USDA
NATURAL RESOURCES
CONSERVATION SERVICE

MARYLAND CONSERVATION
PRACTICE STANDARD

WASTE TREATMENT LAGOON

CODE 359
(Reported by No.)

DEFINITION

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

PURPOSE

To biologically treat waste, such as manure and wastewater, and thereby reduce pollution potential by serving as a treatment component of a waste management system.

CONDITIONS WHERE PRACTICE APPLIES

This practice is applicable where:

1. The lagoon is a planned component in a comprehensive nutrient management plan (CNMP) or a Waste Management Plan (WMP);

2. Treatment is needed for organic wastes generated by agricultural production or processing;

3. The lagoon can be constructed, operated and maintained without polluting air or water resources; and,

4. Lagoons utilizing embankments will have an effective embankment height of 35 feet or less, and damage resulting from failure would be limited to damage of farm buildings, agricultural land, or county roads. Embankments are limited to hazard class (a). Refer to the NRCS National Engineering Manual, Part 520.21, for guidance covering the documentation of hazard classification.

This standard does not apply to waste storage facilities, including waste storage ponds that are used for temporary storage (but not treatment) of wastes. Refer to the Maryland conservation practice standard for Waste Storage Facility, Code 313.

Local Requirements

This practice can only be applied when the laws, rules, and regulations established by the Maryland Department of the Environment and local units of government are met. Local requirements related to such items as depth to groundwater and structure setback need to be incorporated into the siting and design of the practice.

CONSIDERATIONS

General

Lagoons should be located as close to the source of waste as possible.

Solid/liquid separation treatment should be considered between the waste source and the lagoon to reduce loading.

The configuration of the lagoon should be based on the method of sludge removal and method of sealing.

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

Improving Air Quality

To reduce emissions of greenhouse gases, ammonia, volatile organic compounds, and odor:

1. Consider reducing the recommended loading rate for anaerobic lagoons to one-half the values given in the NRCS Agricultural Waste Management Field Handbook (AWMFH), Figure 10-22;

2. Consider alternatives and the need for additional practices such as Composting Facility (Code 317);

3. Consider that aerated lagoons may increase

emissions of ammonia and decrease odors. Adjusting pH below 7 may reduce ammonia emissions from the lagoon but may increase odor when waste is surface applied. (Refer to the Maryland conservation practice standard for Waste Utilization, Code 633.);

4. Consider liquid/solid separation prior to discharge to lagoon will reduce volatile solids (VS) loading resulting in reduced gaseous emissions and odors. Composting of solids will further reduce emissions;

5. Consider designing lagoons to be naturally aerobic or to allow mechanical aeration.

Minimizing the Potential for and Impacts of Sudden Breach of Embankments or Accidental Release from the Required Volume

Features, safeguards, and/or management measures to minimize the risk of embankment 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 1 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 1 may be significantly affected:

1. An auxiliary (emergency) spillway;

2. Additional freeboard;

3. Storage volume for the wet year rather than normal precipitation;

4. Reinforced embankment – such as, additional top width, flattened and/or armored downstream side slopes;

5. Secondary containment;

6. Water level indicators or recorders.

Table 1 – Potential Impact Categories from Breach of Embankment or Accidental Release

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

The following 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 1 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.

Minimizing the Potential of Lagoon Liner Seepage

Consideration should be given to providing an additional measure of safety from lagoon seepage when any of the potential impact categories listed in Table 2 may be affected.

Table 2 – Potential Impact Categories for Liner Seepage

1. Any underlying aquifer is at shallow depth and not confined; 2. The vadose zone is rock; 3. The aquifer is a domestic water supply or ecologically vital water supply; 4. The site is located in an area of carbonate rock (limestone or dolomite).

Should any of the potential impact categories listed in Table 3 be affected, consideration should be given to the following:

1. A clay liner designed in accordance with procedures of AWMFH, Appendix 10D with a thickness and coefficient of permeability so that specific discharge is less than 1 x 10^{-6} cm/sec;

2. A flexible membrane liner;

3. A geosynthetic clay liner (GCL) flexible membrane liner;

4. A concrete liner designed in accordance with slabs on grade criteria, Waste Storage Facility (313), for fabricated structures requiring water tightness.

