NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Waste Storage Facility

(Number)

Code 313

DEFINITION

A waste impoundment made by constructing an embankment and/or excavating a pit or dugout, or by fabricating a structure.

PURPOSE

To temporarily store wastes such as manure, wastewater, and contaminated runoff as a function of an agricultural waste management system.

CONDITIONS WHERE PRACTICE APPLIES

- The storage facility is a component of a planned agricultural waste management system.
- Temporary storage is needed for organic wastes generated by agricultural production or processing.
- The storage facility can be constructed, operated and maintained without polluting air or water resources.
- Soils, geology, and topography are suitable for construction of the facility.
- The practice applies to facilities utilizing embankments with an effective height of 35 feet or less where damage resulting from failure would be limited to damage of farm buildings, agricultural land, or township and country roads. Fabricated structure facilities applies to tanks, stacking facilities, pond appurtenances, and “hoop roofs,” or truss arch shelters.

CRITERIA

General Criteria

Storage period The storage period is the maximum length of time anticipated between emptying events. The minimum storage period shall be based on the timing required for environmentally safe waste utilization considering the climate, crops, soil, equipment, and local, state, and Federal regulations.

Design storage volume The design storage volume shall consist of the total of the following as appropriate:

a. Manure, wastewater, and other wastes accumulated 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.
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. A minimum of 6 inches shall be provided for tanks.
g. Additional storage as may be required to meet management goals or regulatory requirements.

The design storage volume for a waste storage facility is equal to its required volume.

Inlet Inlets shall be of any permanent type designed to resist corrosion, plugging, and freeze damage incorporating erosion protection as necessary. Inlets from enclosed buildings shall be provided with a water-sealed trap and vent or similar devices to control gas entry into the buildings or other confined spaces.

Safety Design shall include appropriate safety features to minimize the hazards of the facility.

Protection. Embankments and disturbed areas surrounding the facility shall be treated to control erosion.

Flexible membranes. Flexible membranes shall meet or exceed the requirements of flexible membrane linings specified in NRCS Practice Standard Pond Sealing and Lining (Code 521A).

Minimum Distance Table for all Animals Except Swine Facilities Sited Under General Statute 106 - 801 through 805

Public or Private Use Facilities	Minimum Distance from Facilities	
	Operation existing prior to 04/15/87 (no enlargement) (no increase in SSLW) [1]	New operation or existing operation that is enlarging SSLW [1]
Any public use area, church, picnic area, playground, etc.	300 ft.	750 ft.
Residence or place of habitation other than owner or his tenant	300 ft.	750 ft.
"Blue line" or perennial water	100 ft. (New or Expanded) Treatment Facilities	
Wells (for human consumption)	100 ft. minimum - General Statutes 87-87 & 87-88. 152A2C.0107 (a) (1) (c)	
Area specified by state or local ordinance	Greater of state/local or NRCS distance shown above	

[1] SSLW - Steady State Live Weight = Average weight per unit x number of units @ capacity.

Any exception to the above distances must be approved by the ASTC(FO) with concurrence from the State Conservation Engineer.

The 750 ft. minimum distance must exist the day of the site investigation. Site evaluations are valid for 12 months.

Minimum Distance for Swine Operations as Dictated by GS 106 - 801 through 805
(Applies to operations sited on or after 10/01/95)

Swine House or Lagoon	• >= 1,500 ft. from any occupied residence • 2,500 ft. from any school, hospital, or church • 500 ft. from any property boundary
Land Application	• 50 ft. from any residential property boundary (any property with a residence on it) • 50 ft. from any perennial stream or river other than an irrigation ditch or canal

CRITERIA

Location
The waste storage pond shall not be located on the floodplain unless it is protected from inundation or damage by a flood that occurs once every 25 years. Waste storage ponds shall be located as close to the source of waste as far from neighboring dwellings or other areas of public use as practical.

Non-polluted runoff, from outside drainage areas, should be excluded to the fullest extent possible. Non-polluted runoff that can not be excluded shall be included in the design capacity.

