laboratories of Canada Standard CAN/ULC-S603.1-92, Standard for Galvanic Corrosion Protection Systems for Steel Underground Tanks for Flammable and Combustible Liquids, Second Edition, 1992.

7.5.1. The use of cathodic protection requires the use of a sacrificial anode consisting of a metal that has a greater need to move to it's natural state than iron, and then to tie the anode to the steel assembly with a conduit or cable.

7.5.2. Over time the capability of the anode is reduced as its size decreases. A Manufacturer's technical representative using specialized equipment should monitor the effectiveness of the anode periodically (approximately every 3 years). Anodes must be replaced when most of its material has been sacrificed and can no longer provide the required protection.

7.5.3. Although nowhere near as common as the anode system, the same protection can be provided by an impressed current from a controlled electrical source.

7.6. Wind Resistance – Thin walled steel tanks are susceptible to sidewall buckling from strong winds if they are not reinforced. One or more horizontal reinforcing rings or vertical girts are required to stiffen the sidewalls. Standards for the design of the stiffening system are contained within the AWWA tank design standards.

7.7. Joints – Joints between wall panels as well as the joint between the bottom panels and the floor shall be made watertight by properly installed caulking and/or a sealing strip containing bentonite. Bolts and nuts shall have a zinc dichromated coating with plastic encapsulated head, or equal protective coating for resistance to corrosion. For bolt specifications, refer to AWWA Standard D103.

7.8. Re-Used Tanks – Only steel tanks specifically designed for nutrient storage and certified by a registered professional engineer are acceptable. The manufacturer should be notified if the tank is to be reassembled or relocated to ensure design loads and erection procedures are consistent with the original design.

SECTION 8 – LIDS AND COVERS

8.1. General Design – Tank lids shall be designed for the loads outlined in the NFBC, OBC and all other applicable codes and standards.

8.2. Ventilation – Where a nutrient storage tank is covered with a lid or floor system that can cause manure gases to accumulate or intensify, a ventilation system shall be installed to eliminate the corrosive gases.

8.2.1. Alternatively, the entire structure shall be designed to accommodate the corrosive nature of manure gases. Where severe exposure to manure gases warrants increased protection:

- **a.** A liner or protective coating shall be used; or
- **b.** A high performance concrete with increased cover over reinforcing steel shall be used in the construction of all components exposed to the gases.

SECTION 9 – QUALITY CONCRETE

9.1. General – The quality of concrete is critical to watertight construction, durability, corrosion resistance and protection for reinforcement. The concrete specified in the design shall be appropriate for the environmental conditions encountered in the nutrient storage structure.

9.2. Concrete Materials – All concrete materials and methods of concrete production and construction shall conform to CSA A23.1. and the concrete producer shall have a valid "Certificate of Ready Mixed Concrete Production Facilities" as issued by the Ready Mixed Concrete Association of Ontario.

9.3. Strength – Concrete used for nutrient storage structures shall have a minimum 28 day compressive strength of:

a. 25 mPa (with a water/cement ratio of 0.55) for plain unreinforced concrete;
b. 30 mPa (with a water/cement ratio of 0.50) for reinforced concrete without freeze/thaw exposure;
c. 32 mPa (with a water/cement ratio of 0.45) for reinforced concrete with freeze/thaw exposure; or
d. 35 mPa (with a water/cement ratio of 0.40) for reinforced concrete exposed to severe manure gases with or without freeze/thaw exposure.

9.4. Air Entrainment – All concrete used for nutrient storage structures shall have air entrainment provided in accordance with CSA A23.1.

9.5. Admixtures – Products for concrete mix enhancement such as high-performance concrete, fly-ash and chemical admixtures may be used to improve the structural design and performance. If chemical admixtures are used they shall meet the requirements of CSA A23.1. The use of water-reducing admixtures is recommended to improve workability and the overall performance of the concrete.

9.6. Sulphate Resistant Concrete – Where concrete is exposed to soils or manure gases with high sulphate contents, Type 50 cement, supplementary cementing materials, or chemical additives suitable for this application shall be used.

9.7. Concrete Cover – Concrete cover guidelines as outlined in CSA A23.1 Table 9 for concrete exposed to earth or weather shall be used for liquid nutrient storage structures unless exposure to severe manure gases warrants an increased level of protection.

SECTION 10 – ACCESSORIES

10.1. Valves and Connections – Manure is naturally corrosive, and all pipes, valves and connections must be resistant to corrosion. Unless otherwise approved by the engineer, use PVC pipe and compatible fittings for all pipes valves and connections. Refer to NSTS-10 for additional information on the standard for transfer piping.

SECTION 11 - RESOURCE INFORMATION

Resource Information Abbreviation used Standards
CSA A23.3 *Design of Concrete Structures*
CSA A23.1 *Concrete Materials and Methods of Concrete Construction*
NBC *National Building Code of Canada* (Parts 3 & 4)
NFBC *National Farm Building Code of Canada*
Underwriters Laboratories of Canada Standard CAN/ULC-S603.1-92, Standard for Galvanic Corrosion Protection Systems for Steel Underground Tanks for Flammable and Combustible Liquids, Second Edition, 1992.
ACI 350 *Environmental Engineering Concrete Structures*
ASAE EP470 *Manure Storage Safety*
ASAE S441 *Safety Signs*
ASCE 7-95 *Minimum Design Loads for Buildings and Other Structures*
ASAE EP393.2 *Manure Storages*
Additional Sources of Information

Midwest Plan Service *TR-9: Circular Concrete Manure Tanks*
Portland Cement Association Bulletin – *Design and Control of Concrete Mixtures – Canadian edition*
Portland Cement Association Bulletin – *Circular Concrete Tanks without Prestressing*
Portland Cement Association Bulletin – *Rectangular Concrete Tanks*
Jofriet, Xhang, Johnson and Bird. 1996. Structural Design of Liquid Manure Tanks. Canadian Agricultural Engineering. Vol 38(l):45-52.
Joffriet, Green and Campbell. 1987. Design Recommendations for Reinforced Concrete Cylindrical Storage Structures for Aqueous Materials. Canadian Journal of Civil Engineering, Vol 14(4):542-549.

Organizations/Associations/Societies
CSA Canadian Standards Association
ASCE American Society of Civil Engineers
ACI American Concrete Institute
ASAE American Society of Agricultural Engineering
PCA Portland Cement Association
NACE National Association of Corrosion Engineers
AWWA American Water Works Association
AISC American Institute of Steel Construction

NSTS-05 STORAGE STRUCTURES FOR SOLID NUTRIENTS

1. PURPOSE AND SCOPE

1.1. Purpose of the Standard – This Standard defines the engineering requirements for the design of structures used for the storage of solid nutrients in agricultural applications. The information required for the structural analysis, design and approval of a solid nutrient storage structure is specified or referenced herein.

