NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

WASTE STORAGE FACILITY

(No.)

CODE 313

DEFINITION

An impoundment made by constructing an embankment and/or excavating a pit, or by fabricating a manmade structure.

PURPOSE

To store or settle agricultural by-products in order to maximize their use as soil amendments in an environmentally safe manner.

CONDITIONS WHERE PRACTICE APPLIES

- The storage and/or settling facility is a component of a conservation plan and Comprehensive Nutrient Management Plan (CMMP), and shall be compatible with other components of the conservation plan and CNMP.
- The facility's function is to store or settle organic by-products generated by agricultural production or processing.
- The storage or settling facility can be constructed, operated, and maintained in an environmentally safe manner, protecting our natural resources such as soil, water, air, plants, and animals.
- The soils, geology, and topography are suitable for construction of the facility.

Earthen facilities only apply to embankments where:

- The total height of the dam is 25 ft or less and the storage volume is 50 acre-ft or less. Total height is the vertical measurement from the low point on the downstream toe to the top of the dam.
- Damage resulting from failure would be limited to farm buildings, agricultural land, and township or country roads.

Covered manure storage facilities – This practice standard applies to covers integrated as part of a structural concrete tank. Otherwise, practice standard 367 -Waste Facility Cover, applies to rigid, semi-rigid, and flexible manure storage covers associated with facilities designed under this standard.

CRITERIA

General Criteria

The criteria stated below is the minimum criteria for facilities installed to meet the purpose of this standard. Additional criteria may apply for installations requiring a State of Ohio Permit to Install (PTI) or National Pollution Discharge Elimination System (NPDES) permit.

Location. To minimize the potential for contamination of streams, facilities should be located outside of flood plains. However, if site restrictions require location within the flood plain, protect the facility from inundation and damage from a 25-yr, 24-hour flood event or larger if required by laws, rules, or regulations. Locate facilities so that prevailing winds and landscape elements such as buildings, landforms, and vegetation, minimize odors and protect or improve the visual quality of the site.

Locate facilities:

- Minimum of 300 ft. from neighboring residences
- Not within the emergency management zone of public surface water supply as designated under the Source Water Assessment and Protection Program, or not within 1500 ft. of the surface supply intake when a emergency management zone has not been established.
- The minimum separation distances from wells and sinkholes are shown in Table 1

Table 1 - Minimum setback distances from water supply wells, sinkholes & agricultural drainage wells

Water well designation	Fabricated Structures	Earthen storage ponds
Public water system supply well (Community, and Non-transient Non- community (NTNC))	Not within the inner management zone (1 year time of travel), or not within 1000 ft. when the time of travel has not been established	Not within the inner management zone (1 year time of travel), or not within 1000 ft. when the time of travel has not been established
Public water system supply well (Community, and Non-transient Non- community (NTNC))	Not within a protection area determined as highly susceptible (5 year time of travel)	Not within a protection area determined as highly susceptible (5 year time of travel)
Transient non-community (TNC) public water system supply well	300 ft	300 ft
Private water supply well not controlled by the owner of the facility to be installed under this practice	300 ft	300 ft
Private water supply well controlled by the owner of the facility to be installed under this practice	100 ft	300 ft. unless it is determined by an engineering geologist or registered professional engineer that a lesser distance will not pollute the well; in this case the distance can be reduced to 100 ft
Known Sinkhole or Agricultural Drainage well	300 ft. unless it is determined by an engineering geologist or registered professional engineer that a lesser distance with special design considerations will not cause pollution; in this case the distance can be reduced to 100 ft	300 ft. unless it is determined by an engineering geologist or registered professional engineer that a lesser distance with special design considerations will not cause pollution; in this case the distance can be reduced to 100 ft

- The Federal Emergency Management Agency (FEMA) has designated Established Regulatory Floodways in the floodplains of some Ohio rivers and streams. Do not locate facilities within an Established Regulatory Floodway.

Biological Hazard. The impact of a sudden breach, liner failure or accidental release needs to be evaluated because of potential water contamination and biological hazard to humans. Section 651.0204 of the Agricultural Waste Management Field Handbook is to be used as a guide for this evaluation. Decisions regarding the evaluation are to be documented in the design file.

Considerations for Minimizing the Potential for and Impacts of Sudden Breach of Embankment or Accidental Release from the Required Volume.

Features, safeguards, and/or management measures to minimize the risk of failure or accidental release, or to minimize or mitigate impact of this type of failure should be considered when any of the categories listed in Table 2 might be significantly affected.
The following should be considered either singly or in combination to minimize the potential of or the consequences of sudden breach of embankments when one or more of the potential impact categories listed in Table 2 may be significantly affected:

1. Manure management plan and crop rotation that facilitates frequent drawdown intervals
2. An auxiliary (emergency) spillway
3. Additional freeboard
4. Storage for wet year rather than normal year precipitation
5. Reinforced embankment -- such as, additional top width, flattened and/or armored downstream side slopes
6. Secondary containment

Table 2 - Potential Impact Categories from Breach of Embankment or Accidental Release

1. Surface water bodies -- perennial streams, lakes, wetlands, and estuaries
2. Critical habitat for threatened and endangered species.
3. Riparian areas
4. Farmstead, or other areas of habitation
5. Off-farm property
6. Historical and/or archaeological sites or structures that meet the eligibility criteria for listing in the National Register of Historical Places.

