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 planned resource management system.
- 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.

CRITERIA

General Criteria

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-year 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 an OEPA designated public groundwater source protection area, or not within 1000 ft. of a public water supply well when a source water protection area has not been established.
- Not within the corridor management zone of public surface water supply, or not within 1500 ft. of the surface supply intake when a corridor management zone has not been established.

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.

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, or within an EPA designated Sole Source Aquifer boundary, or those that require a permit to install from the State of Ohio, 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 in sites that lie above a 100 gpm or greater aquifer. 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.

Maintain a minimum of a thickness of 15 feet of soil (*in-situ* soil plus liner, if necessary) above all aquifers, and 25 feet of soil (*in-situ* soil plus liner, if necessary) above all aquifers yielding 100 gpm or greater. (The depth to aquifers can be obtained from well logs.). All liners above aquifers shall be well compacted and meet hydraulic conductivity requirements for permitted facilities. 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.

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.

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 storage period is the maximum length of time anticipated between clean-out events. Develop a nutrient management plan to determine the necessary storage period between clean-outs. Base the waste utilization plan on NRCS, Ohio Conservation Practice Standard 633, Waste Utilization.

Typical storage periods for the environmentally safe utilization of stored or settled farm by-products are 180 days for earthen storage facilities and 90 days for fabricated structures.

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.

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.
c) Normal runoff from the facility's drainage area during the storage period. (For impermeable surfaces, use a minimum 50% of the rainfall.)

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. A fence is not required for above ground dry stacking facilities that have no access except during loading or unloading. 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.

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.

Facility Closure. Facility closure, usually due to abandonment, requires a site-specific closure and inspection plan. Obtain all required permits prior to the closure operation. Address or include the following items in the closure plan.

- A copy of the facility's "As Built Plans".
- A copy of the facility's geological exploration.
- Removal and utilization of solids and liquids as per NRCS Field Office Technical Guide, Section IV, Ohio Conservation Practice Standard 633, Waste Utilization.
- Contaminated soil removal and utilization.
- Method of disposal or burial of fabricated structures, liners, covers, and other appurtenances.
- Removal or plugging of all transfer systems.
- The type of material and method of filling the facility.
- The grading plan and erosion control measures.
- If applicable, conversion of the facility or facilities for other purposes.
- The timing and amount of inspection required.
- Any tests required for closure.

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.

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.

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:* a minimum 200-psi sheepsfoot roller.
- *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-F, Pond Sealing or Lining – Compacted Earth Liner. 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 Earth Liner (521-F) 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 (Plastic)

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 unless acceptable test data is available showing that stability can be achieved on steeper slopes. 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. Base the location of the agitation or pump-out points on the manufacturers recommendations of the equipment to be used.

Freeboard and Emergency Spillways. Use 1ft 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

Design. Fabricated manure storage structures, and roof systems for manure storage facilities or feedlots shall meet the design criteria in this standard. Construction drawings provided by others shall be stamped by a Professional Engineer and certified to meet this standard.

Location. Locate fabricated structures a minimum 100 ft from a well unless it is determined by an engineering geologist or registered professional engineer that a lesser distance will not pollute the well.

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 1 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 1 – 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 2.

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 2 under the column “Frame Tanks”, which gives pressures comparable to the at-rest condition.
- *Flexible or yielding wall:* Use the values shown in Table 2 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 65psf. When the stored by-products are protected from precipitation and will not become saturated, design for 60psf internal lateral pressure. Use lesser values if supported by actual pressure measurements of the by-products to be stored. If heavy equipment will be operated near the wall (within 5 ft), design for a 100psf 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 EP393.2, Manure Storage. Use the actual axle load for tank wagons having more than 2,000 gallon capacity.

If the facility is to have a roof, snow and wind loads shall be as specified in ASAE EP288.5, Agricultural Building Snow and Wind Loads, or ASCE 7, Minimum Design Loads for Buildings & Other Structures. If the facility is to serve as part of a foundation or support for a building, consider the total load in the structural design. The minimum basic wind speed for Ohio is 80 mph, and the minimum ground snow load (P_g) shall be as shown in Appendix B of this standard.