1.2. Only structural components, including any liners solid nutrient storage systems must be engineered.

2. DESIGN CRITERIA

2.1. Permanent, solid nutrient storage facilities - are those intended to contain nutrient:

a) with a moisture content of less than or equal to 82% (by volume, wet basis); or

b) meets MOE reg. 347 slump test; and

c) Must be constructed with a concrete floor (minimum thickness of 125 m); or

d) Category 3 or smaller operations, with a permanent solid nutrient storage on soil must be located on hydrological soils group C or D with a minimum thickness of 0.5 m above the aquifer or bedrock, as determined using soil maps and/or sampling and analysis techniques.

e) Category 4 operations, with a permanent solid nutrient storage on soil must be located on a minimum of 0.5 m layer of *hydraulically secure soil* as determined by a stage 1 geotechnical or hydrogeological investigation as outlined in NSTS - 03.

2.2. Temporary, in-field, solid nutrient storage shall meet the criteria as outlined in OMAF Standard - NSTS-08 *Temporary In-Field Storage*

2.3. Storage Facilities intended to contain nutrient with a moisture content between 70 - 82% by volume, wet basis shall:

a) be located a minimum of 50 m flow path from a surface water; and

b) be equipped with a roof to prevent entry of precipitation; or

c) be equipped with a runoff storage facility with the capacity to contain all runoff emanating from the storage for the full storage period (i.e., following NMAN/MSTOR criteria), or

d) be equipped with a treatment system that meets the specifications in the applicable Ministry protocol.

2.4. Storage Facilities intended to contain nutrient with a moisture content between 50 - 70% (by volume, wet basis) shall:

2.4.1. meet all of the specifications for storage structures in 2.3; or

2.4.2. be located a minimum of 150 m flow path from a surface water; and

a) have a flow path between the storage and the surface water that is not:

i) tile drained;

ii) closer than 0.9 m to bedrock;

iii) closer than 15 m to a well having a continuous well casing extending a minimum of 6 m below the ground surface;

iv) closer than 100 m from a community well or as established by a municipal wellhead protection plan;

v) closer than 30 m from all other wells, and

b) have the following storage geometry:

i) a minimum 1.22 m high containment walls on 3 sides,

ii) a floor constructed to have a neutral (<1%) slope, and

iii) a maximum footprint of the storage is 300 m^2.

2.4.3 Solid Nutrient storage facilities that meet all the criteria outlined in 2.4.2 do not require runoff storage or treatment.

2.5 Storage Facilities intended to contain nutrient with a moisture content of less than 50% by volume, wet basis:

2.5.1 meet all of the specifications for storage structures in 2.3; or

2.5.2 be located a minimum of 50 m flow path from a surface water; and

a) have a flow path between the storage and the surface water that is not:

i) tile drained;

ii) closer than 0.9 m to bedrock;

iii) closer than 15 m to a well having a continuous well casing extending a minimum of 6 m below the ground surface;

iv) closer than 100 m from a community well or as established by a municipal wellhead protection plan;

v) closer than 30 m from all other wells; and

b) have the following storage geometry:

i) shall have minimum 1.22 m high containment walls on 3 sides;

ii) floor is constructed to have a neutral slope (<1%); and

iii) maximum footprint of the storage is 300 m^2.

2.5.3 Solid Nutrient storage facilities that meet all the criteria outlined in 2.5.2 do not require runoff storage or treatment.

3. All concrete shall meet the specification in NSTS-04, Section 9 - Quality Concrete.

NSTS-06 EARTHEN NUTRIENT STORAGE FACILITIES

1. PURPOSE AND SCOPE

1.1.Purpose of the Standard - This Standard defines the engineering requirements for designing earthen nutrient storage structures and provides additional references to assist with the analysis and design.

1.2. Definition - An *earthen nutrient storage facility* is defined as a containment structure built primarily of soil. It includes a compacted soil liner, a synthetic liner or a composite liner.

1.3. Site Suitability - Earthen nutrient storage facilities may be used for the storage of liquid nutrients at sites where the geology, soil and groundwater conditions are suitable. Guidelines for site assessment and site selection can be found in OMAF Standard NSTS-03; *Site Characterization*.

1.4. Definitions –

1.4.1 Compacted clay – for the purpose of protocols NSTS – 06 and NSTS – 07 the term "compacted clay" means; a *hydraulically secure soil* that is compacted to 95% of standard Proctor at the optimum moisture content to meet a maximum saturated hydraulic conductivity of 1×10^{-9} metres per second (as per ASTM D0698).

2. INFORMATION REQUIREMENTS

2.1. Submissions - In conjunction with each design, the Engineer shall submit all information required in OMAF Standard NSTS-01; *Engineering and Inspection* to the appropriate regulatory agency for the evaluation of an application for a new, expanded or modified structure.

3. DESIGN AND CONSTRUCTION

3.1. Design and Construction Requirements - The design and construction of all earthen nutrient storage structures shall take into account the following:

3.1.1. Nutrient storage volume shall be calculated using the most current version of NMAN/MSTOR software or data contained in OMAF's Agricultural Pollution Control Manual.

3.1.2. Freeboard - The storage shall have a minimum freeboard of 0.3 metres. The freeboard is the unfilled capacity between the physical upper elevation of the storage facility (e.g., top of the berms) and its absolute maximum operating level. The level of liquid in the earthen nutrient storage may only rise above the maximum operating level in a contingency situation. The freeboard must be restored as soon as possible.

3.2. Geometric Design:

3.2.1. Inside Wall Slope -The slopes of the inside walls shall be no steeper than 1:2 (rise:run), unless otherwise specified by the engineer and shall be consistent with the requirements of the liner design and pump out equipment.

3.2.2. Exterior Wall Slope - All exterior wall slopes shall be no steeper than 1:3 (rise:run), unless otherwise specified by the engineer and shall be designed to accommodate seeding and maintenance equipment and erosion control.

3.2.3. The minimum top width of embankments shall be no less than 3 metres, unless otherwise specified by the engineer. Greater widths may be required to accommodate tractors, pumps and other equipment. The top of the berm shall be sloped away from the storage to facilitate drainage.

3.3. Earthwork Protection:

3.3.1. Leakage Protection - Installation of an anti-seepage collar shall be provided around piping and penetrations extending through and below the structure. Trenches excavated for the installation of pipes shall be backfilled with compacted soil. A leak proof bond between the fill and native material shall be provided. An anti-seepage collar shall be provided around the pipe section beneath the berm to prevent leakage along the pipe through the berm.

3.3.2. Protection of Slopes - All exterior slopes shall be covered with topsoil and seeded to grass to prevent erosion. Deep-rooted shrubs and trees shall not be permitted on or near the banks of the earthen nutrient storage.