CRITERIA

General

Types - Waste treatment lagoons are of two general types: anaerobic and aerobic. The term "anaerobic" implies an absence of air or free oxygen and refers to the type of bacteria required to break down the wastes. Since anaerobic bacteria cannot survive in the presence of free oxygen, an anaerobic lagoon should be designed to limit the availability of oxygen in the system. These lagoons will be deep and will have a low surface area-to-volume ratio.

Aerobic lagoons may either be naturally aerobic or mechanically aerated; both are designed to promote the growth of bacteria which are oxygen dependent. The naturally aerobic lagoons have a large surface area in order to enhance the movement of wind across the lagoon surface and, thus, to increase oxygen transfer to the water. This type of lagoon is shallow in order to provide natural mixing of oxygen throughout its full depth. The shallow depth also allows sunlight to penetrate nearly to the bottom, thereby promoting algae growth. Algae in the presence of sunlight produce large quantities of oxygen. Mechanically aerated lagoons have oxygen added through mechanical mixing of the water.

Location – Construct the lagoon in such a way as to avoid leakage and potential ground water pollution. Locate the lagoon as near to the source of waste as practicable and at least 300 feet away from neighboring dwellings. If possible, locate the lagoon where prevailing winds will carry odors away from residences and public areas. Do not allow runoff from adjacent drainage areas to enter the lagoon.

Locate the lagoon and its appurtenances outside the 100-year floodplain when feasible. If the only practical alternative is to locate the structure within the 100-year floodplain, design the facility to protect from inundation and damage from the 25-year frequency flood event or larger if required by laws, rules, and regulations. Lagoons shall be located so the potential impacts from breach of embankment, accidental release, and liner failure are minimized.

Construction activity within the 100-year floodplain requires permits or authorizations from the Maryland Department of the Environment and/or the U.S. Army Corps of Engineers. Obtain all applicable permits and authorizations prior to start of construction.

Soils and Foundation - Site soil characteristics will be investigated by borings made at least two feet below the planned lagoon bottom. Lagoons must be placed in impervious soils or soils suitable for sealing.

The pond bottom elevation must be a minimum of 2 feet above the high water table.

Provide one of the following:

1. A clay liner designed in accordance with procedures of AWMFH, Appendix 10D, with a thickness and coefficient of permeability so that specific discharge is less than 1 x 10 –6 cm/sec. See NEH Part 650, Figure 4-14, for soil permeability rates;

2. A flexible membrane or geosynthetic clay liner (GCL) flexible membrane liner meeting the requirements of the Maryland conservation practice standard for Pond Sealing or Lining, Flexible Membrane (Code 521A);

3. A concrete liner designed in accordance with slabs on grade criteria for fabricated structures requiring water tightness.

Karst Areas – Karst (limestone) areas are characterized by sinkholes, caves, and rapid subsurface drainage making them particularly susceptible to groundwater contamination. Locating animal waste storage facilities in Karst regions creates particular concern due to the potential for sinkholes to develop beneath the structure.

Provide one of the following:

1. A flexible membrane liner over a fine grain material with a low permeability rate. A minimum of two feet of (fine grained) material is required;

2. A geosynthetic clay liner (GCL) flexible membrane liner over a minimum 2 feet of fine grain material with a low permeability rate;

3. A concrete liner designed in accordance with slabs on grade criteria for fabricated structures requiring water tightness. A minimum of two feet of fine grain material with low permeability is required underneath the concrete liner.

In addition to the above, provide subsurface drainage on all waste treatment lagoons constructed below grade and divert surface drainage away from the lagoon.

Treatment Period - The treatment period is the detention time between drawdown events. It shall be the greater of either the 60 days; or the time required to provide the storage that allows environmentally safe utilization of waste considering the climate, crops, soil, and equipment requirements; or as required by local, state, and Federal regulations.

Solids Removal - To reduce sludge buildup, remove solids from waste of animals such as dairy cattle that are fed high roughage rations. Provide a solids trap or a separator between the waste sources and the lagoon. This may be a concrete or earth structure that can be emptied periodically. Provide a minimum of 7 days storage in the separator for milking center waste. If earth structures are used, plan a minimum of two so that one can be dried and cleaned while the other is functioning.

Inlet - Where freezing is not a problem, an open inlet consisting of a concrete ditch may be used. Preference should be given to "V" section ditches to keep velocities high during low flows.

