



**Natural Resources Conservation Service**  
**CONSERVATION PRACTICE STANDARD**  
**WASTE STORAGE FACILITY**

**CODE 313**

**(no)**

**DEFINITION**

An agricultural waste storage impoundment or containment made by constructing an embankment, excavating a pit or dugout, or by fabricating a structure.

**PURPOSE**

This practice is used to accomplish one or more of the following purposes—

- To store manure, agricultural by-products, wastewater, and contaminated runoff to provide the agricultural operation management flexibility for waste utilization

**CONDITIONS WHERE PRACTICE APPLIES**

Use where regular storage is needed for wastes generated by agricultural production or processing and where soils, geology, and topography are suitable for construction of the facility. For reception pits, use the NRCS Conservation Practice Standard, Waste Transfer (Code 634).

For liquid waste storage facilities implemented with an embankment, this practice applies only to low hazard structures as defined in the NRCS National Engineering Manual (NEM), Part 520.23.

This practice does not apply to the storage of human waste or routine animal mortality.

**CRITERIA**

**General Criteria Applicable to All Purposes**

**Laws and Regulations**

Plan, design, and construct the waste storage facility to meet all Federal, State, and local laws and regulations.

**Location**

Locate and design the waste storage facility such that it is outside the 100-year floodplain unless site restrictions require locating it within the floodplain. If located in the floodplain, protect the facility from inundation or damage from a 25-year flood event or larger if required by laws, rules, and regulations. Waste storage facilities shall be located so the potential impacts from breach of embankment, accidental release, and liner failure are minimized; and separation distances are such that prevailing winds and landscape elements such as building arrangement, landforms, and vegetation minimize odors and protect aesthetic values. Additionally, follow the policy found in the NRCS General Manual (GM) 190, Part 410.25, Flood Plain Management, which may require providing additional protection for storage structures located within the floodplain.

**Storage Period**

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

**Design Storage Volume**

Size the facility to store the following volumes as appropriate.

Operational Volume

- Manure, wastewater, bedding, and other wastes accumulated during the storage period.
- For liquid or slurry storage facilities, include normal precipitation (omit diverted roof runoff) less evaporation during the storage period.
- Normal runoff from the facility's drainage area during the storage period.
- Planned maximum residual solids. Provide a minimum of 6 inches for tanks unless a sump or other device allows for complete emptying.
- Additional storage when required to meet management goals or regulatory requirements.

Emergency Volume (liquid storages only)

- 25-year, 24-hour precipitation on the surface of the liquid or slurry storage facility at the maximum level of the required design storage.
- 25-year, 24-hour runoff from the facility's drainage area

Freeboard Volume (for liquid or slurry waste storage exposed to precipitation)

- Minimum of 6" for vertical walled tanks.
- Minimum of 12" for all other facilities.

Exclude non-polluted runoff from the structure to the fullest extent practical except where including the runoff is advantageous to the operation of the agricultural waste management system.

**Inlet**

Design inlet to resist corrosion, plugging, freeze damage, and ultraviolet deterioration. Incorporate erosion protection as necessary.

**Waste Removal**

Provide components for removing waste such as gates, pipes, docks, wet wells, pumping platforms, retaining walls, or ramps. Incorporate features to protect against erosion, tampering, and accidental release of stored waste as necessary. Design ramp slopes to accommodate anticipated equipment and traction available. Use NRCS Nutrient Management (Code 590) for land application of stored material or follow other disposal options outlined in a Comprehensive Nutrient Management Plan (CNMP).

**Accumulated Solids Removal**

To preserve storage volume, make provision for periodic removal of accumulated solids. The anticipated method for solids removal must be accommodated in design, particularly in determining the configuration of impoundments and the type of liner to be used.

**Maximum Operating Level**

The maximum operating level for liquid storage structures is the level that provides the operational volume. The maximum operating level for waste storage ponds shall be the pond level that provides for the required volume less the volume contribution of precipitation and runoff from the 25-year, 24-hour storm event plus the volume allowance for residual solids after liquids have been removed. A permanent marker or recorder shall be installed at this maximum operating level to indicate when drawdown should begin. The marker or recorder shall be referenced and explained in the O&M plan.