3.3.3. Erosion Control around Inlet Pipes - Protection against scouring and erosion at discharge locations shall be provided. Erosion control pads shall consist of rip-rap on an engineered hydraulic filter, a concrete pad or another erosion control device satisfactory to the design engineer.

3.4. Pumping Access and Agitation Pads - Pads and access ramps shall be designed and constructed to ensure the protection of the floor and side slopes of the earthen nutrient storage facility from erosion, tire rutting or other damage.

3.4.1. Pumping stations shall be spaced to ensure adequate agitation and emptying of the earthen nutrient storage.

3.4.2. The location of the pumping pads shall be well marked.

4. CONSTRUCTION PROCEDURES

4.1. Topsoil Removal -Topsoil shall be stripped to the subsoil layer from the area where any berm is to be constructed and stockpiled for use in the outside slopes of the structure.

4.2. Lift Height - All fill material shall be placed and compacted in 150 mm lifts according to the procedures outlined in subsection 4.3 below.

4.3. Compaction – Soils that form a compacted clay liner must be compacted to at least 95 % of standard Proctor density (ASTM D0698) at the optimum moisture content.

4.4. Berms – All berms must be keyed into existing undisturbed natural ground and compacted to prevent seepage and to maintain satisfactory stability of the embankment.

4.5. Equipment - The compaction equipment for the construction of a compacted clay liner berm or embankment shall be the sheepsfoot roller. Other compaction equipment may be used if the lift depth is less than the depth of protruding teeth or feet.

4.6. Final Surface Treatment **–** In all cases, the interior surface of an earthen nutrient storage facility shall be disked to a minimum depth of 150 mm and compacted to at least 95 % of standard Proctor density (ASTM D0698) at the optimum moisture content.

4.7. Construction Below Freezing - Excavation and compaction shall be completed only where soil temperatures are above freezing.

5. LINER DESIGN AND CONSTRUCTION

5.1. All earthen nutrient storage facilities for the purpose of containing prescribed liquid nutrients, require the installation of a clay or synthetic liner unless they meet the criteria stated in NSTS – 03 paragraph 2.5. Details on the design and construction of compacted clay and synthetic liners are provided in OMAF Standard NSTS-09; *Synthetic and Natural Liners*.

6. RESOURCE INFORMATION

Resource Information

OMAF Standard NSTS-03 Site Characterization

OMAF Standard NSTS-01 Engineering and Inspection

OMAF Standard NSTS-07 Synthetic and Natural Liners

ASTM D698-00a *Standard Test Method for Laboratory Compaction Characteristics of Soil using Standard Effort*
ASTM - American Society for Testing and Material

NSTS-07a SYNTHETIC LINERS

1. PURPOSE AND SCOPE

1.1. Purpose of the Standard - NSTS-07a; *Synthetic Liners* Standard provides specifications and construction procedures to Engineers for the design and installation of synthetic liners.

1.2. Requirement for a Synthetic Liner – Synthetic liners may be used to line liquid nutrient storage facilities where a liner is required by NSTS-03; *Site Characterization*.

1.3. Definitions:

1.3.1. Geosynthetic clay liners (GCLs) or bentonite mats consist of high swelling, sodium bentonite between two layers of geotextile fabric.

1.3.2. Geomembranes are very low permeability, synthetic membranes used to control fluid migration in a nutrient storage structure. The geomembrane can be polyvinyl chloride (PVC), high density polyethylene (HDPE), or other materials certified as equivalent by the project engineer or the manufacturer.

2. INFORMATION REQUIREMENTS

2.1. The information required for the evaluation of an application for a new, expanded or modified nutrient storage structure is outlined in standards, *NSTS-01; Engineering and Inspection, NSTS-04; Concrete and Steel Nutrient Storage Structures, NSTS-05; Storage Structures for Solid Nutrients, and NSTS-06; Earthen Nutrient Storage Facilities.*

3. GEOSYNTHETIC CLAY LINERS:

3.1. Design Criteria:

3.1.1. Permeability - Geosynthetic clay liners used to control seepage from a nutrient storage facility shall have a final maximum saturated hydraulic conductivity of 1×10^{-9} metres/second.

3.1.2. Handling, installation, maintenance and repair must be according to the manufacturer's recommendations.

4. GEOMEMBRANE LINERS

4.1. Design Criteria - The design of the geomembrane liner shall take into account the following:

4.1.1. Liner Thickness - A minimum liner thickness of 30 Mil (non-reinforced) shall be used where subgrade can be smoothed as outlined in Section 6.

4.1.1.1. Wherever the subgrade cannot be prepared as outlined in Section 6, a liner thickness greater than 30 Mil of reinforced geomembrane or bedding material such as sand or geotextile cloth is required.

4.1.2. The manufacturer's design specifications for thermal expansion shall be followed.

4.2. Shipping, Handling and Storage - Geomembrane Liners shall be shipped, handled and stored so that damage to the liner is prevented according to the manufacturer's recommendations.

4.3. Installation Procedures - The geomembrane liner shall be installed in the nutrient storage structure according to the manufacturer's recommendations.

4.4. Field Seams and Testing

4.4.1. Factory or fabricated pipe collars shall be used to seal all pipe penetrations.

4.4.2. Seams shall be made by approved solvent welding or double heat fusion wedge welding.

4.4.3. All liner seams shall be subject to nondestructive field testing

4.4.3.1. PVC seams shall be tested using the air lance method or the air channel test where a double sedge welded seam had been used following ASTM D4437.

4.4.3.2.HDPE seams shall be tested using the vacuum test method or air channel test method following ASTM D4437.

4.4.3.3. Other liner types shall be tested following methods approved by the Director.

5. SUBGRADE PREPARATION FOR SYNTHETIC LINERS

5.1. Subgrade Preparation:

5.1.1. The subgrade surface shall be firm, unyielding and free of voids and cracks.

5.1.2. The subgrade surface shall be machine smoothed to ensure that no protrusions greater than 12 mm, ruts, abrupt , unplanned grade change or voids exist within the subgrade.

5.1.3. The slopes and base of the nutrient storage shall be compacted to at least 95 % of maximum standard proctor density (ASTM D698) at the specified moisture content.

5.1.4. The liner shall not be constructed below the seasonal high water table or saturated conditions unless the Engineer can show that the drainage or ballasting system will counteract any potential blow out or other form of deformation or deterioration of the liner or building due to hydraulic pressure.

5.1.5. OMAF Standard NSTS-03; *Siting Characteristics* establishes the minimum distance from the bottom of the nutrient storage structure to the unconfined aquifer or bedrock

5.1.6. If there is a possibility of gas formation under the liner, an appropriate venting system shall be designed and installed.