Where freezing is a problem, the inlet shall consist of a pipe with a minimum diameter of six (6) inches, a minimum slope of one (1) percent and minimum cover of 24 inches. Flushing type flow will keep the pipe free of debris, and during periods of no flow, the pipe will remain dry and will be less likely to freeze. Access to the pipe for cleanout must be provided in case of blockage. Rigidly support and terminate the inlet pipe beyond the inner toe of the cut or fill.

Design inlets to resist corrosion, plugging, and freeze damage by incorporating erosion protection as necessary. Provide a water-sealed trap and vent or similar devices to control gas entry into the buildings or other confined spaces on all inlets in enclosed buildings.

Excavations – Unless supported by a soil investigation, excavated side slopes shall be no steeper than 2 horizontal to 1 vertical.

Outlet - Outlets that automatically release storage from the required storage volume are not permitted. Manually operated outlets shall be of permanent type designed to resist corrosion and plugging. Waste treatment lagoons shall not discharge to surface waters unless the owner determines through the state regulatory agency that such discharge meets water quality standards.

Transfer Lines – A dual valve system or backflow preventer is required on all transfer systems where pipelines are used to convey wastes by gravity or by pumping, and failure of the containment valve may result in accidental release or discharge.

Bottom and Edges – To reduce areas of shallow water and to inhibit weed growth construct the edges of all lagoons below the planned waterline as steep as soil conditions permit. Construct the bottom of aerobic lagoons so that they are approximately level.

Facility Drawdown – Measures that facilitate safe drawdown of the liquid level in the lagoon shall be provided. Access areas and ramps used to withdraw waste shall have slopes that facilitate a safe operating environment. Dock, wells, pumping platforms, retaining walls, etc. shall

permit drawdown without causing erosion or damage to liners.

Safety – Include appropriate safety features to minimize the hazards of the facility. The lagoon shall be fenced around the perimeter and warning signs posted to prevent children and others from using it for other than its intended purpose.

Vegetation – Use the Maryland conservation practice standard for Critical Area Planting (Code 342) to determine the appropriate grass species to be established based on site conditions and use. Do not use plants listed on the Maryland noxious weed list.

Anaerobic Lagoons

Sizing - The maximum operating level of an anaerobic lagoon is a volume requirement plus a depth requirement. The volume requirement is the sum of the following:

1. Minimum treatment volume (MTV), ft^3;
2. Manure volume and wastewater volume (WV), ft^3; and,
3. Sludge volume (SV), ft^3.

The MTV is based on the volatile solids loading rate given in Table 3. Information on the WV and SV is provided in Chapter 10 of the Agricultural Waste Management Field Handbook.

The minimum sludge accumulation period is 15 years. A minimum depth of 6 feet must be maintained in anaerobic lagoons except during sludge cleanout. In addition, sufficient depth must be provided to accommodate the following volumes during the storage period:

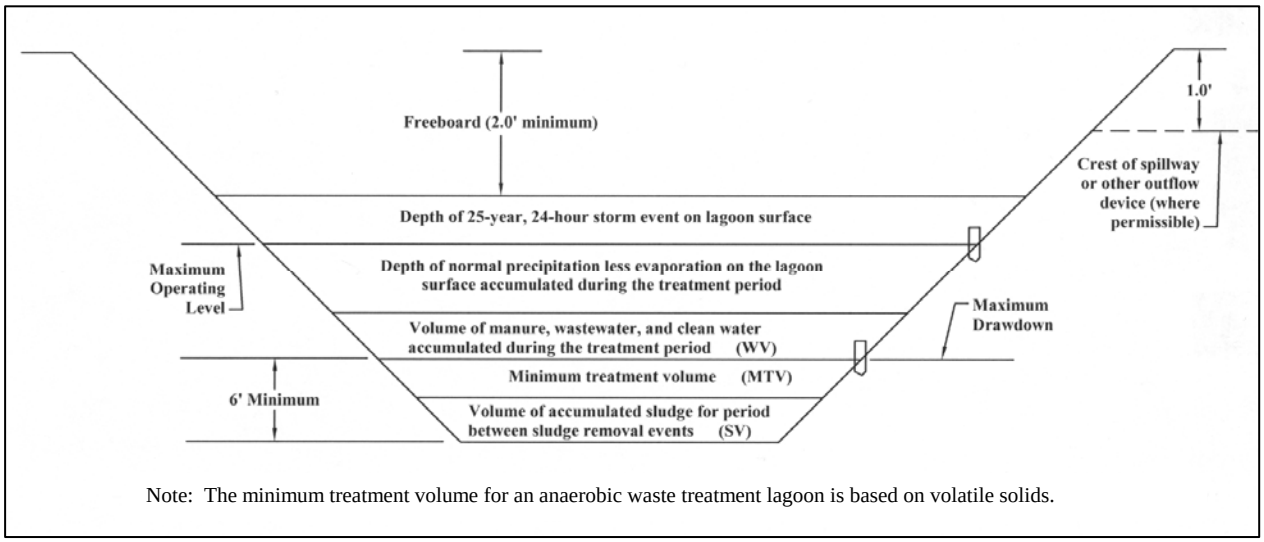
1. Normal precipitation less evaporation on the lagoon surface;
2. The 25-year, 24-hour storm precipitation on the lagoon surface; and,
3. Freeboard.