The following options should be considered to minimize the potential for accidental release from the required volume through gravity outlets when one or more of the potential impact categories listed in Table 2 may be significantly affected:

1. Outlet gate locks or locked gate housing
2. Secondary containment
3. Alarm system
4. Another means of emptying the required volume

Considerations for Minimizing the Potential of Waste Storage Pond Liner Failure.

Sites with categories listed in Table 3 should be avoided unless no reasonable alternative exists. Under those circumstances, consideration will be given to providing an additional measure of safety from pond seepage when any of the potential impact categories listed in Table 3 may be significantly affected.

Table 3 - Potential Impact Categories for Liner Failure, and High pollution Potential Areas

1. Any underlying aquifer zone is less than 15’ below the bottom of the planned facility
2. The vadose zone is rock
3. The aquifer is a domestic water supply or ecologically vital water supply
4. The site is located in an area of solutionized bedrock (karst) such as limestone or gypsum.
5. The site has a DRASTIC rating of 160 or greater

Should any of the potential impact categories listed in Table 3 be affected, design considerations in Table 4 are to be used. Clay & synthetic liners are to meet the following criteria shown here and in the *Lining Waste Storage Ponds or Settling Facilities* section of this standard:

1. A clay liner designed in accordance with procedures of AWMFH Appendix 10D with a thickness and coefficient of permeability so that specific discharge is less than 1×10^{-6} cm/sec
2. A flexible membrane liner over a clay liner
3. A geosynthetic clay liner (GCL) flexible membrane liner
4. A concrete liner designed in accordance with slabs on grade criteria for fabricated structures requiring water tightness

Soil and Foundation. Where available, use the Ohio Department of Natural Resources (ODNR), Division of Water, Ground Water Pollution Protection (DRASTIC) Maps to determine the pollution potential for each site. Areas having a pollution potential index above 160 indicate a high potential to pollute groundwater. All sites in a high pollution potential area (see table 3), or within an EPA designated Sole Source Aquifer boundary, or those that require a permit to install from the Ohio Department of Agriculture, Livestock Environmental Permitting Program require a geological exploration completed by an engineering geologist or registered professional engineer competent to perform such work. Consider the need for laboratory testing prior to design.

Examine the ODNR County Ground Water Resource maps where available, and near-by well logs to determine potential aquifer yields and depth to the aquifer. Information obtained from the DRASTIC maps, County Ground Water Resource maps, and well logs shall be included in the facility design report.

A subsurface geological exploration is required for all facilities to determine conditions that may adversely affect groundwater quality. The total number of test pits or borings required is dependent on the soils and geological formations on site. A rule of thumb is a minimum of four test pits or borings placed at each corner of an approximately 200 foot x 200 foot, or smaller, area. Additional test pits will be required for larger ponds. In all cases, the complexity of the subsurface conditions and susceptibility to leakage will determine the number of test pits. Extend exploration borings and/or test pits to a minimum of 5 ft below the planned bottom of the facility. A trackhoe is recommended for all subsurface explorations. The use of a soil-exploration type of drill rig may also be necessary when the depth to the aquifer zone is to be determined. Record (log) all soil and rock types present, their depths, their moisture conditions, depths to ground water flow, and an estimate of the flow. Guidance on logging foundation conditions is given in AWMFH, Chapter 7, Amendment OH 7, Geology and Groundwater Considerations. Determine the minimum requirements for design as per the findings of the geological exploration. Include the geological exploration logs in the design documentation. Table 4 shall be used to determine the construction needed to protect groundwater:

Table 4 – Minimum Design Criteria for the protection of Groundwater

Criteria	Fabricated Structure **1**/, **2**/	Holding Pond
ODA permitted facility	Recommendations of geotechnical report inclusive of lab tests, and ODA rules	Recommendations of geotechnical report inclusive of lab tests, and ODA rules
DRASTIC Index < 160 and > 15' to aquifer zone	• Manure tight floor & walls or • Pen pack with gravel floor option permitted	Recommendation of geology report; lab analysis not necessary unless directed by on-site soil logger
DRASTIC Index > 160 and > 15' to aquifer zone Or DRASTIC Index < 160 and < 15' to aquifer zone	• Manure tight floor & walls or • Pen pack with concrete floor	Lab analysis necessary; Design to min criteria in AWMFH Appendix 10-D
DRASTIC Index > 160 and < 15' to aquifer zone	• 3' of compacted soil below structure and manure tight structure or • Pen pack with sealed concrete floor **3**/	3' of compacted soil below pond bottom designed to min criteria in AWMFH Appendix 10-D, plus synthetic liner with leak detection
Bottom of facility is within 15' of rock that is not an aquifer (In addition to DRASTIC & aquifer zone criteria)	• Manure tight floor & walls or • Pen pack with gravel floor option permitted	3' of compacted soil below pond bottom Design to min criteria in AWMFH Appendix 10-D
Bottom of facility is within 15' of rock that is an aquifer (In addition to DRASTIC & aquifer zone criteria)	• 3' of compacted soil below structure and manure tight floor & walls or • Pen pack with sealed concrete floor **3**/	3' of compacted soil below pond bottom designed to min criteria in AWMFH Appendix 10-D, plus synthetic liner with leak detection