6. ANCHORING SYNTHETIC LINERS

6.1. The liner shall be anchored or bonded to the structure and/or subgrade and/or earthen berms according to good engineering practices or to the manufacturer's specification.

6.2. Where cover materials are used to anchor the synthetic liner they shall be carefully placed over the liner to prevent damage to the liner.

7. PROTECTIVE COVER FOR SYNTHETIC LINERS

7.1. Placement of the Liner Cover - The liner must be protected from environmental or mechanical damage including livestock or wildlife trampling.

7.2. On sloped sidewalls, a minimum cover of 300 mm shall be placed on all areas. In areas where traffic may occur and around pumping pads and pipe inlets, a minimum cover of 600 mm is required.

8. INSTALLATION OF OTHER STRUCTURES

8.1. Installation of accessory structures – Where accessory structures (e.g.,erosion pads, agitator pads, access ramps, concrete, riprap, or geogrid) are installed on a soil cover material over a synthetic liner they shall be installed without intrusion into the soil cover material.

8.2. Bonding to accessory structures – Where an accessory structure (e.g., erosion control pads, access ramps, agitator pads etc.) creates a discontinuity in the synthetic liner, the liner must be bonded to that structure using a method satisfactory to the manufacturer or the project engineer.

8.3. On sloped sidewalls, all concrete ramps or pads shall be designed with sufficient anchorage at the top of the berm to prevent any sliding.

9. MAINTENANCE AND REPAIR OF SYNTHETIC LINERS

9.1. Inspection prior to filling or covering – A synthetic liner must be inspected to ensure that there are no damage or perforations within the synthetic liner and any damage or perforations discovered during inspection must be repaired prior to filling of the structure or covering of the liner.

9.2. Damaged Areas - Damaged areas identified during construction or routine inspection shall be repaired according to the manufacturer's or engineer's specifications.

9.3. The project Engineer shall inspect all repairs and either approve the repairs or require additional protection such as erosion protection at inlet pipes, transfer lines, or agitator pads and protection from wheel damage.

9.4. The owner shall undertake routine observations of the liner condition. Problem areas shall be repaired as soon as possible, according to the manufacturer’s specifications.

9.5. An engineering assessment is required where the damage is such that it cannot be repaired according to the manufacturer’s specifications or where the damage is associated with a bond between the liner and an accessory structure.

10. REFERENCES

OMAF Standard NSTS-01; *Engineering and Inspection*
OMAF Standard NSTS-03; *Site Characterization*
OMAF Standard NSTS-06; *Earthen Nutrient Storage Structures*

National Farm Building Code of Canada

ASTM D698 Test Methods for Laboratory Compaction Characteristics of Soil using Standard Effort

ASTM D4437 Standard Practice for Determining the Integrity of Field Seams used in Joining Polymeric Membranes

NSTS-07b Compacted Clay Liners

SECTION 1- PURPOSE AND SCOPE

1.1. Purpose of the Standard –This protocol provides specifications and construction procedures to Engineers for the design of compacted clay liners.

1.2. Requirement for a Compacted Clay Liner - Compacted Clay Liners may be used to line liquid nutrient storage facilities where a liner is required by NSTS-03; *Site Characterization*.

1.3. Definition of a Compacted Clay Liner - A compacted clay liner is a seepage barrier constructed of a cohesive soil that is compacted to increase its dry bulk density, homogeneity, reduce porosity and decrease soil permeability. Within the earthen nutrient storage structure, the compacted clay liner is designed to impede seepage of the liquid nutrient into the subsurface below or adjacent to the structure.

1. 4 Scope of the Standard - For a compacted clay liner to function properly, it must be designed and constructed according to strict engineering standards and specifications. This standard describes the design criteria, methods of construction, and quality assurance and control procedures required for the acceptable construction of these liners.

1.5 Definitions –

1.5.1 Compacted clay – for the purpose of protocols NSTS – 06 and NSTS – 07 the term "compacted clay" means; a *hydraulically secure soil* that is compacted to 95% of standard Proctor at the optimum moisture content to meet a maximum saturated hydraulic conductivity of 1 x 10^{-9} metres per second (as per ASTM D0698).

SECTION 2 - MATERIAL SUITABILITY

2.1. The qualified professional shall be responsible to ensure that the required tests are carried out to accurately characterize the material used to construct the compacted clay liner.

2.2. Laboratories - Only laboratories approved by the regulatory authority shall be used to analyze materials to be used in the construction of compacted clay liners for particle size distribution, Atterberg limits and hydraulic conductivity.

2.2.1. All materials to be used in the construction of a compacted clay liner shall be analyzed for particle size distribution following ASTM D2487-00 and Atterberg Limits following ASTM D4318-00 or any other method approved by the Director.

SECTION 3 - MATERIALS AND TESTING

3.1. If the distribution of the particle size classes and the Atterberg limits fall within the acceptable ranges given in Subsection 3.1.1. and 3.1.2, the material is considered acceptable for compacted clay liner construction without the need for additional laboratory testing providing it is installed using the recommended methods and equipment as described in Sections 4 and 5. The use of acceptable materials (as defined above) with the appropriate construction methodologies and equipment are expected to produce compacted clay liners with hydraulic conductivities of 1 x 10^{-9} metres/second or less.

3.1.1. Acceptable Particle Size Ranges (by weight):
- Percent Fines ; = 50 %;
- Clay Content ; = 20 %;
- Sand Content ; = 45 %;
- Gravel Content; = 50%; and

3.1.2. Acceptable Atterberg Limits:.
- Plasticity Index (PI): 20% = PI $\leq$ 30 %.
- Liquid Limit (LL): 30% = LL $\leq$ 60 %

3.2 Where the materials used to construct the compacted clay liner do not meet the specifications set out in subsections 3.1.1 and 3.1.2 the materials must be laboratory tested and a liner design and

construction method specified to ensure that the liner will meet a final maximum saturated hydraulic conductivity of 1 x 10^{-9} metres per second.

3.3. Required Testing for All Materials -The Engineer must complete a standard Proctor density test following ASTM 0698 to determine the maximum dry unit weight and optimum soil moisture content.

3.4. In situ testing – Moisture and density tests must be performed on the liner during and after construction to ensure that the liner meets the required design specifications.

SECTION 4 -CONSTRUCTION EQUIPMENT

4.1. Recommended Equipment -The recommended compaction equipment for the construction of a compacted clay liner is the Sheepsfoot Roller Compactor. Rollers meeting the following criteria shall be considered acceptable:

4.1.1. Soil Contact Pressures - The compaction equipment or rollers shall be ballasted to attain soil contact pressures of at least 2400 kPa.