The combination of these volumes and depths is illustrated in Figure 1. The terms are explained in Chapter 10 of the Agricultural Waste Management Field Handbook.

Table 3 - Anaerobic Lagoon Loading Rate
(pounds of volatile solids/1000 ft^3/day)

County	Lbs.	County	Lbs.
Allegany	2.4	Howard	2.6
Anne Arundel	2.7	Kent	2.6
Baltimore	2.5	Montgomery	2.6
Calvert	2.7	Prince George's	2.4
Caroline	2.7	Queen Anne's	2.7
Carroll	2.5	St. Mary's	2.8
Cecil	2.6	Somerset	2.8
Charles	2.7	Talbot	2.7
Dorchester	2.8	Washington	2.4
Frederick	2.5	Wicomico	2.8
Garrett	2.4	Worchester	2.8
Harford	2.6		

Multiple cells may be used. If a 2-stage lagoon is designed, effluent from the second stage will be of higher quality. The primary cell is designed to contain at a minimum the MTV and SV and the cell is not pumped below the minimum treatment level. The secondary cell is sized for the WV plus one-half of the primary MTV, plus the volume of rainfall minus evaporation during the storage period and the 25-year, 24-hour storm. Do all pumping from the second cell.



Note: The minimum treatment volume for an anaerobic waste treatment lagoon is based on volatile solids.

Figure 1 - Anaerobic Lagoon Cross-Section.

Aerobic Lagoons

The design of aerobic lagoons is based on the amount of BOD_5 added per day and waste and sludge volumes. The BOD_5 loading rate determines lagoon surface area and the waste and sludge volumes dictate lagoon depth. See Table 4 for BOD_5 loading rates. Sludge volumes (SV) and waste volumes (WV) are provided in Chapter 10 of the Agricultural Waste Management Field Handbook.

Table 4 - Aerobic Lagoon Loading Rate
(pounds of BOD_5/acre/day)

County	Lbs.	County	Lbs.
Allegany	38	Howard	40
Anne Arundel	42	Kent	42
Baltimore	40	Montgomery	40
Calvert	43	Prince George's	42
Caroline	43	Queen Anne's	42
Carroll	39	St. Mary's	43
Cecil	41	Somerset	45
Charles	42	Talbot	43
Dorchester	43	Washington	39
Frederick	39	Wicomico	45
Garrett	38	Worchester	46
Harford	40		

The operating depth must range from 2 feet minimum to 5 feet maximum. In addition, sufficient depth must be provided to accommodate the following volumes during the storage period:

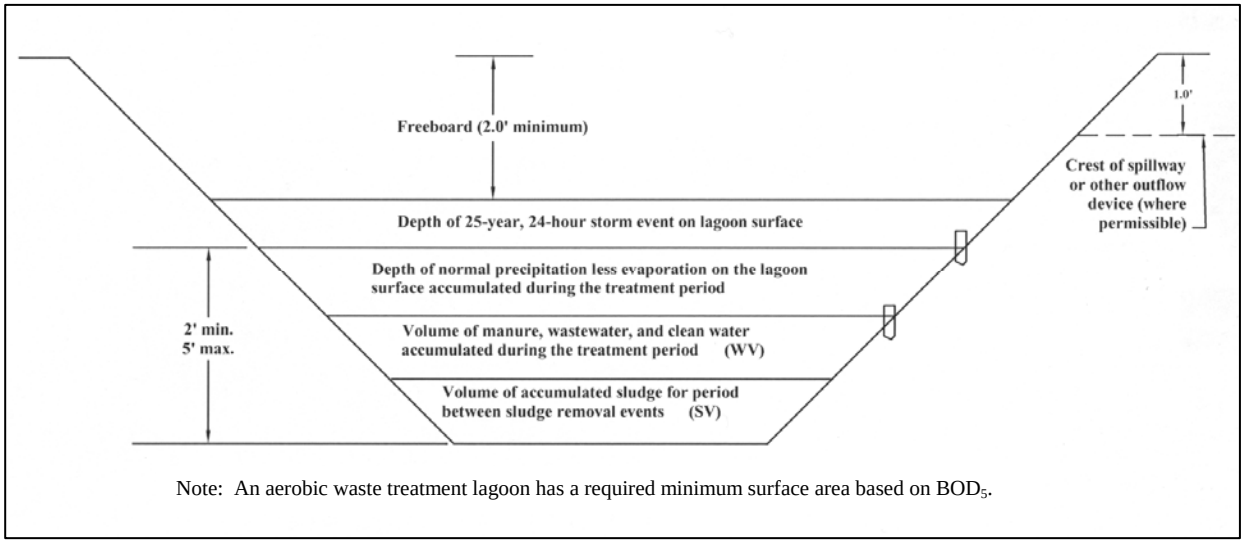
1. Normal precipitation less evaporation on the lagoon surface;

2. The 25-year, 24-hour storm precipitation on the lagoon surface; and,

3. Freeboard.

The combination of these volumes and depths is illustrated in Figure 2. The terms are explained in Chapter 10 of the Agricultural Waste Management Field Handbook.

Mechanically aerated lagoons are designed on the basis of BOD_5 or ultimate BOD loading and on the basis of the equipment manufacturer's performance data for oxygen transfer and mixing. When used for odor control, provide aeration equipment capable of a minimum of 1 pound of oxygen for each pound of BOD_5 contributed daily.



Note: An aerobic waste treatment lagoon has a required minimum surface area based on BOD_5.

Figure 2 - Aerobic Lagoon Cross-Section.

Earth Embankment

The following criteria are applicable to waste storage lagoons that have embankments.

Top Width - The minimum top width of the embankment is shown in Table 5. If the embankment needs to be crossed periodically by vehicles, the minimum top width is 10 feet. Guardrails or other safety measures are to be used where necessary.

For this standard, the maximum effective height of the dam is 35 feet.

Table 5 – Top Width of Embankment

Total Height of Embankment (feet)	Minimum Top Width (feet)
14.9 or less	8
15 – 19.9	10
20 – 24.9	12
25 – 29.9	14
30 – 35	15

Side Slopes - The minimum combined side slopes of the settled embankment are five horizontal to one vertical (5:1) with neither slope steeper than 2:1. Slopes must be designed to be stable in all cases, even if flatter side slopes are required. Treat disturbed areas surrounding the facility to control erosion.

Auxiliary Spillway - Design the lagoon with an auxiliary (emergency) spillway. Locate the spillway at the design high storage elevation or higher. The minimum bottom width of the spillway is 8 feet.

In lieu of an auxiliary spillway, a reinforced embankment may be provided. Increase the required embankment top width by two feet and increase the back slope of the dam to a slope no steeper than 5 horizontal to 1 vertical.

Allowance for Settlement – Increase the design height of the embankment by 5 percent to insure that the design top of fill elevation will be maintained after all settlement has taken place.

PLANS AND SPECIFICATIONS

Plans and specifications for waste treatment lagoons shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

All references in this standard to ASTM and AASHTO specifications apply to the most recent version.

OPERATION AND MAINTENANCE

Develop a written operation and maintenance plan that is consistent with the purposes of the practice, its intended life, safety requirements, and design criteria. At a minimum, include operational requirements compliant with the overall Comprehensive Nutrient Management Plan (CNMP) or the Waste Management Plan (WMP) and other requirements as shown below. Include additional requirements for maintenance of the facility as needed.