Hazard Classification
The area downstream of the embankment must be evaluated carefully to determine the impact from a sudden breach of the proposed embankment on both structural and environmental features. This evaluation must consider all existing improvements and those improvements that may reasonably be expected to be made during the useful life of the structure. The results of this examination provides for the proper hazard classification of the embankment. Only hazard class (a) embankments are to be designed under this standard. See Engineering Notekeeping, Field Office Technical Guide Pond Standard (Code 378) or National Engineering Manual 520.21 for guidance concerning documentation of hazard class determination.

Emergency Action Plan
An Emergency Action Plan shall be prepared for each waste storage pond. The plan will outline steps to be followed in case of an emergency with the storage pond such as overflow, breaching, leakage, need for emergency land application, etc. As a minimum it will contain the

following items for the owner/operator to carry out in the event of an emergency:

- Call the Division of Environmental Management (DEM) to report the problem. Include name and phone number of the appropriate regional office. If outside normal business hours, call the NC Emergency Management Office in Raleigh and ask them to contact DEM. Give the name of the facility, location and DEM registration/ certification number.
- Call 911 or the Sheriff's Department if there is danger to downstream property (residences, road, etc.). Include phone number.
- Contact Contractor(s) of owner's choice to begin repair of problem to minimize off-site damage. Include names and phone number(s).
- Contact the technical specialist who certified the waste storage pond. Include phone number. If this specialist is no longer working, contact one who has design approval.

A copy of this plan containing current telephone numbers must be available at each site. It should be posted in a readily available location.

Site Investigation
A detailed site investigation shall be made for each waste storage pond prior to design. This investigation should include, but not be limited to evaluations of, distance from residences and other private or public use facility, proximity to the 100-year floodplain, perennial streams as shown on the USGS Quad Sheet, zoning jurisdiction of municipalities, utilities in the construction area, wetlands, available land for disposal, soils, and other environmental factors, etc.

If wetlands may be involved, contact the Corps of Engineers and/or NRCS for a wetland determination/delineation. If wetlands are involved, a 401 water quality certification and a 404 permit may be needed.

During the site investigation or construction phase, it must be verified that no subsurface tile lines are present. On sites that are located on cropland or land that has been cropped in the past and is land with soil types that respond to subsurface drainage, an observation trench along the entire length of the embankment shall be constructed to a minimum depth of 5 feet. The observation trench may be excavated during the soils investigation phase or during construction; in which case, it may be incorporated into the cutoff trench. The trench shall have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations, and the side slopes shall be 1:1 or flatter. If any tile lines are present in the area of the embankment they must be removed for a minimum distance of 15 feet beyond the embankment toe. If a tile line exists above the embankment it shall be rerouted around the pond.

Soil and foundation
Locate the waste storage pond on soils of slow to moderate permeability or on soils that can seal through sedimentation and biological action. Avoid gravelly soils and shallow soils over fractured or cavernous rock. The finished bottom elevation of the structure shall be above the seasonal high water table.

A detailed soils investigation with special attention to the water table and seepage potential must be a part of each plan and design. The soils investigation must extend at least two feet below the planned bottom. In the vicinity of the embankment but not under it, the soils investigation shall be to a depth equal to the height of the embankment or until rock is encountered. When poor foundation conditions are anticipated the investigation shall extend to the depth determined by the designer.
If rapid self sealing is not probable, special considerations such as mechanical treatment, lining, or other techniques must be considered and addressed in the design. A liner, or equivalent sealant, is required in SP, SW, GP, and GW, or problem soils as classified according to the Unified Soil Classification System. A liner is also required for most SM soils. A determination as to whether a liner is needed for other soils will be made during the on-site soils investigation prior to the design. If a liner is required and a clay liner is the sealant of choice, it will be designed and installed in accordance with Agricultural Waste Management Field Handbook, Appendix 10-D - Geotechnical, Design, and Construction guidelines. Where a liner is required a qualified construction inspector must be on site during construction as necessary to verify proper liner construction or the liner must be tested to verify a maximum hydraulic conductivity of 1.25×10^{-6} cm/sec. (.003 ft/day).

When an embankment is involved, samples of the proposed fill material should be obtained and

tested. Tests required are at the discretion of the designer. The test results shall be used to determine the design requirements for the embankment

Since soils are not always consistent, small areas of unsatisfactory material which were not evident during the investigation may be found during construction. They should be over excavated and lined with clay or other suitable sealant material as specified by the designer. Other sealant or lining techniques should be planned according to industry accepted design, installation and operational procedures appropriate for the selected technique.