**Staff Gauge**

Place a staff gauge or other permanent marker in the liquid storage facility to clearly indicate the following elevations:

- Maximum operating level (top of the operational volume).
- Emergency level (top of the design storage volume).

For storages where the contents are not visible and a staff gauge would not be visible, such as below a slatted floor, identify the method for the operator to measure the depth of accumulated waste in the Operation and Maintenance Plan.

### **Safety**

Include appropriate safety features to minimize the hazards of the facility (refer to American Society of Agricultural and Biological Engineers (ASABE) Standard EP470, Manure Storage Safety for guidance, as needed).

Provide warning signs, fences, ladders, ropes, bars, rails, and other devices as appropriate, to ensure the safety of humans and livestock. Provide ventilation and warning signs for covered waste holding structures, as necessary, to prevent explosion, poisoning, or asphyxiation.

Design covers and grating over openings such that livestock or humans cannot accidentally displace them and fall into the facility.

Design pipelines with a water-sealed trap and vent, or similar device, if there is a potential for gases from the pipe to accumulate in confined spaces.

Place a fence around impoundments and uncovered tanks which have exposed walls less than 5 feet above ground surface. Use the NRCS Fence (Code 382) for design of a fence that will prevent accidental entry by people or animals likely to be onsite. Post universal warning signs to prevent children and others from entering liquid waste storage structures.

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

### **Roofs and Covers**

Use NRCS Roofs and Covers (Code 367) for design of waste storage facility covers or roofs, as needed.

### **Treated Wood**

Use criteria from NRCS Roof and Covers (Code 367) for treated wood and fasteners.

### **Additional Criteria for Liquid Waste Storage Impoundments**

A liquid waste storage impoundment is a facility where the stored material does not consistently stack and is either a natural topographic depression, manmade excavation, or diked area formed primarily of earthen materials, such as soil (although the unit may be lined with manmade materials) .

### **Foundation**

Locate the impoundment in soils with a permeability that meets all applicable regulations or line the impoundment with suitable material. Use liners which meet or exceed NRCS Practice Standard Pond Sealing or Lining (Codes 520, 521, or 522).

Perform subsurface investigations for all waste storage impoundments sufficient in detail and analysis to support the design in accordance with NRCS NEM, Part 531, Geology. Describe the soil material encountered, location of any seeps, depth-to-high-water table, depth to bedrock, and presence of sink holes in karst topography.

For the design of a liner on a site located in a floodplain and other locations where there is potential for uplift, include an evaluation of all potential buoyant uplift forces on the liner. Limit projected uplift head under clay liners to a gradient of less than 0.5 ft/ft in the clay liner. The gradient is determined as the

difference in total head between the top and the bottom of a clay liner when buoyant forces exist (such as when the floodplain is flooded) divided by the thickness of the clay liner.

**Seepage Control**

Seepage-related criteria for siting, investigating, and designing liquid waste storage facilities are presented in Table 1. Additional information and guidance regarding seepage control of waste impoundments are found in the Agricultural Waste Management Field Handbook (AWMFH), Appendix 10D.

The target maximum specific discharge (unit seepage) shall be  $1 \times 10^{-6}$  cm<sup>3</sup>/cm<sup>2</sup>/sec. No credit shall be given for manure sealing. General sampling and soil mechanics testing requirements are summarized in Tables 1 and 2. Testing requirements vary depending on the relative vulnerability of the site to groundwater contamination, and on the potential impacts of seepage on designated uses of groundwater and hydraulically-connected surface water resources including drinking water supply and fisheries habitat.

Seepage control criteria developed for the specially designated Chino Basin shall be used in lieu of the criteria described above.