1/ All pen pack facilities must be underlain with a subgrade consisting of a 3' minimum thickness of soils in permeability groups II, III, or IV as listed in Table 10D-2 of AWMFH- Appendix 10D

2/ Post & plank walls shown in drawing OH-N-531 are considered manure tight; concrete design is to meet the requirements of the current edition of ACI 318, *Building Code Requirements for Structural Concrete*

3/ Concrete floor shall be dowelled Type S2 slab with sealed control joints

Maintain a minimum thickness of 15 feet of soil (*in-situ* soil plus liner, if necessary) between the bottom of the waste storage facility and the top of the aquifer zone of all aquifers unless special design considerations as shown in table 4 are used. (The depth to aquifers can be obtained from well logs). Liners are to be designed following the recommendation of a geotechnical report following lab testing of the soil to be used in the liner.

All earthen liners above aquifers shall meet the hydraulic conductivity requirements for permitted facilities and be designed for specific discharge of no more than 1×10^{-6} cm/sec.

Ground water flow shall be prevented from entering the bottom of the facility after construction by maintaining a minimum of 3 feet of impermeable in- place soil (inclusive of a well compacted liner, if necessary) between the water and the bottom of the facility. Maintain a minimum of 3 ft (inclusive of a liner, if necessary) between the bottom of the facility and bedrock that is not an aquifer. See Appendix A of this standard for aquifer definition.

All ground water seepage shall be sealed off with a liner when appropriate, or drained away from the facility by the use of a perimeter drain. Drains shall be located as far away from the inside slope as possible. However, field conditions may require a drain to be placed on the inside slope of a storage pond. In such cases, the drain shall be covered by a minimum of three feet of well compacted soil liner and be installed with a down slope inspection port for future monitoring. The inspection port shall consist of a capped watertight riser with a minimum diameter of 8 in. The top of the riser shall be elevated a minimum of 12" above the ground and located a minimum of 50 ft. from the edge of the storage pond where it will not be subjected to damage, or otherwise protected.

In all cases, ground water pollution is to be prevented. Therefore, additional measures may be necessary. They may include: 1) placing a compacted soil liner containing hydraulic conductivity reducing additives, 2) an impermeable membrane or barrier placed according to the manufacturer's recommendations, or 3) current technology may offer other acceptable solutions.

No existing subsurface drainage line shall be allowed to remain within fifty feet of the edge of the waterline of any manure storage pond or manure treatment lagoon. Existing subsurface drainage lines within this area shall be removed or relocated. Subsurface drainage lines installed as part of the project are allowed within the 50' area as follows:

- Perimeter drain installed for seepage control under a liner.
- Subsurface drains installed as part of a surface water diversion system adjacent to the facility. These lines must be no closer than 25 ft. from the design waterline.

Inlet. Use permanent type inlets designed to resist corrosion, plugging, and freeze damage. Incorporate erosion protection as necessary. For pipelines from enclosed buildings, provide a water-sealed trap and vent or similar device(s) to control gas entry into the building or other confined areas.

Storage Period. The minimum design storage period shall be the maximum length of time anticipated between clean-out events that facilitate the crop rotation and nutrient management components of a Comprehensive Nutrient Management Plan (CMNP). The storage period shall be sufficiently long that the nutrient management plan will not require manure to be applied on frozen or snow covered soil as part of normal operations unless the winter manure application criteria found in practice standard 633 is included in the CNMP.

Where the stored manure will not be land applied on the producers cropland, but instead moved off-farm through an agreement with another user, the minimum storage period shall be sufficient to accommodate the manure transfer agreement and not involve application on frozen or snow covered fields.

Design storage volume. Divert non-contaminated runoff from the waste management facilities to the fullest extent possible except where its utilization is advantageous to the operation of the waste management system.

The design inputs used to size the facility must be documented by one (or both) of the following:

- NRCS Animal Waste Management (AWM) computer program using NRCS-2008 data source
- Hand calculations referencing manure volumes from the current edition of NRCS National Engineering Handbook (NEH) Part 651, Agricultural Waste Management Field Handbook, Chapter 4, and rainfall/ runoff volumes from NRCS publications

Include the following into the design volume as is appropriate:

a) Manure, wastewater, and other by-products generated during the storage period.

b) Normal precipitation less evaporation on the surface area of the facility during the storage period, except that rainfall less evaporation shall not be less than zero for any month during the design period. Evaporation can be ignored to yield a more conservative design.

c) Normal runoff from the facility's drainage area during the storage period.

d) 25-year, 24-hour precipitation on the surface of the facility.

e) 25-year, 24-hour runoff from the facility's drainage area.

f) Residual solids after liquids have been removed. (Typically 6 in for tanks and 1 ft for earthen facilities).

g) Additional storage as may be required to meet management goals or regulatory requirements.