Liners. Liners shall meet or exceed the criteria in NRCS Practice Standard, Pond Sealing and Lining (Code 521).

When a liner is not required the bottom and cut slopes of the storage pond shall be scarified to a minimum depth of six inches and compacted to decrease the permeability of the soil. Compaction shall be with a sheepsfoot roller or tamping roller at optimum moisture content or wetter.

Storage period
The storage period is the maximum anticipated length of time between removal of effluent, based on climate, crops, equipment, and labor. A minimum of six months storage is recommended except when special management practices or techniques permit otherwise. In no case shall a plan be developed with less than 60 days of storage capacity.

A means of clearly identifying the level of the pool at maximum planned volume shall be installed at each site. A permanent marker shall be placed in the pool area to clearly indicate the maximum level of waste that can accumulate before removal of effluent must be initiated.

Design volume
Waste storage ponds shall store the design volume plus an allowance for freeboard. Design volume is the minimum volume required to store waste for the planned storage period. It is the total of the following table.

Domestic and industrial waste from washdown facilities, showers, toilets, sinks, etc., shall not be discharged into the animal waste management system.

Design Volume

With Outside Drainage Area	Without Outside Drainage Area
1. Manure and excess water [1]	1. Manure and excess water [1]
2. Normal precipitation that falls on pond surface less evaporation on pond surface for the time of year which results in the greatest storage requirements [1]	2. Normal precipitation that falls on pond surface less evaporation on pond surface for the time of year which results in the greatest storage requirements [1]
3. Undiverted runoff from drainage area for normal rainfall storage period	3. 25-year, 24-hour precipitation on pond surface
4. 25-year, 24-hour precipitation on pond surface	
5. Undiverted runoff from 25-year, 24-hour storm	

[1]Accumulated during the storage period.
Note: Additional temporary storage may be provided to meet management goals.

Cutoff Trench
A cutoff of relatively impervious material shall be provided under the embankment if necessary for seepage control. The cutoff shall be located at or upstream from the centerline of the dam. It shall extend up the abutments as required and be deep enough to extend into a relatively impervious layer or provide for a stable embankment when combined with seepage control. The cutoff trench shall have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations, and the side slopes shall be 1:1 or flatter.

All foundation cutoffs shall be dewatered before backfilling.

Earth Embankment
For this standard, the maximum effective height (see Pond Standard, Code 378) of the dam is 35 feet. The side slopes of all waste holding ponds shall be uniform from top to bottom and shall be stable for existing soil conditions. The combined upstream and downstream side slopes of the settled embankment shall not be less than 5 horizontal to 1 vertical, and neither slope steeper than 2:1. Where embankments are to be mowed; 3:1 or flatter slopes are recommended. The minimum elevation of the top of the settled

embankment shall be 1 foot above the maximum design liquid surface in the pond.

The minimum top width for embankments are shown below. If the embankment top is to be used as a public road, the minimum width shall be 16 feet for one-way traffic and 26 feet for two-way traffic. Guardrails or other safety measures shall be used where necessary and shall meet the requirements of the responsible road authority. When the embankment top is used as a road, provision shall be made for protecting the emergency spillway from damage.

Table 1: Minimum Top Width

Total Height of Embankment (ft.)	Minimum Top Width (ft.)
up to 20	10
20 to 24	12
24 to 34	14
35	15

The top of the embankment should have a slight slope away from the pool area to reduce drainage into the pool.
The design height of the embankment shall be increased by the amount needed to insure that the design top elevation will be maintained after all settlement has taken place. The increase should not be less than 5 percent.

Compaction of the fill material shall be in accordance with the specified design requirements for compaction and moisture content. As a minimum, compaction shall be equivalent to, or better than, the following:

1. Layers of fill shall not exceed 9 inches in thickness before compaction.
2. Route the hauling and spreading equipment over the fill in such a manner that every point on the surface of each layer of fill will be traversed by not less than one tread track of the loaded equipment traveling in a direction parallel to the main axis of the fill.
3. Clayey soils shall be compacted with a "sheepsfoot" or tamping roller. (See Appendix 10-D).