4.1.2. Tamping Feet Requirement -The tamping feet shall be 200 mm to 250 mm in length from the cylindrical surface of the roller. The tamping feet shall have a face area between 4500 and 6000 mm^2 . The compactor feet shall be spaced to provide at least 4 tamping feet for each 0.25 m^2 of cylindrical surface**.**

4.1.3. When a Sheepsfoot Roller Compactor is not available, other compaction equipment may be used, subject to approval of the Director.

SECTION 5 - COMPACTED CLAY LINER CONSTRUCTION

5.1 The minimum thickness of the completed compacted clay liner shall be 1.0 m

5.2 The inside side slopes of the earthen nutrient storage structure shall be no steeper than 1:2 (rise:run). The Engineer may recommend flatter slopes or specify the use of procedures or equipment to ensure proper compaction of the liner.

5.3. To allow proper sealing between lifts, the interface surface of lower lifts shall be properly disked or scarified, before placement of subsequent lifts of material.

5.4. The clay liner shall be compacted at least 95% of standard Proctor maximum dry density as determined for this soil at a specified optimum water content.

5.5. All rocks and stones of significant size, roots and other organic debris shall to be removed from liner material prior the compaction.

5.6. Excavation and compaction shall be completed during soil temperatures that are above freezing.

5.7. Each compacted lift shall be protected from drying out to prevent cracking due to shrinkage.

5.8. The overlap between equipment passes shall not be less than 10 % of the width of the equipment being used to ensure lateral bonding between placed materials.

SECTION 6 - RESOURCE INFORMATION

OMAF Standard NSTS-01; *Engineering and Inspection*
OMAF Standard NSTS-03; *Site Characterization*
OMAF Standard NSTS-06; *Earthen Nutrient Storage Structures*
National Farm Building Code of Canada
ASTM D698-00a *Standard Test Method for Laboratory Compaction Characteristics of Soil using Standard Effort*
ASTM D2487-00 *Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)*

ASTM D4318-00 *Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils*

NSTS-08 TEMPORARY IN-FIELD STORAGE OF PRESCRIBED NUTRIENTS

1. No person shall store liquid nutrients in a temporary, in-field nutrient storage site.

2. The location of a temporary, in-field nutrient storage site shall satisfy the following requirements:
   - (a) the minimum depth of unconsolidated soil to bedrock shall be 1.5 metres;
   - (b) the minimum depth of unsaturated soil shall be 0.9 metres permanent water table;
   - (c) nutrient with more than 70% moisture content shall not be stored on soils that have rapid infiltration rates (Hydrological Soil Group A) as defined by soil hydrologic group in the Drainage Guide (Ministry of Agriculture and Food Publication 29); and
   - (d) it shall not,
     - (i) be located in the regional or 1 in 100 year flood zone; or
     - (ii) have a slope greater than 3%.

3. Temporary in-field nutrient storage sites shall be managed in accordance with the following criteria:

   - (a) except as provided for in section 7, a farmer receiving nutrients and storing them in a temporary in-field nutrient storage site on a farm unit can not receive and store a volume of nutrients that is greater than the quantity of nutrients that the farmer plans to use for crop production at that farm unit based on a compliant nutrient management plan;
   - (b) non-agricultural source material stored in a site must be used at the farm unit where it is stored and can not be transferred to another farm unit;
   - (c) if more than one type of nutrient is stored at a site the nutrients shall be managed in accordance with the most restrictive requirements applicable to any of the nutrients on the site;
   - (d) where the site is located on a slope it shall be located near the top of the slope to minimize the exposure of the nutrients to up-slope runoff or the site shall be equipped with runoff diversion structures;
   - (e) where a temporary nutrient in-field storage is located within a 150 m long flow path from surface water a vegetated buffer strip at least 3 metres wide is required between the site and the surface water;
   - (f) if the site is located in an area that is tile-drained the field tiles shall be the site shall
     - i) be pre-tilled or the tiles shall be monitored on a weekly basis for indicator colour and odour; and
     - ii) a contingency plan to plug or reroute the tile drains must be in place and acted upon.
   - (g) nutrients shall not be stored at a site for longer than the maximum time prescribed for each nutrient; and
   - (h) the site may be used again in the following year if:
     - i) the site is cultivated after the nutrients are spread on the land or removed from the site; and
     - ii) a vegetative cover has been established during the growing period following the removal of the nutrients from the site; and
     - iii) the soil phosphorus levels are maintained below 101 parts per million (sodium bicarbonate extractable).

4. No person shall locate a temporary, in-field nutrient storage site:

(a) within 45 metres of a well that has a continuous steel casing that extends at least 6 metres below the surface of the ground;
(b) within 90 metres of any other well;
(c) with less than a 90 metre flow path to surface water;
(d) within 200 metres of a single residence if the site contains de-watered municipal sewage biosolids;
(e) within 125 metres of a single residence if the site contains prescribed materials other than de-watered municipal sewage biosolids;
(f) within 450 metres of a residential area if the site contains de-watered municipal sewage biosolids; or
(g) within 250 metres of a residential area if the site contains prescribed material other than de-watered municipal sewage biosolids.

5. Subject to section 7 no person shall store nutrients in a temporary in-field nutrient storage site for longer than the following periods:

a) De-watered municipal sewage biosolids may be stored for a maximum of 10 days;
b) Prescribed material which is left uncovered may be stored for a maximum of 60 days with the exception of municipal sewage biosolids and manure stored in accordance with clause c.
c) Manure may be stored uncovered for 120 days if it is stored in a pile with a maximum height of 3 meters and a maximum width of 6 meters and it is turned, so that every piece of material in the pile is displaced from its former position and mixed or inverted, every;
   i) 15 days if the moisture content of the manure is greater than 70 percent;
   ii) 30 days if the moisture content of the manure is greater than 50 percent and not more than 70 percent; or
   iii) 60 days if the moisture content of the manure is not more than 50 percent;
d) Prescribed material that is covered, with the exception of municipal sewage biosolids, may be stored for 120 days.

6. The operator shall maintain records for all temporary in-field nutrient storage sites under the operator's control including;

a) the date the site was established;
b) the date or dates the pile was displaced and mixed or inverted, if applicable,
c) the date the pile was removed; and
d) a sketch indicating the location of the site relative to surface waters and other temporary in-field storage sites

7. The Director may authorize a person to increase the storage period or the amount of prescribed material which may be received at a temporary in-field nutrient storage site if he or she is satisfied that the person is meeting the Ministry of the Environment Interim Guidelines for the Production and Use of Aerobic Compost in Ontario or the Ministry of Agriculture and Food Protocol for On-Farm Composting.

NSTS-09 SEEPAGE MONITORING, LEAKAGE DETECTION and MANAGEMENT

1. PURPOSE AND SCOPE - this standard must be applied to storage facilities containing all prescribed nutrient materials situated within a two-year water capture zone.