Service, Life, and Durability. Plan, design, and construct storage and settling facilities to provide a minimum service life of 10 years.

Plan, design, and construct the waste management system with sound and durable materials commensurate with the anticipated service life, initial and replacement costs, maintenance and operation costs, safety and environmental considerations.

Safety. Include all safety features necessary in the design to minimize the hazards of the facility to both animals and people.

Include a permanent fence (or structural cover) and warning signs for all facilities included in the design. However, a fence is not required for the following conditions:

- Above ground dry stacking facilities that have no access except during loading or unloading.
- Liquid storage ponds where **both** of these conditions apply:
  - The livestock are confined at all times to a building, or excluded from the pond area by permanent fencing, and
  - The manure goes through solids separation prior to entering the holding pond, or the pond is designed only for storage of runoff or washwater.

  A holding pond without a floating crust poses a similar risk for loss of life as does a farm pond. In this circumstance, fencing the pond and providing flotation devices for public safety shall be at the discretion of the landowner. If there is a possibility that small children will play or have access to the pond, it is recommended that the pond be fenced. The landowners' decision shall be documented in the assistance notes. When used, warning signs with a rope and safety flotation device shall be placed on at least two sides of an unfenced pond.

When the facility is fenced, locate the permanent fence so that easy access is possible for the agitating and pumping equipment. The fence needs to exclude livestock from the embankment area and make it difficult for humans to enter the facility. Follow the fencing requirements in the Ohio Conservation Practice Standard 382, Fencing with the following additional requirements:

- Barbed wire fencing requires a minimum of 5 strands.
- The bottom of any fence can be no more than 10 inches off the ground.

Fencing details shall be included in the drawings

Install safety stops, gates, or both at push-off ramps and load-out areas to prevent accidental entry of machinery. Provide warning signs, ladders, ropes, flotation devices, bars, and rails as appropriate to ensure the safety of humans and livestock. To prevent the inhalation of poisonous gases, asphyxiation, or explosion; provide ventilation systems and warning signs near pumping ports for covered waste-holding structures.

Erosion Protection. Vegetate embankments and all disturbed areas surrounding facilities to control erosion. Refer to NRCS, Ohio Conservation Practice Standard 342, Critical Area Planting.

Pond Criteria

Location. Do not locate facilities within 300 ft from any well unless it is determined by an engineering geologist or registered professional engineer that a lesser distance will not pollute the well.

Design Volume for Settling Ponds as a Component of a Treatment System

Design settling ponds for treatment systems for a minimum 6 months manure production from the animals plus any solid by-products entering the storage or treatment system. Measure the maximum design volume to the invert of the transfer pipe.

Outlet. No outlet shall automatically release effluent from the required storage volume except to a treatment system. Install permanent type outlets that are manually or hydraulically operated and designed to resist corrosion and plugging.
A gravity pipe, when used to empty a storage pond, shall be equipped with two valves to prevent an accidental release. One valve is to be located near the pipe inlet below the frost line, and the other located near the pipe outlet. Each valve shall have an independent power source and be dual acting (able to apply pressure to flow in either direction).

Embankments. Increase the embankment height a minimum 5 percent for settlement. The minimum top width shall be 8 ft for embankments less than 15 ft total height, 10 ft for embankments from 15 ft to less than 20 ft, and 12 ft for embankments from 20 to 25 ft. Increase the top width to a minimum of 12 ft for embankments traversed by farm equipment. Use a minimum 20-ft top width for agitation and pump-out areas.

Do not design the combined side slopes for the settled embankment less than 5 horizontal to 1 vertical. Do not design for a settled embankment slope steeper than 2 horizontal to 1 vertical.

Liquid level Marker. Holding ponds shall be equipped with a permanent level marker set at the "full" elevation. The full elevation is the elevation representing the maximum design volume minus the depth representing the 25 yr-24 hr. storm volume (rainfall on the pond surface plus runoff into the pond).

At the option of the producer, depth markers can also be installed to represent the ½ and ¾ full elevations.

Soil Compaction. The following are minimum requirements for compacting CL or SC soils used for embankments and for sealing the pond bottom as necessary when special liners are not required.