**Table 1- Criteria for Siting, Investigation, & Design of Liquid Waste Storage Facilities**

Risk →  ↓ Vulnerability	Very High	High	Moderate	Slight
	<1,500' from public drinking water supply wells;  OR < 100' from any domestic well or Class 1 stream	Doesn't meet Very High Risk criteria; AND Recharge areas for Sole Source aquifers;  OR 100' - 600' from unconfined domestic water supply well (or where degree of aquifer confinement is unknown) or Class 1 stream	Doesn't meet High Risk criteria; AND 600' - 1,000' from unconfined domestic well (or where degree of aquifer confinement is unknown) or Class 1 stream;  OR < 600' from unconfined non-domestic water supply well (or where degree of aquifer confinement is unknown) or Class 2 stream	Doesn't meet Moderate Risk criteria; AND >1,000' from unconfined domestic well (or where degree of aquifer confinement is unknown) or Class 1 stream;  AND > 600' from unconfined non-domestic water supply well (or where degree of aquifer confinement is unknown) or Class 2 stream
<b>Very High</b> Large voids (e.g. karst, lava tubes, mine shafts); OR Highest anticipated groundwater elevation within 5' of invert; OR < 600' from improperly abandoned well*	Evaluate other storage alternatives * (or properly seal well and re-evaluate vulnerability)	Evaluate other storage alternatives * (or properly seal well and re-evaluate vulnerability)		
<b>High</b> Doesn't meet Very High Vulnerability criteria; AND Bedrock (assumed fractured) within 2' of invert; OR Coarse soils/parent material (Permeability Group I soils as defined in AWMFH, always including GP, GW, SP, SW); OR Highest anticipated groundwater elevation is between 5' - 20' below invert; OR 600' - 1,000' from improperly abandoned well*		<b>Synthetic Liner Required</b> * (or properly seal well and re-evaluate vulnerability).  No additional site characterization required	<b>Liner Required</b> * (or properly seal well and re-evaluate vulnerability). ~ Specific Discharge $\leq 1 \times 10^{-6}$ cm <sup>3</sup> /cm <sup>2</sup> /sec ~ No manure sealing credit ~ Earthen liner design includes sampling and testing of liner material (Classification, Standard Proctor compaction, Permeability)	<b>Liner Required</b> * (or properly seal well and re-evaluate vulnerability). ~ Specific Discharge $\leq 1 \times 10^{-6}$ cm <sup>3</sup> /cm <sup>2</sup> /sec ~ No manure sealing credit ~ Earthen liner design includes sampling and classification testing of liner material ~ Published permeability data and construction method specifications may be used.
<b>Moderate</b> Doesn't meet High Vulnerability criteria; AND Medium soils/parent material (Permeability Group II soils as defined in AWMFH, usually including CL-ML, GM, SM, ML); OR Flocculated or blocky clays (typically associated with high Ca); OR Complex stratigraphy (discontinuous layering); OR Highest anticipated groundwater elevation is between 21' - 50' below invert	Evaluate other alternatives or Synthetic liner as allowed.  Local regulations may apply	<b>Further evaluate need for liner</b> ~ Specific Discharge $\leq 1 \times 10^{-6}$ cm <sup>3</sup> /cm <sup>2</sup> /sec ~ No manure sealing credit ~ Earthen liner/no liner design includes sampling and testing of liner/ in-place material (Classification, Standard Proctor compaction/ in-place density, Remolded/ Undisturbed sample Permeability)	<b>Further evaluate need for liner</b> ~ Specific Discharge $\leq 1 \times 10^{-6}$ cm <sup>3</sup> /cm <sup>2</sup> /sec ~ No manure sealing credit ~ Earthen liner/no liner design includes sampling and testing of liner/ in-place material (Classification, Standard Proctor compaction/ in-place density, Remolded/ Undisturbed sample Permeability)	<b>Further evaluate need for liner</b> ~ Specific Discharge $\leq 1 \times 10^{-6}$ cm <sup>3</sup> /cm <sup>2</sup> /sec ~ No manure sealing credit ~ Earthen liner/no liner design includes sampling and classification testing of liner/ in-place material + in-place density ~ Published permeability data and construction method specifications may be used.
<b>Low</b> Doesn't meet Moderate Vulnerability criteria; AND Fine soils/parent material (Permeability Group III and IV soils as defined in AWMFH, usually including GC, SC, MH, CL, CH); AND Highest anticipated groundwater elevation is >50' below invert	Consult with Area Engineer	<b>Further evaluate need for liner</b> ~ Specific Discharge $\leq 1 \times 10^{-6}$ cm <sup>3</sup> /cm <sup>2</sup> /sec ~ No manure sealing credit ~ Earthen liner/no liner design includes sampling and testing of liner/ in-place material (Classification, Standard Proctor compaction/ in-place density, Remolded/ Undisturbed sample Permeability) ~ Scarify and recompact surface to seal cracks and break down soil structure as appropriate	<b>Liner not required</b> ~ Specific Discharge $\leq 1 \times 10^{-6}$ cm <sup>3</sup> /cm <sup>2</sup> /sec ~ Field classification and published permeability data may be used ~ Construction method specifications may be used ~ Scarify and recompact surface to seal cracks and break down soil structure as appropriate	