2. The owner or operator of a new or expanding agricultural operation that is located within the two-year water capture zone of a well that supplies water to a municipal water system that includes a permanent liquid nutrient storage facility shall ensure that monitoring of groundwater movement under the facility is carried out in accordance with sections 4 to 12 of this protocol.

3. For all category 4 agricultural operations a professional engineer shall carry out the installation and monitoring of the monitoring system and samples shall be submitted to an approved laboratory for analysis whenever they are collected.

4. An internal monitoring system for groundwater movement shall be comprised of a water leachate collection and monitoring system located between the 1^{st} and 2^{nd} protective layers of the facility that is composed of granular material that is capable of capturing any leakage that may occur from the permanent liquid nutrient storage facility.

5. For the purposes of section 4., a protective layer includes a synthetic liner, a natural liner, concrete, or hydraulically secure soil.

6. (1) For all category 1 to 3 agricultural operations, a qualified person shall carry out installation of the internal monitoring system for groundwater movement.

(2) The owner of the storage facility or a person designated by the owner shall monitor the system and take samples of any liquid that is found in the monitoring system and the owner is responsible for submitting the samples to an approved laboratory for analysis when they are taken.

7. The samples shall be tested for ammonium and chlorides.

8. If ammonium or chlorides are found in the sample at levels which are 10 times greater than the levels established by monitoring background levels,

- (a) all liquid in a tile drain monitoring system shall be pumped into the permanent liquid nutrient storage facility or into an approved treatment system; and
- (b) the monitoring system shall be monitored on a weekly basis and any liquid found shall be tested until ammonium or chlorides are less that 10 times greater than the levels established by monitoring background levels.

9. If ammonium or chlorides levels are not greater than 10 times the background levels in the weekly samples or if adequate volumes are not present for sampling, the sampling and testing shall be carried out on a bi-weekly basis, reduced to a bi-monthly basis after 4 tests and further reduced to 2 times per year after 5 years of operation.

10. (1) An accredited laboratory shall analyze samples taken from a monitoring system.
(2) The results of the analysis shall be reported to the owner or operator of the farm unit.

11. The owner or operator of the farm unit shall notify the Ministry of the Environment by speaking with a person at the Ministry's Spills Action Centre if the amount of leakage exceeds predicted levels for a new facility as specified by the designer.

12. The owner or operator of the farm unit shall ensure that a record of the leakage monitoring results is kept at the business office of the farm unit.

NSTS-10 TRANSFER SYSTEMS FOR LIQUID NUTRIENTS

SECTION 1 - PURPOSE AND SCOPE

1.1. Purpose of the Standard – This Standard defines the requirements for the design of permanent transfer systems within or associated with liquid nutrient storage structures.

1.2. Objective – The objective of this protocol is to establish a minimum standard for the design, materials, construction, and installation of liquid nutrient transfer systems.

1.3. No person shall transfer liquid nutrients from place to place on a farm unit by means of a liquid nutrient transfer system unless the system has been designed and constructed and is operated in accordance with this protocol.

1.4. A nutrient transfer system that has been constructed in accordance with this protocol does not require monitoring for groundwater movement.

SECTION 2 - EQUIVALENTS

2.1. General - The provisions in this protocol are not intended to limit the appropriate use of materials, systems, equipment, and procedures not specifically described herein.

2.2. Alternatives – Alternatives not specifically described herein, or which may vary from specific requirements of this protocol, or for which no specified test procedure has been established, are permitted to be used:

c. If it can be shown that these alternatives are based on sound engineering principles and are equivalent on the basis of tests, evaluation or past performance; and

d. If the authority having jurisdiction is satisfied that these alternatives provide a level of public and environmental protection that is equivalent to the performance required by this protocol.

SECTION 3 – GRAVITY FLOW PIPING SYSTEMS

3.1. General – The size of the transfer pipe shall be adequate to develop sufficient flow velocity to transport the solids. Generally, no pipe smaller than 200 mm diameter shall be used for gravity flow systems.

3.2. Pipe Strength – The pipe must be able to withstand all loading conditions it is likely to be exposed. This shall include:

a. Internal pressure due to surcharge or head pressure from liquids stored in the tank;

b. External earth loads, superimposed live loads, and the supporting strength of the pipe under various types of installations and bedding conditions; and

c. Frost loads.

3.3. Pipe Materials – The pipe used in gravity flow systems shall be gasketed PVC (Polyvinyl Chloride) pipe certified to CSA B182.2 and conforming to ASTM D3034.

3.3.1. Alternative corrosion resistant pipe materials are acceptable if they have been manufactured in conformity with the latest acceptable standards issued by the Canadian Standards Association, the American Society for testing materials, or other recognized standards writing organization.

3.4. Fittings – Only purpose made gasketed fittings such as “Tees”, “Saddles”, “End caps” and “Elbows”, congruent with the pipe material, shall be used for pipe connections. Rough sawn holes, sealed with concrete are not acceptable.

3.5. Pipe Venting – Adequate pipe venting shall be installed to ensure the transfer piping system operates effectively. Pipe vents to the exterior shall extend 2 m above grade level with a protected opening.

3.6. Cleanouts – Cleanouts, allowing access from one direction shall be installed in the upstream end of all liquid nutrient transfer pipes. The spacing of cleanouts shall not exceed 90 m and shall be installed in a manner to facilitate removal of blockages.

3.7. Tank Connections - Where the pipe enters or leaves a storage tank, a flexible watertight gasket or membrane should be installed between the pipe material and the floor or wall of the storage tank to serve as an anti-seepage collar.

3.8. Floor Drains – Floor drains in buildings that connect to a liquid nutrient storage structure shall be installed in a manner that prevents manure gases from adversely affecting or accumulating in the adjoining building.

3.8.1. Except as noted in Sentence (2.4.2.), floor drains that lead from any building into a liquid manure storage structure shall be equipped with a trap and venting system constructed in accordance with the Ontario Building Code.

3.8.2. A trap is not required where an alternate system of ventilation has been designed to prevent manure gases from adversely affecting or accumulating in the adjoining building.

SECTION 4 – FORCEMAIN PIPING SYSTEMS

4.1. General – Forcemain systems shall be utilized where the pipe pressure exceeds an equivalent liquid head of 3.5 m.

4.2. Sizing – The size of the transfer pipe shall be adequate to develop a flow velocity of 0.8 to 2.5 m/s for the pump used. Generally, no pipe smaller than 100 mm diameter shall be used for forcemain systems.

4.3. Pipe Strength – The pipe must be able to withstand all loading conditions it is likely to be exposed. This shall include:

a. Internal operating pressure due to surcharge or head pressure from the pump;

b. Transient pressures or water hammer shock caused by rapid valve operation and pump start-up and shut-down;

c. External earth loads, superimposed loads, and the supporting strength of the pipe under various types of installations and bedding conditions; and

d. Frost loads.