- *Precompacted Lift thickness:* The lift thickness shall be equivalent to the length of the feet of the sheepsfoot roller plus 3 inches; not to exceed 9 inches in total thickness.
- *Maximum rock diameter:* 3 inches.
- *Minimum Moisture content:* - The soil material shall be of sufficient moisture to easily form it into a moist, somewhat soft, ball by hand and not develop any cracks. This moisture content approximates optimum plus 2%.
    - *Compaction equipment:* Sheepsfoot roller with a minimum 200-psi foot contact pressure, and feet a minimum of 7" in length.
    - *Compaction effort:* a minimum of 6 passes of the roller over all points of each lift. When the moisture content is adequate, the sheepsfoot roller will penetrate the soil and ride on the drum. The soil is too dry if the sheepsfoot roller does not fully penetrate the soil.
- Any additional water needed for proper compaction shall be thoroughly mixed in with a disk prior to compaction.
- The surface of a compacted lift must be sufficiently moist to allow bonding with the next lift, otherwise the surface needs to be scarified, wetted to the minimum moisture content, and recompacted prior to placement of the next lift

Lining Waste Storage Ponds or Settling Facilities. Determine the need for pond lining during the geological exploration performed by an engineering geologist or registered professional engineer. Liner criteria will be by one of these four methods:

1. Compacted soil.

Laboratory testing of soil samples (taken during the geologic exploration) will be performed to determine compaction requirements necessary to meet allowable design seepage of a recompacted clay liner.
Soil liners shall be designed using procedures in Section 651.1080 (Appendix 10 D) of the AWMFH, and Conservation Practice Standard 521-D, Pond Sealing or Lining – Compacted Clay Treatment. Liners must be designed to resist uplift pressures with a minimum factor of safety of 1.1.
When liners or sealing is required, Ohio construction Practice Standard - Pond Sealing or Lining, Compacted Clay Treatment (521-D) shall be used.

2. Concrete

The minimum thickness for concrete liners is 5 inches. Use non-metallic water stops for all joints. Reinforce the concrete as per the Fabricated Structure Criteria in this practice standard. Caution should be used when designing concrete liners where uneven settlement may occur.

3. Flexible Membranes (Synthetic)

Installation of flexible membranes must be supervised by the manufacturer or his/her representative and include written certification that the liner was installed as per the manufacturers recommendations. The flexible membrane, appurtenances, and installation procedures must meet NRCS Practice Standard 521a, Construction Specification 97 and Material Specification 594 (HDPE & LLDPE Flexible Membrane Liner). Flexible liners manufactured of EPDM (ethylene, propylene, diene monomer rubber), Polypropylene, and PVC (polyvinyl chloride) are acceptable subject to design review by the State Conservation Engineer.

The design of flexible membrane liners must consider relief of hydrostatic uplift pressures and venting of entrapped gas under the liner.

4. Geosynthetic Clay Liners (GCL).

Installation of GCL must be supervised by the manufacturer or his/her representative and include written certification that the liner was installed as per the manufacturers recommendations. The flexible membrane, appurtenances, and installation procedures must meet NRCS Construction Specification 98 and Material Specification 595 (Geosynthetic Clay Liners).

Installation of GCL shall meet the following additional requirements. Placement of GCL is limited to 3:1 (H:V) slopes or flatter. Provide a minimum of 1.5 ft of soil cover on the liner to protect against erosion and provide confining pressure.

The design of GCL liners must consider relief of hydrostatic uplift pressures and venting of entrapped gas under the liner.

Emptying Facilities. Provide a dock, a pumping platform, retaining wall, ramp, or other appropriate measures for emptying the facility. Design emptying appurtenances to accommodate the anticipated equipment used to empty the facility. Entrance or exit ramps shall have a slope of 10 horizontal to 1 vertical or flatter.

Include provisions in the plan for periodic removal of accumulated solids to preserve the storage capacity. The anticipated method for doing so must be considered in planning, particularly in determining the size and shape of the pond and type of seal.

Scour Protection. Scour protection is required at agitation or pump-out points on all ponds except those lined with concrete. This can be accomplished with a 20 ft diameter concrete pad at each agitation or pump-out location. The location of the agitation or pump-out points should be based on manufacturer's recommendations for pumping equipment, or from custom manure applicators the producer intends to use.

Freeboard and Emergency Spillways. Use 1 ft of freeboard for earthen facilities and 1.5 ft (includes the capacity to contain a 25 year storm event) for earthen settling ponds designed for treatment facilities. Measure the freeboard for earthen facilities above the maximum design volume. Measure the freeboard for settling ponds from the invert of the overflow.

Consider an emergency spillway to protect the embankment. To determine the need for an emergency spillway, investigate or consider the drainage area, pond size, precipitation amounts, storage period, potential downstream damages, and type of receiving waters.

Fabricated Structure Criteria. Fabricated manure storage structures designed under this standard are categorized into one of two criterion as listed in table 4:

- Manure Tight Concrete - These structures are designed with a concrete floor and sidewalls.