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 2 - 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 requirements for fabricated structures are as follows:

The minimum 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 CCA preservative or equivalent. All other timber shall contain a minimum of 0.4 lbs/cubic foot of CCA preservative or equivalent.
- *Reinforced Concrete.* Building Code Requirements for Reinforced Concrete, ACI 318, American Concrete Institute. The minimum compressive strength for concrete is 3500psi. 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.

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. Type S-3 concrete slabs shall be used when the contraction joint spacing is to be more than 15 feet, when no contraction joints are wanted, when reduced seepage is required, or when a water-tight slab is required. Type S-3 concrete slabs without contraction joints, shall be used under the following conditions:

- Slabs installed as a component of a liquid or slurry manure storage facility
- Slabs installed as a component of a solid or semi-solid manure storage facility, where seepage that could occur with a Type S-1 or Type S-2 slab has potential of polluting groundwater, and cannot be captured for treatment.

Design Criteria for Type S-1, S-2 and S-3 concrete slabs is found in the NRCS Concrete Construction specification (210-VI-EFH, Amend OH-17, February 14, 2000).

Freeboard. Design for a minimum 6 inches of freeboard for all structures except solids stacking facilities that do not receive runoff or rainfall, 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 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 design 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 1999. 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, Chapter 7, Amendment OH7, Geology and Groundwater Considerations, May, 1999

NRCS Concrete Construction specification (210-VI-EFH, Amend OH-17, February 14, 2000).

Sole Source Aquifer maps are available at: http://www.epa.gov/reg5oh2o/grnwater/gwssa.htm

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/pubs/fs_div/fctsht09.htm

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/pubs/fs_div/fctsht10.htm

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

NRCS drawing and design information Web Sites:

The Agricultural Waste Management Field Handbook and Animal Waste Management (AWM) design program are available from the NRCS National Water and Climate Center: http://www.wcc.nrcs.usda.gov

Standard engineering drawings and conservation practice standards are available from the NRCS Ohio State Office: http://www.oh.nrcs.usda.gov

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.

Appendix B - Ohio Ground Snow Loads, (Pg)
Used in ASAE EP288.5, Section 4

Northwest

County	Lb/ft^2
Allen	20.0
Auglaize	20.0
Crawford	20.0
Defiance	20.0
Delaware	20.0
Fulton	20.0
Hancock	20.0
Hardin	20.0
Henry	20.0
Lucas	20.0
Marion	20.0
Morrow	20.0
Ottawa	20.0
Paulding	20.0
Putnam	20.0
Sandusky	20.0
Seneca	20.0
Union	20.0
Van Wert	20.0
Williams	20.0
Wood	20.0
Wyandot	20.0

Northeast

County	Lb/ft^2
Ashland	20.0
Ashtabula	30.0
Columbiana	25.0
Coshocton	20.0
Cuyahoga	30.0
Erie	20.0
Geauga	30.0
Holmes	20.0
Huron	20.0
Knox	20.0
Lake	30.0
Licking	20.0
Lorain	20.0
Mahoning	20.0
Medina	20.0
Portage	20.0
Richland	20.0
Stark	20.0
Summit	20.0
Trumbull	25.0
Wayne	20.0

Southwest

County	Lb/ft^2
Butler	20.0
Champaign	20.0
Clark	20.0
Clermont	20.0
Clinton	20.0
Darke	20.0
Fairfield	25.0
Fayette	20.0
Franklin	20.0
Greene	20.0
Hamilton	20.0
Highland	20.0
Logan	20.0
Madison	20.0
Mercer	20.0
Miami	20.0
Montgomery	20.0
Pickaway	20.0
Preble	20.0
Ross	20.0
Shelby	20.0
Warren	20.0

Southeast

County	Lb/ft^2
Adams	20.0
Athens	25.0
Belmont	20.0
Brown	20.0
Carroll	25.0
Gallia	20.0
Guernsey	25.0
Harrison	20.0
Hocking	25.0
Jackson	20.0
Jefferson	25.0
Lawrence	20.0
Meigs	25.0
Monroe	20.0
Morgan	25.0
Muskingum	25.0
Noble	20.0
Perry	25.0
Pike	20.0
Scioto	20.0
Tuscarawas	25.0
Vinton	25.0
Washington	20.0