## Criteria for Siting, Investigation, & Design of Liquid Waste Storage Facilities

### Table 1, continued Definitions

**AWMFH.** NRCS Agricultural Waste Management Field Handbook (210-VI-651). *Individual chapters online at <http://www.info.usda.gov/CED>*

**Class 1 Stream.** Watercourses that provide domestic supplies (including springs, on site and/or within 100 feet downstream of the operations area), and/or where fish are always or seasonally present onsite (including habitat to sustain fish migration and spawning). *Definition from California Forest Practice Rules, online at [f](http://www.fire.ca.gov/php/rsrsmgt_content/downloads/2005FPRRulebook.pdf) (Sections 916.5, 936.5, 956.5).*

**Class 2 Stream.** Watercourses where fish are always or seasonally present offsite within 1000 feet downstream; and/or aquatic habitat is available for non-fish aquatic species. Definition excludes Class III waters (no aquatic life present) that are tributary to Class 1 waters. *Definition from California Forest Practice Rules.*

**Permeability Group (I through IV) Soils.** Empirically-derived permeability classification of soils based on percent *Specific criteria for each of the four classes are listed in Table 10D-1 of passing the 200 sieve and Plasticity Index (PI). Appendix 10D of the AWMFH* <http://www.info.usda.gov/CED/ftp/CED/neh651-ch10.pdf>.

**Risk.** Risk categories (very high, high, moderate, slight) are based on the potential impacts of seepage on designated uses of groundwater and hydraulically connected surface water resources. *Designated uses include drinking water supply, nondomestic water supply, and aquatic habitats including fisheries.*

**Sole Source Aquifer.** An EPA-administered program that requires EPA review of all Federal financially assisted projects which have the potential to contaminate officially designated Sole Source Aquifers. <http://www.epa.gov/safewater/ssanp.html>. *Currently there are four Sole Source Aquifer areas in California, including the Fresno aquifer* [http://www.epa.gov/safewater/swp/ssa/pdfs/map\\_ssa\\_fresno.pdf](http://www.epa.gov/safewater/swp/ssa/pdfs/map_ssa_fresno.pdf).

**Unconfined Aquifer.** An aquifer containing water that is not under pressure; the water level in a well is the same as the water table outside the well. <http://www.epa.gov/OCEPAterms/utterms.html>. *Compared to confined aquifers, unconfined aquifers tend to be close to the ground surface and lack a low permeability confining layer that reduces seepage of potential contaminants from surface sources.*

**Vulnerability.** Vulnerability categories (very high, high, moderate, low) are based on geologic and hydrogeologic conditions at the site that influence seepage rates from the surface to the aquifer. *Geologic and hydrogeologic conditions include the texture and plasticity of the soil and geologic material in the vadose zone; and the separation distance between the invert of the proposed storage facility and the water table. The presence of improperly abandoned water wells is also considered a potential vulnerability factor.*

Table 2 - Soil Mechanics Testing Requirements for Design of Waste Storage Ponds

Test		ASTM reference	Where test should be run	
			No liner alternative	Compacted earth liner alternative
Classification	Sieve Analysis	D 422	Xa	X
	Hydrometer	D 422	Xa	X
	Atterberg Limits	D 4318	Xa	X
Compaction	(Standard Proctor)	D 698		Xb
In-place density		D 1556; D 2922	X	
Permeability	Remolded	D 5084		Xb
	Undisturbed and/or in-situ	D 5126	X	
<p><sup>a</sup> Field Classification of soil material may be used in lieu of laboratory-based classification where vulnerability is low <i>and</i> risk is slight or moderate <sup>b</sup> Published permeability data and assumed compaction may be used in lieu of lab testing of remolded samples where risk is slight</p>				

### Design Bottom Elevation

Locate the impoundment bottom elevation a minimum of 5 feet above the seasonal high water table unless special design features are incorporated that address buoyant forces, impoundment seepage rate and nonencroachment of the water table by contaminants. The water table may be lowered by use of drains to meet this requirement.