A qualified inspector designated by the designer must be on site during construction, as necessary, to verify proper construction. Testing will be required as deemed necessary by the inspector.

If needed to protect the face of the embankment, special measures, such as berms, rock riprap, sand-gravel, soil cement, or special vegetation shall be provided (TR-56 and TR-69).

Inlet
If freezing is not a problem, an open inlet, such as a concrete channel, may be used. If freezing is a problem, the inlet shall consist of a pipe having a minimum diameter of 15 cm (6 in) and a minimum slope of 0.5 percent, except that a minimum diameter of 10 cm (4 in) may be used for milking center waste. Required pipe size is to be determined by the designer. Access should be provided to the pipe for rodding in case of blockage.

Pipes and open inlets that convey waste to the pond shall be designed and installed in a manner that will prevent erosion of the pond side slope. This will be accomplished by:
(1) extending the pipe or inlet beyond the slope of the pond,
(2) installing an armoring surface such as rock riprap or concrete on the slope, or
(3) using a flexible pipe that will conform to the surface of the slope and safely convey the effluent into the pond.

Pipes
If any pipes are to be placed through the embankment, the location and method of installation shall be approved by the designer of the embankment or a technical specialist designated by the Soil and Water Conservation Commission to design and approve waste storage ponds. The installation shall be certified by the inspector.

Emergency Spillway
Waste storage ponds having a maximum design liquid level of 3 feet or more above natural ground shall be provided with an emergency spillway to prevent overtopping. The crest of the emergency spillway shall be located at the same elevation as the top of the 25-year, 24-hour storm storage. The emergency spillway shall be placed in undisturbed soil when possible. When it must be placed in fill material, precautions shall be taken to insure the integrity of the structure.

The emergency spillway shall pass a 25-year, 24-hour storm without overtopping the embankment. There shall be a minimum of 1 foot of freeboard above the designed depth of flow in the emergency spillway. Where a waste

storage pond empties into another waste storage pond and the liquid level is positively controlled by an adequately sized overflow pipe, no emergency spillway is required for the primary waste storage pond.

Protection
If the pond will create a safety hazard, it shall be fenced and warning signs posted to prevent children and others from using it for purposes other than intended.

A protective cover of vegetation will be established on all disturbed areas. Temporary vegetation may be used until permanent vegetation can be established. Vegetation will be established in compliance with the Critical Area Treatment Standard (Code 342) of the Technical Guide.

The pond shall be fenced, if necessary, to protect the vegetation.

Erosion and Sediment Control Measures
Plans for waste storage ponds shall include temporary measures for the control of erosion and sedimentation during the construction period. Permanent vegetation will be established on all disturbed areas.

Fabricated Structure Criteria

Foundation. The foundations of waste storage structures shall be proportioned to safely support all superimposed loads without excessive movement or settlement.
Where a non-uniform foundation cannot be avoided or applied loads may create highly variable foundation loads, settlement should be calculated 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 2 or another nationally recognized building code. In using presumptive bearing values, adequate detailing and articulation shall be provided to avoid distressing movements in the structure.

Table 2: Presumptive Allowable Bearing Stress Values[1]

Foundation Type	Allowable Stress
Crystalline Bedrock	12000 psf
Sedimentary Rock	6000 psf
Sandy Gravel or Gravel	5000 psf
Sand, Silty Sand, Clayey Sand, Silty Gravel, Clayey Gravel	3000 psf
Clay, Sandy Clay, Silty Clay, Clay Silt	2000 psf

[1]Basic Building Code, 12th Edition, 1993, Building Officials and Code Administrators, Inc. (BOCA)

Structural loadings. Waste storage structures shall be designed to withstand all anticipated loads including internal and external loads, hydrostatic uplift pressure, concentrated surface and impact loads, water pressure due to seasonal high water table, and frost or ice pressure and load combinations in compliance with this standard and applicable local building codes.

The lateral earth pressures 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 TR-74. If soil strength tests are not available, the presumptive lateral earth pressure values indicated in Table 3 shall be used.

Lateral earth pressures based upon equivalent fluid assumptions shall be assigned according to the structural stiffness or wall yielding as follows:

* Rigid frame or restrained wall. Use the values shown in Table 3 under the column "Frame Tanks," which gives pressures comparable to the at-rest condition.

