PART IV - SEALING PONDS AND RESERVOIRS

1. SEALING METHODS

GENERAL

Excessive seepage losses in farm ponds usually are due to the selection of a site where the soils are too permeable to hold water. This may be the result of inadequate site investigations in the planning stage. However, the need for water may be so important as to justify the selection of a permeable site. In such cases, plans for reducing seepage losses by sealing should be part of the design.

The problem of reducing seepage losses is one of reducing the permeability of the soils to a point where the losses become tolerable. Losses may be reduced by the methods discussed below, the choice of which will depend largely on the proportions of coarse grained sand and gravel and fine grained silt and clay in the soil. A thorough investigation of the materials to be sealed should be made by a soils scientist before the method of sealing is selected. In some cases it may be necessary to have a laboratory analysis of the materials.

SEALING BY COMPACTION ALONE

Pond areas containing a high percentage of coarse grained material can be made relatively impervious by compaction alone if the material is well graded from small gravel or coarse sand to fine sand, clay, and silt. This mathod of sealing is the least expensive of those presented in this chapter, but its use is limited to the soil conditions described.

The pond area should be cleared of all trees and other vegetation and all stump holes, crevices, and similar areas should be filled with relatively impervious material. The soil should be scarified to a depth of 8 to 10 inches with a disk, roto-tiller, pulverizer or similar equipment and all rocks and tree roots should be removed. The loosened soil should be rolled under optimum moisture conditions to a dense, tight layer with four to six passes of a sheepsfoot roller.

The thickness of the compacted seal should not be less than 8 inches for impoundments up to 10 feet in depth. Since seepage losses vary directly with the depth of water impounded, the thickness of the compacted seal should be increased proportionately when the depth of water exceeds 10 feet. This will require compacting the soil in two or more layers not exceeding 8 inches in thickness over that portion of the pond where the water depth exceeds 10 feet. In these cases the top layer or layers of soil will have to be removed and stockpiled while the bottom layer is being compacted.

USE OF CLAY BLANKETS

Pond areas containing high percentages of coarse grained soils but lacking sufficient amounts of clay to prevent high seepage losses can be

sealed by blanketing. The blanket should cover the entire area over which water is to be impounded. It should consist of material containing a wide range of particle sizes varying from small gravel or coarse sand to fine sand and clay in the desired proportions. Such material should contain approximately 20 percent by weight of clay particles.

The thickness of the blanket will depend on the depth of water to be impounded. The minimum thickness should be 12 inches for all depths of water up to 10 feet. The minimum should be increased by 2 inches for each foot of water over 10 feet. The construction procedure is similar to that described previously for constructing earth embankments.

Clay blankets require protection from cracking that results from drying or freezing and thawing. A cover of gravel, 12 to 18 inches thick, placed over the blanket may be used for this purpose. Blanketed areas should be protected by a cantilevered pipe or rock riprap where flow into the pond is concentrated.

SEALING WITH BENTONITE

Seepage losses in well graded coarse grained soils may be reduced by the addition of Bentonite. Bentonite is a fine textured colloidal clay that will absorb several times its own weight in water. At complete saturation it will swell from 8 to 15 times its original volume. When Bentonite is mixed in the correct proportions with the coarse grained material, and the mixture is thoroughly compacted and saturated, the particles of Bentonite will fill the pores in the material and make it nearly impervious. A laboratory analysis of the material is essential to determine the amount of Bentonite that should be applied per unit of area. Rates of application range from 1 to 3 pounds per square foot, depending on site conditions. Bentonite, upon drying, will return to its original volume and leave cracks in the pond area. For this reason, Bentonite is not recommended for ponds where a wide fluctuation in the water level is expected.

As with other methods, the pond area should be cleared of all vegetation and all holes, crevices and areas of exposed gravel should be filled or covered with suitable compacted material.

The soil moisture level in the area to be treated should be optimum for good compaction. If the area is found to be too wet, sealing operations should be postponed until moisture conditions are satisfactory. If the material is too dry, water should be added by sprinkling.

The Bentonite should be spread uniformly over the area to be treated at the rate determined by the laboratory analysis. The Bentonite is then thoroughly mixed with the soil to a depth of at least six inches with a roto-tiller, disk, or similar equipment. The area should then be compacted with four to six passes of a sheepsfoot roller.

Since considerable time may elapse between application of the Bentonite and the filling of the pond it may be necessary to protect the treated area by mulching with straw or hay anchored to the surface by the final passes of the sheepsfoot roller. Treated areas subject to inflow should be protected by riprap or other mechanical means.

TREATMENT WITH CHEMICAL ADDITIVES

Excessive seepage losses often occur in fine grained clay soils because of the arrangement of the clay particles which form a honeycomb structure. Such soils are said to be aggregated and have a relatively high permeability rate. The application of small amounts of certain chemicals to these aggregates may result in collapse of the open structure and rearrangement of the clay particles. The chemicals used are called dispersing agents.

For chemical treatment to be effective, the soils in the pond area should contain more than 50 percent of fine grained material (silt and clay finer than .074 mm diameter) and at least 15 percent of clay finer than .002 mm diameter. The soils should contain less than 0.5 percent soluble salts (based on dry soil weight). Chemical treatment is not effective in coarse grained soils.

While there are many soluble salts that meet the requirement of a dispersing agent, sodium polyphosphates are most commonly used. Tetrasodium Pyrophosphate (TSPP) and Sodium Tripolyphosphate (STPP) are most effective. These dispersants should be finely granular with 95 percent passing a No. 30 sieve and less than 5 percent passing a No. 100 sieve. They usually are applied at a rate of from 0.05 to 0.10 pounds per square foot. Sodium chloride, which is less effective, is applied at a rate of from 0.20 to 0.33 pounds per square foot. A laboratory analysis of the soils in the pond area is essential to determine which of these dispersing agents will be most effective and the rate at which it should be applied.