  - Slabs used for manure scraping and storage access aprons can be either a Type S1 or Type S2 slab as appropriate for foundation conditions. Type S1 and S2 slabs are described in the current Ohio Construction Specification - Concrete.
  - Slabs used in manure storage facilities, and subjected to vehicular traffic necessary for manure loading and/or unloading shall be dowelled Type S2 slabs.
  - Manure storage tanks shall meet the minimum design criteria in ACI 318. Midwest Plan Service publications MWPS-36, *Rectangular Concrete Manure Storages*, or MWPS-TR 9, *Circular Concrete Manure Tanks* may be used design tanks installed under this standard with the following additional criteria:

    - The minimum floor thickness is 5.5" with a minimum top bar cover of 1.5"

- Pen Pack – These are permanently covered facilities where livestock are housed, the manure builds up in the housing area to a design depth, and is periodically removed. The facility is managed in such a way that the solids content of the manure is high enough that it will not flow.

  The sides of pen pack facilities are to be designed as manure tight. Aggregate floors designed to meet practice standard 561 – Heavy Use Area Protection may be used in pen pack manure storage facilities when both the following conditions exist, otherwise a concrete floor meeting Type 1 or 2 slab criteria as described in the Ohio Concrete Construction standard is required:

  - Manure is removed by means where the pad is minimally disturbed by tire spinning, loader gouging, and turning of loading equipment. This generally means access is straight in and out.
  - Manure is removed from the facility three times each year or less.

  Pen pack manure storage facilities are to be designed with a manure storage height of 24 to 30" and the floor area is the minimum of:

  - Livestock stocking density recommendations from Midwest Plan Service or livestock industry publications, or
  - The corresponding area necessary to meet the storage volume interval documented in the CNMP or grazing management plan.

Design

Fabricated manure storage structures shall meet the design criteria in this standard. Construction drawings provided by others shall be stamped by a Professional Engineer or Registered Architect, and certified to meet this standard.

Foundation

Proportion the foundation of a fabricated structure to safely support all superimposed loads without excessive movement or settlement.

If a non-uniform foundation exists, or applied loads may create highly variable foundation loading, calculate the settlement from site specific soil test data. Index tests of site soil may allow correlation with similar soils for which test data is available. If no test data is available, presumptive bearing strength values for assessing actual bearing pressures may be obtained from Table 5 or another nationally recognized building code. In using presumptive bearing values, provide adequate detailing and articulation to avoid movements that could overstress the structure.

To eliminate potential uplift pressures, install a drainage system entirely around the foundation, discharged by gravity or a sump pump. Large structures may require additional drains at intermediate depths.

Table 5 – Presumptive Allowable Bearing Stress Values[1]	
Foundation Description	Allowable Stress (psf)
- Crystaline Bedrock	12,000
- Sedimentary Rock	6,000
- Sandy Gravel or Gravel	5,000
- Sand, Silty Sand, Clayey Sand, Silty Gravel, Clayey Gravel	3,000
- Clay, Sandy Clay, Silty Clay, Clayey Silt	2,000
[1] Basic Building Code, 12th Edition, 1993, Building Officials and Code Administrators, Inc. (BOCA)	

Structural Loading. Design structures to withstand all anticipated internal and external loads including: hydrostatic and uplift pressure, concentrated surface and impact loads, any loading associated with water, and combination loads. Design the structure in compliance with this standard and applicable local building codes.

The lateral earth pressure should be calculated from soil strength values determined from the results of appropriate soil tests. Lateral earth pressures can be calculated using the procedures in Technical Release 74. If soil strength tests are not available, use the presumptive lateral earth pressure values in Table 5.

Assign lateral earth pressures based upon equivalent fluid assumptions according to the structural stiffness or wall yielding as follows:

- *Rigid frame or restrained wall:* Use the values shown in Table 6 under the column “Frame Tanks”, which gives pressures comparable to the at-rest condition.
- *Flexible or yielding wall:* Use the values shown in Table 6 under the column “Freestanding Wall”, which gives pressures comparable to the active condition. Walls in this category are designed on the basis of gravity for stability or as a cantilever having a base wall thickness to height of backfill ratio not more than 0.085.

When the stored by-products are not protected from precipitation, design for an internal lateral pressure of 65 lbs./sq.ft./ft. of depth. When the stored by-products are protected from precipitation and will not become saturated, design for 60 lbs./sq.ft./ft. of depth internal lateral pressure. Use lesser values if supported by actual pressure measurements of the by-products to be stored. Roofed facilities designed to stored dry materials such as sawdust bedded horse stable manure or well managed livestock mortality compost may be designed using a lateral pressure of 35 lbs./sq.ft./ft. of depth. If heavy equipment will be operated near the wall (within 5 ft), design for a 100 psf horizontal surcharge.

Design tank covers to withstand both dead and live loads. Use the minimum live load values for covers contained in ASAE EP378.3, Floor and Suspended Loads on Agricultural Structures Due to Use, and in ASAE EP393.3, Manure Storage. Use the actual axle load for tank wagons having more than 2,000 gallon capacity.

If the facility is to serve as part of a foundation or support for a building, consider the total load in the structural design.

Structural Design. For structural design, consider all items that will influence the performance of the structure, including loading assumptions, material properties, and construction quality. Indicate the design assumptions and construction requirements on the plans.