- Flexible or yielding wall. Use the values shown in Table 3 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 are designed as a cantilever having a base wall thickness to height of backfill ratio not more than 0.085.

Internal lateral pressure used for design shall be 65 lbs/ft^2 where the stored waste is not protected from precipitation. A value of 60 lbs/ft^2 may be used where the stored waste is protected from precipitation and will not become saturated. Lesser values may be used if supported by measurement of actual pressures of the waste to be stored. If heavy equipment will be operated near the wall, an additional two feet of soil surcharge shall be considered in the wall analysis.

Tank covers shall be designed to withstand both dead and live loads. The live load values for covers contained in ASAE EP378.3, Floor and Suspended Loads on Agricultural Structure Due to Use, and in ASAE EP393.2, Manure Storages, shall be the minimum used. The actual axle load for tank wagons having more than a 2,000 gallon capacity shall be used.

TABLE 3: Lateral Earth Pressure Values

Soil		Equivalent fluid pressure (lb/ft^2/ft of depth)			
		Above seasonal high water table[2]		Below seasonal high water table[3]	
Description[4]	Unified Classification[4]	Free standing wall	Frame tanks	Free standing wall	Frame tanks
Clean gravel, sand, or sand-gravel mixtures (maximum 5% fines)	GP, GW, SP, SW	30	50	80	90
Gravel, sand, silt and clay mixtures (less than 50% fines); Coarse sands with silt and/or clay (less than 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% or more fines); Fine sands with silt and/or clay (less than 50% fines)	CL, ML, CL-ML, SC, SM, SC-SM	45	75	90	105
Low to medium plasticity silts and clays with little sand and/or gravel (50% or more fines)	CL, ML, CL-ML	65	85	95	110
High plasticity silts and clays (liquid limit more than 50%) [6]	CH, MH	–	–	–	–

1 For lightly compacted soils (85% to 90% 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 in accordance with ASTM D 2488 and D 653.
5 Generally, only washed materials are in this category
6 Not recommended. Requires special design if used.

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

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

Tanks may be designed with or without covers. Covers, beams, or braces that are integral to structural performance must be indicated on the construction drawings. The openings in covered tanks shall be designed to accommodate equipment for loading, agitating, and emptying. These openings shall be equipped with grills or secure covers for safety, and for odor and vector control.

All structures shall be underlain by free draining material or shall have footing located below the anticipated frost depth.

Minimum requirements for fabricated structures are as follows:

- **Steel**. "Manual of Steel Construction", American Institute of Steel Construction.
- **Timber**. "National Design Specifications for Wood Construction", American Forest and Paper Association.
- **Concrete**. "Building Code Requirements for Reinforced Concrete, ACI 318", American Concrete Institute.
- **Masonry**. "Building Code Requirements for Masonry Structures, ACI 530", American Concrete Institute.
- **Slabs on grade**. Slab design shall consider the required performance and the critical applied loads along with both the subgrade material and material resistance of the concrete slab. Where applied point loads are minimal and liquid-tightness is not required, (such as barnyard and feedlot slabs subject only to precipitation), and the subgrade is uniform and dense, the minimum slab thickness shall be 4 inches with a minimum joint spacing of 10 feet. Joint spacing can be increased if steel reinforcing is added based on subgrade drag theory.

- **Liquid Tightness**. For applications where liquid-tightness is required such as floor slabs of storage tanks, the minimum thickness for uniform foundations shall be 5 inches and shall contain distributed reinforcing steel. The required area of such reinforcing steel shall be based on subgrade drag theory as discussed in industry guidelines such as American Concrete Institute, ACI 360, "Design of Slabs-on-Grade".

* **Heavy Equipment**. When heavy equipment loads are to be resisted and/or where a non-uniform foundation cannot be avoided, an appropriate design procedure incorporating a subgrade resistance parameter(s) such as ACI 360 shall be used.

* **Safety provisions**. Entrance ramps shall be no steeper than 10 horizontal to 1 vertical. Warning signs, ladders, ropes, bars, rails, and other devices shall be provided, as appropriate, to ensure the safety of humans and livestock. Ventilation and warning signs must be provided for covered waste holding structures, as necessary, to prevent explosion, poisoning, or asphyxiation. Pipelines from enclosed buildings shall be provided with a water-sealed trap and vent or similar devices to control gas entry into the buildings.