### Outlet

An outlet that can automatically release stored material is not permitted except for septic tanks that feed a treatment system such as a waste treatment strip or leaching field or outlets leading to another storage facility with adequate capacity. Design a permanent outlet that will resist corrosion and plugging. Provide a backflow prevention measure for an outlet that pumps wastewater to secondary storage located at a higher elevations.

### Embankments

For an impoundment with greater than one acre of surface area and where wave action is a concern, increase the embankment height to account for calculated wave height. In all cases, increase the constructed embankment height by at least 5 percent to allow for settlement. Stabilize all embankments to prevent erosion or deterioration.

Minimum embankment top widths are shown in table 3. Design the combined side slopes of the settled embankment to be equal to or flatter than 5 horizontal to 1 vertical, with neither slope steeper than 2 horizontal to 1 vertical unless provisions are made for stability. (Lined ponds may require flatter inside slopes as described in NRCS Practice Standard 521, Pond Sealing and Lining). The total embankment height (effective height) is the difference in elevation between the auxiliary (emergency) spillway crest or the settled top of the embankment if there is no auxiliary spillway and the lowest point in the cross section taken along the centerline of the embankment.

Table 3. Minimum Top Widths

Total embankment height (ft)	Top width (ft)
Less than 15	8
15–19.9	10
20–24.9	12
25–30	14
30–35	15

### Spillway or Equivalent Protection

For a facility having a total embankment height greater than 20 feet, construct an auxiliary (emergency) spillway or route through the spillway or store below the spillway another volume equivalent to the emergency volume.

### Excavations

Design excavated side slopes to meet the requirements of the liner used, see NRCS Practice Standard Pond Sealing or Lining, Compacted Soil Treatment (Code 520), Pond Sealing or Lining, Flexible Membrane (Code 521a) or Pond Sealing or Lining, Concrete (Code 522), .

### Additional Criteria for Fabricated Structures

#### Foundation

Based on subsurface investigation, provide a foundation for fabricated waste storage structures to safely support all superimposed loads without excessive movement or settlement. Perform subsurface investigations for all fabricated structures sufficient in detail and analysis to support the design in accordance with NRCS NEM, Part 531, Geology. Describe the soil material encountered, location of any seeps, depth to high water table, depth to bedrock, and presence of sink holes in karst topography.

Where a non-uniform foundation cannot be avoided or where applied loads may create highly variable foundation loads, calculate settlement based upon 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 are available, use presumptive bearing strength values for assessing actual bearing pressures obtained from table 4 or another nationally recognized building code. In using presumptive bearing values, provide adequate detailing and articulation to avoid distressing movements in the structure.

For bedrock foundations with joints, fractures, or solution channels, separate the floor slab and the bedrock by—

- A minimum of 1 foot of soil.
- A liner that meets or exceeds Practice Standard NRCS Pond Sealing or Lining (Codes 520, 521, or 522).
- Other appropriate method or alternative that achieves equal protection.

Table 4. Presumptive Allowable Foundation and Lateral Pressure<sup>1</sup>

Class of materials	Allowable foundation pressure (psf)	Lateral bearing (psf/ft) below natural grade	Coefficient of friction	Cohesion (psf)
Crystalline bedrock	12,000	1,200	0.70	-
Sedimentary and foliated rock	4,000	400	0.35	-

Class of materials	Allowable foundation pressure (psf)	Lateral bearing (psf/ft) below natural grade	Coefficient of friction	Cohesion (psf)
Sandy gravel or gravel (GW and GP)	3,000	200	0.35	-
Sand, silty sand, clayey sand, silty gravel, clayey gravel (SW, SP, SM, SC, GM and GC)	2,000	150	0.25	-
Clay, sandy clay, silty clay, clayey silt, silt and sandy silt (CL, ML, MH and CH)	1,500	100	-	130