Tanks may be designed with or without covers. Covers, beams, or braces that are integral to structure performance must be indicated on the construction drawings. Design openings in covered tanks to accommodate equipment for loading, agitating, and emptying. Equip these openings with grills or secure

covers for safety. Consider solid covers if odor and vector control is necessary.

Underlay all structures with free draining material or locate the footing below the anticipated frost depth

Table 6 - Lateral Earth Pressure Values[1]

Soil		Equivalent Fluid Pressure (lbs./sq.ft./ft. of depth)			
Description4	Unified Classification[4]	Above Seasonal High Water Table[2]		Below Seasonal High Water Table[3]	
		Free Standing Wall	Frame Tanks	Free Standing Wall	Frame Tanks
- Clean gravel, sand or sand-gravel mixtures (maximum 5% fines)[5]	GP, GW, SP, SW	30	50	80	90
- Gravel, sand, silt and clay mixtures (< 50% fines) - Course sands with silt and/or clay (< 50% fines)	All gravel/sand dual symbol classifications and GM, GC, SC, SM, SC-SM	35	60	80	100
- Low-plasticity silts and clays with some sand and/or gravel (≥ 50% fines) - Fine sands with silt and/or clay (< 50% fines)	CL, ML, CL-ML, SC, SM, SC-SM	45	75	90	105
- Low to medium plastic silts and clays with little sand and/or gravel (≥ 50% fines)	CL, ML, CL-ML	65	85	95	110
- High plasticity silts and clays (liquid limit > 50)[6]	CH, MH	-	-	-	-

[1] For lightly compacted soils (85% to 95% maximum standard density). Includes compaction by use of typical farm equipment.

[2] Also below seasonal high water table if adequate drainage is provided.

[3] Includes hydrostatic pressure.

[4] All definitions and procedures are in accordance with ASTM D-2488 and D-653.

[5] Generally, only washed materials are in this category.

[6] Not recommended. Requires special design criteria.

The minimum design and material quality requirements for fabricated structures are as follows:

- *Steel.* Manual of Steel Construction, American Institute of Steel Construction.
- *Timber.* National Design Specification for Wood Construction, American Forest and Paper Association. Timber used as foundation members, such as posts, shall contain a minimum of 0.6 lbs/cubic foot of MCQ, CCA or ACQ preservative, or equivalent. All other timber or lumber exposed to weather or manure contact shall contain a minimum of 0.4 lbs/cubic foot of CCA or ACQ, or MCQ @ 0.34 lbs/cubic foot preservative, or equivalent.
- Timber shown on the construction drawings that is specified to meet quality standards must be delivered to the site with the appropriate grade stamped on the timber at the mill. Grading information for Southern Yellow Pine is available from the Southern Pine Inspection Bureau: http://www.spib.org/grademarks.shtml?/lumberservices.
  Engineered timber products (such as glue laminated timber, laminated veneer lumber (LVL), and nail laminated timber) are to be grade stamped, or the manufacturer must provide documentation upon product delivery showing that the material properties conform to the structural requirements shown on the drawings.
- *Timber Posts.* Structures with timber post foundations are to be designed using ANSI/ASAE EP486.1, Shallow Post Foundation Design
- *Reinforced Concrete.* Building Code Requirements for Reinforced Concrete, ACI 318, American Concrete Institute and Ohio NRCS Concrete Construction specification (210-VI-EFH, Amend OH-18, March 6, 2000). The minimum compressive strength for concrete is 4000psi. For concrete with reinforcing steel, meet all local electric codes dealing with Concrete Embedded Elements, Equipotential Planes, and Voltage Gradients.

- *Masonry Concrete.* Building Code Requirements for Masonry Structures, ACI 530, American Concrete Institute.
- *Precast Concrete.* Guide Specifications for Precast Concrete, National Precast Concrete Association. Precasters shall be certified by the National Precast Concrete Association's Plant Certification Program or meet quality control standards described in section 6.2 of the guide specifications. The precast supplier must provide certification that delivered products conform to the guide specifications. Certified plant listing: http://www.precast-online.org/source/Members/CertifiedPlants.cfm
    - ***Slabs on Grade***. Design slabs considering the required performance and the critical applied loads. The subgrade material must be evaluated as to the suitability and denseness. A 4-inch thick layer of crushed gravel or limestone shall be provided as a uniform subbase. Where the subgrade is uniform and dense, a Type S-1 concrete slab is acceptable. Type S-2 concrete slabs shall be used where the subgrade material is non-uniform or has variable density, and it is not economical or feasible to improve the subgrade. The subgrade thickness in question is generally 12 inches, but could be more, depending on the soil profile. Contraction joints shall be filled with joint sealer meeting ASTM D 6690.

Design Criteria for Type S-1 and S-2 concrete slabs is found in the NRCS Concrete Construction specification.

Freeboard. Design for a minimum 6 inches of freeboard for all structures except solids stacking facilities that do not receive runoff, in which no freeboard is required.