CRITERIA FOR THE "HOOP ROOF"

In addition to the applicable criteria for fabricated structures, the following criteria shall be met.

Foundation. The foundation shall be designed, approved, and sealed by a professional engineer licensed to practice engineering in North Carolina.

Walls. Four (4) ft. high pony walls shall be constructed along the sides for the purposes of fastening the trusses and supporting the waste stored in the structure. The walls shall meet the manufacturer's design requirements.

Design. The design of the "Hoop Roof" (truss arch shelter) shall be approved and sealed by a professional engineer licensed to practice engineering in the state of North Carolina.

Construction. The construction of the "Hoop Roof" structure shall be approved by a professional engineer licensed to practice engineering in the state of North Carolina.

CONSIDERATIONS

Waste storage facilities should be located as close to the source of waste and polluted runoff as practicable.

Non-polluted runoff should be excluded from the structure to the fullest extent possible except where its storage is advantageous to the operation of the agricultural waste management system.

Freeboard for waste storage tanks should be considered.

Solid/liquid separation of runoff or wastewater entering pond facilities should be considered to minimize the frequency of accumulated solids removal and to facilitate pumping and application of the stored waste.

Due consideration should be given to environmental concerns, economics, the overall waste management system plan, and safety and health factors.

Considerations for Minimizing the Potential for 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 4 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 4 may significantly affect:

1. An auxiliary (emergency) spillway
2. Additional freeboard
3. Storage for wet year rather than normal year precipitation
4. Reinforced embankment—such as additional top width, flattened and/or armored downstream side slopes
5. Secondary containment

Table 4: Potential Impact Categories from Breach of Embankment or Accidental Release

• Surface water bodies—perennial streams, lakes, wetlands, and estuaries
• Critical habitat for threatened and endangered species
• Riparian areas
• Farmstead or other areas of habitation
• Off-farm property
• Historical and/or archaeological sites or structures that meet the eligibility criteria for listing in the National Register of Historical Places: http//www.nr.nps.gov/nrlocl.htm

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 4 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 5 should be avoided unless no reasonable alternative exists. Under those circumstances, consideration should be given to providing an additional measure of safety from pond seepage when any of the potential impact categories listed in Table 5 may be significantly affected.

Table 5: Potential Impact Categories for Liner Failure

• Any underlying aquifer is at a shallow depth and not confined
• The Vaduz zone is rock
• The aquifer is a domestic water supply or ecologically vital water supply
• The site is located in an area of solutionized bedrock such as limestone or gypsum

Should any of the potential impact categories listed in Table 5 be affected, consideration should be given to the following:

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

Considerations for minimizing the impact of Odors

An anaerobic lagoon instead of a waste storage pond should be considered for sites located in rural areas where odors are a concern. This should be especially considered where odors would affect neighboring farms having enterprises that do not cause odors and/or neighbors who earn a living off-farm. The recommended loading rate for anaerobic lagoons at sites where odors must be minimized is one-half the values given in the AWMFH Figure 10-22.

For sites located near urban areas, practices such as the following should be considered to reduce odor emissions:

1. Covering the storage facility with a suitable cover
2. Using naturally aerated or mechanically aerated lagoons
3. Using composting in conjunction with a solid waste system rather than a liquid or slurry system
4. Using a methane digester and capture system

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be developed that is consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for its design. The plan shall contain the operational requirements for emptying the storage facility. This shall include the requirement that waste shall be removed from storage and utilized at locations, times, rates, and volume in accordance with the overall waste management system plan. In addition, for ponds, the plan shall include an explanation of the permanent marker or recorder installed to indicate the maximum operating level. The plan shall include a strategy for removal and disposition of waste with the least environmental damage during the normal storage period to the extent necessary to insure the pond's safe operation. This strategy is for the removal of the contribution of unusual storm events that may cause the pond to fill to capacity prematurely with subsequent design inflow and usual precipitation prior to the end of the normal stage period. Development of an emergency action plan should be considered for waste storage facilities where there is a potential for significant impact from breach or accidental release. The plan shall include site-specific provisions for emergency actions that will minimize these impacts.