4.4.Pipe Materials – The pipe used in forcemain systems shall be gasketed PVC (Polyvinyl Chloride) pipe certified to CSA B137.3 and conforming to AWWA C905 standard.

4.4.1. Alternative corrosion resistant pipe materials are acceptable if they have been manufactured in conformity with the latest acceptable standards issued by the Canadian Standards Association, the American Society for testing materials, or other recognized standards writing organization.

4.4.2. All exposed piping and fittings for liquid nutrient transfer piping is to be treated with a surface applied UV inhibitor as recommended by the manufacturer.

4.5. Fittings – Only purpose made gasketed fittings such as "Tees", "Saddles", "End Caps" and "Elbows", congruent with the pipe material, shall be used for pipe connections.

4.6. Tank Connections - Where the pipe enters or leaves a storage tank, a flexible watertight gasket or membrane should be installed between the pipe material and the floor or wall of the storage tank to serve as an anti-seepage collar.

4.7. Emergency Shut-Off - A primary shut-off valve is required in the transfer pipe where there is an opportunity for backflow to the pump or pump-out chamber. An emergency valve or secondary shut-off is to be installed adjacent to the primary valve. The emergency shut-off shall be easily accessible and failsafe.

4.8. Thrust Blocks – Adequate restraint shall be provided to prevent pipe movement and joint failure by thrust blocks positioned at all plugs, caps, tees, reducers, wyes, and bends greater than 22.5 degrees. Thrust blocks are to be constructed in accordance with OPSS 1103.020 standards with a minimum concrete mass of 0.03 cubic meters.

SECTION 5 - PIPE INSTALLATION

5.1. Assembly – Proper assembly will involve the following:

a. CLEAN: Before starting assembly, make certain that the factory installed gasket, bell recess and beveled spigot end are free of all dirt.

b. LUBRICATE: Apply approved lubricant to the surface of the spigot end up to the stop mark, including the tapered end of the spigot. Also apply lubricant on the full circumference of the gasket.

c. ASSEMBLE: Lay out the pipe with the bell end of the pipe upgrade. Align the spigot to the bell and insert the spigot into the bell as far as the stop mark, either by hand or with a bar and block. Insert until the stop mark is adjacent to, but not covered by the pipe bell.

d. CHECK: All gasket joints must be checked, at intervals around the pipe, with a feeler gauge to ensure that the gasket has not been displaced during assembly. If the gasket is not in position, disassemble the joint, reassemble and check again.

e. ALIGNMENT: Joints are not designed to allow for substantial deflection of the pipe. Proper fittings or bends must be installed to change pipe direction.

5.2. Handling – The following care shall be taken with the unloading and handling to prevent damage to pipe:

a. Inspect all material for damage from transit or handling before assembly.

b. Store pipe at site, according to manufacturer's instructions.

5.3. Trench Preparation - The trench bottom must be excavated as close as possible to the required grade. Where the trench is dug to below grade, material should be added and compacted, to restore the proper grade. Added material should be compacted to a density similar to undisturbed material.

5.4. Backfill – The backfill shall be installed in accordance with the limitations and guidelines of the pipe manufacturer.

a.) Material used for backfilling should be free of stones, frozen lumps or other deleterious materials that might damage the pipe. Selected native material when suitable is usually used as backfill. Imported material may be used if the native material is not suitable.

b.) Care should also be taken to ensure that the placing of the backfill does not shift the pipe in a horizontal or vertical direction. The backfill should provide even support along the entire length of the pipe.

5.5. Crossing Under Roadways - If a liquid nutrient pipe must cross under a roadway, there should be adequate backfill cover depth to ensure road loads are properly distributed to avoid crushing the pipe. Check with the manufacturer regarding the required cover depth for the specific pipe size.

5.5.1. Frost penetration and pipe freezing under roadways may also be a concern. Ideally there should be at least 1.2 m of cover over the pipe. However, frost penetration is typically deeper under cleared roadways, the placement of an insulating material over the pipe might be required.

5.6. Backflow Protection - In situations where the liquid nutrient storage structure is located at a higher elevation than the barn, an adequate backflow check valve should be incorporated into the transfer system. This will prevent manure from flowing back into the barn should the pump malfunction.

5.7. Safety – All work shall be carried out in accordance with the Ministry of Labour – Construction Health and Safety Standards.

SECTION 6 - QUALITY ASSURANCE FOR PIPING SYSTEMS

6.1. Deflection Testing – The maximum allowable pipe deflection in PVC piping is 7.5%.

6.2. Construction Review - The project engineer shall review the integrity of the complete liquid nutrient transfer piping system during and immediately following completion of the construction. The review shall be performed on a rational sampling of the work completed prior to backfill.

SECTION 7 - FLOOR TRANSFER SYSTEMS

7.1 All floors used for the transfer of liquid manure shall be constructed with concrete.

7.2 All floor transfer systems shall be capable of containing the liquids and transferring them to a storage structure as defined in the applicable protocol.

7.3 Livestock housing areas within a barn that are not intended to collect liquid manure are not deemed to be a liquid transfer system. These include areas under dairy free-stalls, feed trough areas and floors under solid manure pack areas.

SECTION 8 - REFERENCES

Ontario Provincial Standard Specification 410 (OPSS 410), April 1999.

Ontario Building Code

National Farm Building Code of Canada

ASTM D3034

American Water Works Association - AWWA C905

Canadian Standards Association – CSA B182.2, and CSA B137.3

NSTS-11 DECOMMISSIONING OF STORAGE STRUCTURES CONTAINING NUTRIENTS

SECTION 1 - PURPOSE AND SCOPE

1.1 Purpose – The purpose of this standard is to outline the requirements for decommissioning a nutrient storage structure.

1.2 Scope – This standard applies to all new and existing nutrient storage structures.

SECTION 2 – GENERAL REQUIREMENTS

2.1 It is the owner's responsibility to maintain all nutrient storage facilities in a state of good repair whether they are utilized or not.

2.2 The owner or operator of a permanent nutrient storage structure shall ensure that it is properly decommissioned if:

a.) The structure will no longer be required for the storage of nutrients; or

b.) The structure is temporarily taken out of service

SECTION 3 – **TEMPORARY DECOMMISSIONING**

3. (1) A person who is temporarily decommissioning a permanent nutrient storage facility shall:

a.) remove the contents of the storage facility or maintain the contents in a manner that does not jeopardize the safe operation of the structure for future use;

b.) maintain a minimum of 0.3 m freeboard at all times; and

c.) maintain the facility in a good state of repair and safe working condition.