<sup>1</sup> International Building Code (IBC), 2015, International Code Council (ICC)

### Structural Loadings

Design the waste storage structure to withstand all anticipated loads in accordance with the requirements in NRCS NEM, Part 536, Structural Design. Such loads should include internal and external loads, hydrostatic uplift pressure, concentrated surface and impact loads, and water pressure due to seasonal high water table, frost or ice pressure and load combinations in compliance with this standard and applicable local building codes.

Calculate loading from lateral earth pressures using soil strength values determined from the results of appropriate soil tests and procedures described in NRCS Technical Release 210-74, Lateral Earth Pressures. Table 5 provides minimum lateral earth pressure values when soil strength tests are not available. If heavy equipment will operate near the wall, use an additional soil surcharge or an additional internal lateral pressure in the wall analysis as appropriate.

For the lateral load from stored waste not protected from precipitation, use a minimum 65 lb/ft<sup>2</sup>/ft of depth as the design internal lateral pressure. Use a minimum value of 60 lb/ft<sup>2</sup>/ft of depth for the lateral load from stored waste protected from precipitation and not likely to become saturated. Use a minimum internal lateral pressure of 72 lb/ft<sup>2</sup>/ft of depth for sand-laden manure storage if the percentage of sand exceeds 20%. Designers may use lesser values if supported by measurement of actual pressures of the waste to be stored.

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 Structures Due to Use, and in ASAE EP 393.2, 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. 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.

Table 5. Minimum Lateral Earth Pressure Values<sup>1</sup>



Description of backfill material <sup>c</sup>	Unified soil classification	Design lateral soil load (lb/ft <sup>2</sup> /ft of depth) <sup>a</sup>	
		Active pressure	At-rest pressure
Well-graded, clean gravels; gravel-sand mixes	GW	30	60
Poorly graded clean gravels; gravel-sand mixes	GP	30	60
Silty gravels, poorly graded gravel-sand mixes	GM	40	60
Clayey gravels, poorly graded gravel-sand mixes	GC	45	60
Well-graded, clean sands; gravelly sand mixes	SW	30	60
Sand-silt clay mix with plastic fines	SP	30	60
Silty sands, poorly graded sand-silt mixes	SM	45	60
Sand-silt clay mix with plastic fines	SM-SC	45	100
Clayey sands, poorly graded sand-clay mixes	SC	60	100
Inorganic silts and clayey silts	ML	45	100
Mixture of inorganic silt and clay	CL-ML	60	100
Inorganic clays of low to medium plasticity	CL	60	100
Organic silts and silt clays, low plasticity	OL	Note b	Note b

Description of backfill material <sup>c</sup>	Unified soil classification	Design lateral soil load (lb/ft <sup>2</sup> /ft of depth) <sup>a</sup>	
		Active pressure	At-rest pressure
Inorganic clayey silts, elastic silts	MH	Note b	Note b
Inorganic clays of high plasticity	CH	Note b	Note b
Organic clays and silty clays	OH	Note b	Note b

<sup>1</sup> Table 1610.1, Lateral Soil Load, International Building Code (IBC), 2015, International Code Council (ICC).

<sup>a</sup> Design loads based on moist conditions for the specified soils at optimum density. Include the weight of the buoyant soil plus hydrostatic pressure for submerged or saturated soil.

<sup>b</sup> Unsuitable as backfill material.

<sup>c</sup> Base the definition and classification of soil in accordance with ASTM D 2487.

### Structural Design

The structural design shall consider all items that will influence the performance of the structure, including loading assumptions, durability, serviceability, material properties and construction quality. Design assumptions and construction requirements shall be indicated on standard plans. Ensure that the material used for a fabricated structure is compatible with the waste product to be stored. All structures shall be underlain by free draining material or shall have a footing located below the anticipated frost depth.