CONSIDERATIONS

Locate the storage or settling facilities as close to the source of waste and contaminated runoff as practical.

Divert off-site surface and roof water away from the facility before it contacts manure

When calculating the design storage volume, the amount of evaporation should be selected considering the effects of crusting, shading, or covering of the effluent surface.

Consider landscaping with trees, shrubs, and flowers to improve the aesthetics and visual quality of the area.

Due consideration should be given to economics, the overall nutrient management plan, safety, health factors, and environmental pollution potential.

PLANS AND SPECIFICATIONS

Prepare plans and specifications in accordance with the criteria of this standard and describe the requirements for applying the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

Develop an operation and maintenance plan that is consistent with the purposes of the practice, its intended life, safety requirements, and the design criteria. Include the operational requirements for filling and emptying the facilities in the plan. Include the requirement that waste be removed from storage and utilized at locations, times, and rates in accordance with the overall waste management system plan. For facilities receiving storm runoff, include the following requirement, "Waste shall be removed at the earliest environmentally safe period to ensure that sufficient capacity is available to accommodate subsequent storms". Address or include the following operation and maintenance requirements in the O&M plan for all waste storage facilities.

- The number of animals designed for.
- The total design volume
- The design storage period
- Odor Management
- Safety Measures

- Transfer Systems
- Integrity of the embankment (stability, vegetative management, rodent control)
- Method of unloading the facility
- Equipment to be used
- Other considerations

REFERENCES

ACI. 1992. 360R. Design of Slabs on Grade. ACI, P.O. Box 9094, Farmington Hills, MI.

ACI. 1995. 318. Building Code Requirements for Structural Concrete. ACI, P.O. Box 9094, Farmington Hills, MI.

ASAE. 1996. EP379. Control of Manure Odors. ASAE Engineering Practices, ASAE. St. Joseph, MI.

ASAE 2000. EP486.1, Shallow Post Foundation Design. ASAE Engineering Practices, ASAE. St. Joseph, MI.

MidWest Plan Service. 1993. Livestock Waste Facilities Handbook, MWPS-18, all chapters. Iowa State University, Ames, IA.

Natural Resources Conservation Service. 1992. National Engineering Handbook, Part 651, Agricultural Waste Management Field Handbook, all chapters, USDA, Washington D.C.

Ohio Natural Resources Conservation Service:

National Engineering Handbook, Part 651, Agricultural Waste Management Field Handbook, Ohio Issue 1 Chapter 7, Geology and Groundwater Considerations, May, 1999
http://www.oh.nrcs.usda.gov/technical/engineering/references/awmfh_suppl.html

Drastic Maps for selected counties are available from ODNR; information about the maps is available by calling (614) 265-6740, or on-line at:
http://www.dnr.state.oh.us/water/Home/gwppmaps/default/tabid/3541/Default.aspx

Water well logs from ODNR, Division of Water, can be located on-line at:
http://www.dnr.state.oh.us/water/maptechs/wellogs/app/default.asp

County Ground Water Resource maps are available from ODNR, information on map is available by calling (614) 265-6740, or on-line at:
http://www.dnr.state.oh.us/water/Home/gwrmaps/default/tabid/3629/Default.aspx

Information about Ohio EPA's Source Water Assessment and Protection Program (SWAP) and Sole Source Aquifers is available at:
http://www.epa.state.oh.us/ddagw/swap.aspx

NRCS drawing and design reference Web Sites:

The Agricultural Waste Management Field Handbook and Animal Waste Management (AWM) design program : http://www.oh.nrcs.usda.gov/technical/engineering/engineering_software.html

Ohio NRCS Standard engineering drawings:
http://www.oh.nrcs.usda.gov/technical/engineering/cadd2.html

Ohio conservation practice standards (e-FOTG):
http://www.oh.nrcs.usda.gov/technical/ohio_eFOTG.html

NRCS Ohio Construction Specification - Concrete:
http://www.oh.nrcs.usda.gov/technical/engineering/neh20.html

Ohio technical references- general link:
http://www.oh.nrcs.usda.gov/technical/engineering/references/tech_refs.html

APPENDIX A

Aquifer. A geologic unit, soil or rock, that can store, transmit, and yield a significant amount of water to a well or spring. Except in extreme unusual circumstances, aquifers can yield a minimum of 5 gpm for a considerable length of time. The upper boundary of most aquifers is usually below 25 ft of depth and separated from the ground surface by material of low hydraulic conductivity. In some areas the depth to the top of an aquifer may be less than 25 feet.

The upper surface of a zone of saturated water within soil or rocks known as the water table. Water tables can be “perched” or elevated due to a less permeable material below them, or the water table may lie at the top surface of an aquifer.

The following conditions do not constitute an aquifer: 1) pore spaces within unsaturated soil that contain water. 2) a perched water table that allows small amounts of water to move continuously through the soil. 3) a perched water table that allows moderate amount of water to move into an open pit for some time and then stop.