(2) A person who has temporarily decommissioned a permanent nutrient storage facility shall,

a.) inspect the facility periodically and not less frequently than once a year to ensure that it doesn't present a hazard to people or the natural environment; and

b.) have the facility inspected and evaluated by a professional engineer at 10 year intervals in accordance with NSTS-12

SECTION 4 – **PERMANENT DECOMMISSIONING**

4.1 (1) A person who is permanently decommissioning a permanent nutrient storage facility shall,

a) remove all remaining nutrient from the facility;
b) pressure wash the walls and floors of the facility to remove any nutrient left on those surfaces if the facility is made out of concrete or steel; and
c) dispose of the remaining nutrient and wash water in accordance with a compliant nutrient management plan;

(2) If the facility is made out of concrete or steel the person shall,

- a.) collapse the walls of the structure onto the floor if the structure is located below grade; or
- b.) manage or dispose of the steel and concrete components of the structure in accordance with provincial law.

(3) If the facility is made out of earth the person shall,

- a.) remove any earth that is contaminated by nutrients and dispose of it in accordance with a compliant nutrient management plan; and
- b.) push any berms made of earth into the cavity.

(4) In the case of either subsection (2) or (3) the person shall complete the decommissioning of the facility by,

- a.) filling the cavity with clean soil or other fill material that has the same permeability as the surrounding soil;
- b.) mounding the fill above the original grade to allow for settling of the fill;
- c.) top-dressing the site with 150 millimetres of top soil; and
- d.) establishing vegetation on the site.

a. 4.2 No person shall allow water to accumulate on the site of a permanently decommissioned permanent nutrient storage facility

NSTS-12 EXISTING OPERATIONS

This standard is intended to outline the evaluation process required for existing nutrient storage facilities.

Facilities:

1. (1). Subject to subsection (2) owners and operators of existing agricultural operations that generate nutrients shall carry out a comprehensive evaluation of the permanent nutrient storage facilities located on their operations within the following time limits:

(a) Category 4 - on or before March 31, 2004;
(b) Category 2 and 3 – on or before March 31, 2005;
(c) Category 1 – on or before March 31, 2008.

(2). Where the owner or operator built a permanent nutrient storage facility in accordance with the standards contained in the “Agricultural Pollution Control Manual” between April 1, 1994 and March 31, 2003, the owner or operator shall have a comprehensive evaluation of the facility carried out by a professional engineer within 10 years of the date the building permit for the facility was issued or the date as determined by subsection (1), whichever is the later.

2. (1) Subject to subsection (2) owners and operators of agricultural operations that receive nutrients but do not generate nutrients shall have their permanent nutrient storage facilities evaluated by a professional engineer within the following time limits:

(a) Category 4 - on or before March 31, 2004;
(b) Category 2 and 3 – on or before March 31, 2005; and
(c) Category 1 – on or before March 31, 2008.

(2) Where the owner or operator built a permanent nutrient storage facility in accordance with the standards contained in the “Agricultural Pollution Control Manual” between April 1, 1994 and March 31, 2003, the owner or operator shall have a comprehensive evaluation of the facility carried out by a professional engineer within 10 years of the date the building permit for the facility was issued or the date as determined by subsection (1), whichever is the later.

3. Within the time periods specified in sections 1 and 2 all owners and operators of existing agricultural operations shall ensure that their permanent nutrient storage facilities are capable of containing at least all of the nutrient produced on or received at the operation during a period of 240 days with the following exceptions:

(a) a farmer who sends some of the nutrient generated on the farmer’s agricultural operation to a broker and that broker require an aggregate storage capacity of 240 days between them;
(b) where the period of use of a permanent livestock confinement area is less than 240 days the storage capacity of the permanent nutrient storage facility associated with the area must be adequate for the period of confinement; or
(c) where the nutrient management plan allows for a lesser period of time to be required for storage then the storage will meet the requirements of the plan

4. For the purposes of sections 1 and 2 an owner or operator of,

(a) any agricultural operation must demonstrate on the basis of reliable information that each permanent liquid nutrient storage facility located on the owner's or operator's agricultural operation; and

(b) a category 4 agricultural operation that stores solid nutrient on the operation in a facility that does not have a concrete floor must demonstrate on the basis of reliable information that each permanent solid nutrient storage facility located on the owner's or operator's agricultural operation,

is not having an adverse effect on surface or groundwater resources including,

(i) ensuring that there is no evidence of significant leakage into perimeter drains around the facility; and

(ii) determining the need for an observation station.

5. For the purposes of section 4 "reliable information" includes,

(a) a report based on an investigation conducted by a professional engineer that takes into consideration the topographic, geologic and hydrogeologic features of the agricultural operation in relation to the siting and operation of its permanent nutrient storage facilities; or

(b) a peer-reviewed Environmental Farm Plan prepared by or on behalf of the owner or operator of the agricultural operation that has been evaluated from time to time in accordance with the requirements of the plan.

6. No person shall construct or enlarge an operation that generates or stores non-agricultural prescribed materials unless the new or expanded operation has a permanent nutrient storage facility or facilities that is or are capable of containing at least all of the nutrient produced on or received at the operation during a period of 240 days.

7. Owners or operators of existing operations that generate or store non-agricultural prescribed materials shall manage such materials in accordance with their nutrient management strategy.

8. If an existing permanent nutrient storage facility does not meet the setback requirements of this regulation the owner or operator of the facility shall provide documentation in the owner's or operator's nutrient management plan that indicates the shortfall between the set back of the existing facility and the setback requirements of this regulation.

9. To determine with reasonable proof that the storage structure is operated and maintained in an acceptable manner consistent with the intent of the original design, the following checks must be made:

a.) surface water is directed away from the structure and prevented from ponding adjacent to the building, and controlled in a manner that prevents spills from adversely effecting surface and groundwater.

b.) the volume of storage is in accordance with the requirements of the Nutrient Management Plan.

c.) provisions for loading, agitation, and emptying have been made and the construction of the storage structure is in conformity with the equipment used for these purposes.

d.) the ventilation system has sufficient capacity to prevent the accumulation of corrosive gases.

e.) transfer piping is vented in conformance with NSTS-10.

f.) transfer piping has secondary shut-off valves in conformance with NSTS-10.

g.) safety fences are installed in accordance with NFBC Section 4.1.1.4.

h.) signage is installed clearly describing the risk of manure gases in accordance with NFBC Section 4.2.4.1.

10. Additional investigation or testing shall be performed where potential problems were identified in the evaluation and a thorough examination is required to resolve a solution.

11. Notification – If the engineer cannot demonstrate with reasonable proof that the items listed in section 9 meet an acceptable level of performance:

a. the engineer shall notify the authority having jurisdiction; and
b. the owner shall perform the necessary repairs or decommission the storage structure.