Lagoons must be managed properly if they are to function as designed. Specific instructions about lagoon operation and maintenance must be included in the overall comprehensive nutrient management plan.

There are several factors that are involved in the operation that have a direct effect on the success of the lagoon, as follows:

Initial Loading - Following construction, a lagoon must be pre-charged with fresh water before any waste can be placed in it.

To enhance the operation of a new lagoon, it is best to start loading waste in the spring in order to maximize the number of warm months for bacterial action.

Monitoring pH - The pH should be measured frequently. Many problems associated with lagoons are related to pH in some manner. For this reason, it is mandatory that the waste is sampled and an analysis is obtained so that the waste can be better utilized and that potential environmental problems are avoided.

Operating Levels - Lagoons are designed based on a given loading rate. If an increase in the number of animals is anticipated, sufficient capacity to handle the entire expected waste load should be available. The most common problem in using lagoons is overloading, which can lead to odors, malfunctioning and sludge accumulation. Periodically, sludge accumulation levels should be checked to assure the lagoon is functioning as designed.

The maximum operating level should be marked with a staff gage set in the lagoon or by other means to indicate when drawdown is needed. The minimum operating level should be that level needed for the design loading except when the lagoon is drawn down to permit sludge removal or addition of dilution water.

Normally an anaerobic lagoon is managed so that the liquid level is maintained at or below the maximum operating level. The liquid level is lowered to the minimum treatment level at the end of the treatment period.

SUPPORTING DATA AND DOCUMENTATION

Field Data and Survey Notes

The following is a list of the minimum data needed:

1. System plan sketch;
2. Topographic survey of the site showing building locations, elevations at structure location and at outlets from barns, separators, etc., location of dwellings, wells, floodplains, etc.;
3. Soils investigation showing seasonal high water table;
4. Operator data.

Design Data

Record on appropriate engineering paper. For guidance on the preparation of engineering plans see Chapter 5 of the EFH, Part 650. The following is a list of the minimum required design data:

1. Comprehensive Nutrient Management Plan or Waste Management Plan;
2. Plan view including, location map, all system components, material and construction specifications;
3. Complete design computations including a completed AWMFH worksheet 10A-3 or 10A-4 or equivalent;
4. Construction drawings including profile along centerline of embankment, cross sections of embankment and pool area, and component details;
5. Structure and component design and details;
6. Area grading plan;
7. Quantities estimate;
8. Job class on plan;
9. Details of foundation drainage, when required;
10. Planting plan. This must meet the criteria, specifications, and documentation requirements of the Maryland conservation practice standard for Critical Area Planting, Code 342.

Construction Check Data/As-built

Record on survey notepaper, SCS-ENG-28, or other appropriate engineering paper. Survey data will be plotted on plans in red. The following is a list of minimum data needed for As-builts:

1. Documentation of site visits on CPA-6. Include the date, who performed the inspection, specifics as to what was inspected, all alternatives discussed, and decisions made and by whom;
2. Actual dimensions of installed structure;
3. Verification of adequate foundation preparation;
4. Documentation of installation of foundation drainage;
5. Documentation of reinforcing steel and proper concrete installation, if applicable;
6. Condition of precast panels, if applicable;
7. Certification that work meets plans and specifications;
8. Statement on seeding and fencing;
9. Final quantities and documentation for quantity changes, and materials certification;
10. Sign and date check, notes and plans by a person with appropriate job approval authority. Include statement that practice meets or exceeds plans and NRCS practice standards.

REFERENCES

1. American Society for Testing and Materials, *ASTM Standards*, Philadelphia, Pennsylvania.

2. Maryland Department of Transportation, State Highway Administration, *Standard Specifications for Construction and Materials*, Baltimore, Maryland, January 2001.

3. MidWest Plan Service, MWPS-18, *Livestock Waste Facilities Handbook*, 1975.

4. USDA, Natural Resources Conservation Service, *Maryland Field Office Technical Guide, Section IV, Standards and Specifications.*

5. USDA, Natural Resources Conservation Service, *National Engineering Handbook, Part 650.*

6. USDA, Natural Resources Conservation Service, *National Engineering Handbook, Part 651, Agricultural Waste Management Field Handbook.*

7. USDA, Natural Resources Conservation Service, *National Engineering Manual.*

8. USDA, Natural Resources Conservation Service, *National Handbook of Conservation Practices.*