Design structures with, steel, wood, or masonry materials shall be in accordance with NRCS-NEM, Part 536, Structural Engineering. Design of structures with reinforced concrete shall be according to the criteria of the Code Requirements for Environmental Concrete Structures, ACI 350, American Concrete Institute, NRCS National Engineering Handbook 6, Structural Design or NRCS Technical Release 67, Reinforced Concrete Strength Design.

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.

### 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. Design slabs-on-ground subject to regular or frequent heavy truck or heavy agricultural equipment traffic in accordance with ACI *Guide to Design of Slabs-on-Ground (ACI 360R)*. Design liquid-tight slabs in accordance with ACI *Code Requirements for Environmental Concrete Structures, Slabs-on-Soil (ACI 350, Appendix H)*.

Where applied point loads are minimal and liquid-tightness is not required, such as barnyard and feedlot slabs which store only manure solids (20% or more solids) removed by a mechanical separator or equivalent, and subject only to precipitation, and the subgrade is uniform and dense, the minimum slab thickness shall be 4 inches. Maximum contraction joint spacing of plain concrete slabs shall be 10 feet. Joint lay out and joint type details need to be shown on the construction drawings.

### Sensitive Environmental Settings

Where liquid-storage is to be provided in sensitive environmental settings (i.e., tanks in areas with shallow wells in surface aquifers, high-risk karst topography, or other site-specific concerns), design the storage

structure as a reinforced concrete service hydraulic or environmental structure according to NRCS NEM, Part 536, Structural Design. Alternatively, use a flexible liner membrane, designed and constructed in accordance with standard engineering and industry practice, to provide secondary liquid containment for structures constructed with other methods described in NRCS NEM, Part 536, Structural Design. Applications such as tanks, that require liquid tightness shall be designed and constructed in accordance with standard engineering and industry practice appropriate for the construction materials used to achieve this objective.

### **Additional Criteria - Stacking Facilities**

A stacking facility may be open, covered, or roofed and is used for wastes which behave primarily as solid. Determine the wall height using the anticipated stacking angle of the waste material. Construct a stacking facility of durable materials such as reinforced concrete, reinforced concrete block, or treated lumber. Design the stacking facility with adequate safety factors to prevent failure due to internal or external pressures, including hydrostatic uplift pressure and imposed surface loads such as equipment which may be used within, on, or adjacent to the structure.

### **Seepage**

Prevent leachate in amounts that would pollute surface or groundwater with collection and disposal of liquids in a safe manner as necessary. Prevent influent seepage in amounts that would infringe on designed storage capacity. Seepage control may not be necessary on sites that have a roof, waste material with little seepage potential or in certain climates.

### **Internal Drainage**

Make provisions for drainage of leachate, including rainfall from the stacking area (especially those without a roof). Collect leachate in a tank or waste storage impoundment, or properly treat in a lagoon or vegetated treatment area.

### **Poultry Litter Stacking Facility**

To reduce the potential for spontaneous combustion damage to wood walled facilities, design the height of the litter stack not to exceed 7 feet, with litter to wood contact limited to 5 feet.

## **CONSIDERATIONS**

For exposed liners utilizing HDPE or similar materials that are slippery when wet, consider the use of textured liners or addition of features such as tire ladders that would allow for escape from the waste storage structure.

Consider solid/liquid separation of runoff or wastewater entering impoundments 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.

Since the economics and risks associated with waste storage facilities are quite high, consider providing the operator with the cost to close the facility. Cost should include removal of the planned sludge accumulation volume and the waste stored at the maximum operating volume.

### **Considerations for Siting**

Consider the following factors in selecting a site for waste storage facilities:

- Proximity of the waste storage facility to the source of waste.
- Access to other facilities.
- Ease of loading and unloading waste.
- Compatibility with the existing landforms and vegetation, including building arrangement, to minimize odors and adverse impacts on visual resources.

- Adequate maneuvering space for operating, loading, and unloading equipment.

**Considerations for Minimizing the Potential for and Impacts of Sudden Breach of Embankment or Accidental Release from the Waste Storage Facility**

Consider 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 when any of the categories listed below might be significantly affected.

Potential impact categories from breach of embankment or accidental release include—

- 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 archaeological sites or structures that meet the eligibility criteria for listing in the National Register of Historical Places.

Consider the following either singly or in combination to minimize the potential of or the consequences of sudden breach of embankments:

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

Options to consider to minimize the potential for accidental release from the waste storage facility through gravity outlets include—

- Outlet gate locks or locked gate housing.
- Secondary containment.
- Alarm system.
- Another nongravity means of emptying the waste storage facility.

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

Avoid sites with categories listed below unless no reasonable alternative exists.

Potential impact categories for liner failure are—

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

For a site with one or more of these site conditions, consider providing a leak detection system in conjunction with the planned liner to provide an additional measure of safety.

### **Considerations for Stacking Facilities**

Internal seepage collection within a stacking facility can be accomplished by use of a timber wall with the boards installed vertically, leaving 3/4-inch cracks. The timber wall drainage section may be included in a concrete or masonry block wall. Use the design criteria for timber walls.

For any facility that is an organic producer or that sells manure to organic producers, consider using rot-resistant or treated lumber that meets the requirements for organic production. The producer should consult with the organic certifier as to the use and acceptability of treated lumber for waste storage.

### **Considerations for Improving Air Quality**

Liquid manure storage may result in emissions of volatile organic compounds, ammonia, hydrogen sulfide, methane, nitrous oxide, and carbon dioxide. Solid manure storage may result in emissions of particulate matter, volatile organic compounds, ammonia, carbon dioxide, and nitrous oxide.

To reduce emissions of greenhouse gases, ammonia, volatile organic compounds, particulate matter and odor, other NRCS Practice standards such as Anaerobic Digester (Code 366), Roofs and Covers (Code 367), Waste Treatment (Code 629), Amendments for Treatment of Agricultural Waste (Code 591), Composting Facility (Code 317), and Air Filtration and Scrubbing (Code 371) can be added to the waste management system.

Adjusting pH below 7 may reduce ammonia emissions from the waste storage facility but may increase odor when waste is surface applied—see NRCS practice Standard Nutrient Management (Code 590).

Some fabric and organic covers have been shown to be effective in reducing odors.

Maintain appropriate manure moisture content for solid manure storage facilities. Excessive moisture will increase the potential for air emissions of volatile organic compounds, ammonia, and nitrous oxide, and may lead to anaerobic conditions, which will increase the potential for emissions of methane and hydrogen sulfide. Too little moisture will increase the potential for particulate matter emissions.

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 AWMFH Figure 10-22.

## **PLANS AND SPECIFICATIONS**

Prepare plans and specifications that describe the requirements for applying the practice to achieve its intended use. As a minimum, include the following in the engineering plans and specifications:

- Plan view of system layout.
- Structural details of all components, including reinforcing steel, type of materials, thickness, anchorage requirements, lift thickness.
- Locations, sizes, and type of pipelines and appurtenances.
- Requirements for foundation and preparation and treatment.
- Vegetative requirements.
- Quantities.
- Approximate location of utilities and notification requirements.

## **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 criteria for its design. At a minimum, the plan will contain where appropriate:

Include the operational requirements for emptying the storage facility including the expected storage period. Begin removal of the liquid storage facility as soon as practical after the maximum operating level has been reached. Also include the requirement that waste be removed from storage and utilized at locations, times, rates, and volume in accordance with the overall waste management system plan.

For impoundments and other liquid storages include an explanation of the staff gauge or other permanent marker to indicate the maximum operating level. For storages where the contents are not visible and a staff gauge would not be visible, such as below a slatted floor, identify the method for the operator to measure the depth of accumulated waste.

Include a provision for emergency removal and disposition of liquid waste in the event of an unusual storm event that may cause the waste storage structure to fill to capacity prematurely.

Include instructions as needed for ventilating confined spaces according to ASABE Standard S607, Venting Manure Storages to Reduce Entry Risk.

Develop an emergency action plan for waste storage facilities where there is a potential for significant impact from breach or accidental release. Include site-specific provisions for emergency actions that will minimize these impacts.

Include a description of the routine maintenance needed for each component of the facility. Also include provisions for maintenance that may be needed as a result of waste removal or material deterioration.

## REFERENCES

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