The dispersing agent is mixed with the surface soil and compacted to form a blanket. For depths of water up to 8 feet, the blanket thickness should be at least 6 inches. For depths of water greater than 8 feet, the blanket should be 12 inches thick treated in two 6-inch lifts. A minimum thickness of 12 inches is recommended for all areas in the range of water surface fluctuation.

The area to be treated should be cleared of all vegetation and trash. Rock outcrops and other exposed areas of highly permeable material should be covered with from 2 to 3 feet of fine grained soil. This material should then be thoroughly compacted. In cavernous limestone areas, the success or failure of the seal may depend upon the thickness and compaction of this initial blanket.

The soil moisture level in the area to be treated should be near optimum for compaction down to a depth of 12 inches. If the soil is too wet treatment should be postponed. Polyphosphates release water from the soil and the job could easily become too wet to handle. If the soil is too dry, water should be added by sprinkling.

The dispersing agent should be applied uniformly over the pond area at a rate determined by the laboratory analysis. The dispersant may be applied with a seeder, drill, fertilizer spreader or by hand broadcasting.

The dispersing agent should be thoroughly mixed into each 6-inch layer with a disk, roto-tiller, pulverizer or similar equipment. Operating the mixing equipment in two directions will produce best results. Each chemically treated layer should be thoroughly compacted with 4 to 6 passes of a sheepsfoot roller.

The treated blanket should be protected from puncture by livestock trampling. Areas near the normal waterline should also be protected from erosion by covering with a 12- to 18-inch blanket of gravel or other suitable material. Areas where inflow into the pond is concentrated should be protected with riprap or other erosion resistant materials such as concrete or metal pipe.

Due to rapid technologic advancements, new chemical additives are being developed constantly. Some of these may prove useful in reducing seepage losses.

USE OF FLEXIBLE MEMBRANES

Another method of reducing excessive seepage losses is the use of flexible membranes of Polyethylene, vinyl and butyl rubber.

Thin films of these materials are structurally weak but, if kept intact, they are almost completely watertight. Polyethylene films are less expensive and have better aging properties than vinyl. Vinyl is more resistant to impact damage and is readily seamed and patched with a solvent cement. Polyethylene can be joined or patched only by heat sealing. Butyl rubber can be joined or patched with a special cement.

These thin films must be protected from mechanical damage if they are to be serviceable. All polyethylene and vinyl rubber membranes should have a cover of earth or earth and gravel not less than 6 inches thick. Butyl rubber membranes need to be covered only in areas subject to travel by livestock. In these areas, a minimum cover of 9 inches should be used over all types of membranes. The bottom 3 inches of cover should not be coarser than silty sand.

All membranes should be of a quality that meets or exceeds the minimum requirements shown in the State Standards and Specifications for Pond Sealing or Lining. The minimum normal thickness should equal or exceed the value shown below for the soil material being covered and the type of membrane used.

Soil Material Not Coaser than:	Polyethylene	Vinyl	Butyl Rubber
Sands, Clean or Silty	8 mil.	8 mil.	15 mil.
Gravels, Clean, Silty or Clayey	15 mil.	15 mil.	30 mil.

The area to be lined should be drained and allowed to dry until the surface is firm and will support the men and equipment that must travel over it during installation of the lining.

The pond area should be cleared of all vegetation and all roots, sharp stones or other objects that might tend to puncture the film. If the material over which the lining is to be placed is stony or of very coarse texture, it should be covered with a cushion layer of fine textured material before the lining is placed. All banks, side slopes and fills within the area to be lined should be uniformly sloped no steeper than 1:1 for exposed lining and 3:1 for covered lining. The cover material may slide on the lining if placed on steeper slopes.

Certain plants penetrate vinyl and polyethylene film. For this reason, it is desirable to sterilize the subgrade with chemicals, particularly the side slopes where nutgrass, Johnsongrass, quackgrass, and other plants having a high penetrating power are present. Sterilization is not required where butyl rubber membranes are used.

The top edges of the lining should be anchored in a trench excavated completely around the area to be lined at the planned elevation of the top of the lining. The trench should be 8 to 10 inches deep and about 12 inches wide. The lining should then be anchored by burying 8 to 12 inches of the lining in the anchor trench and securing it with compacted backfill.

The linings are usually laid in sections or strips with a 6-inch overlap for seaming. Vinyl and butyl rubber linings should be laid smooth but in a loose state. Polyethylene should have up to 10 percent slack. Extreme care must be exercised in handling to avoid puncture.

The materials used to cover the membrane should be free of large clods, sharp rocks, sticks and other objects that would puncture the lining. The cover should be placed to the specified depth without damage to the membrane.

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

POND SEALING OR LINING
COMPACTED CLAY TREATMENT

(NO.)

CODE 521D

DEFINITION

A liner for a pond or waste storage impoundment constructed using compacted soil without soil amendments.

PURPOSE

To reduce seepage losses from ponds or waste storage impoundments constructed for water conservation and environmental protection.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Soils at the site would exhibit seepage rates in excess of acceptable limits or would allow an unacceptable migration of contaminants from the impoundment.

- An adequate quantity of soil suitable for constructing a clay liner without amendments is available at an economical haul distance.

CRITERIA

Criteria for Limiting Seepage

Compacted soil liners for ponds not storing animal waste shall be designed to reduce seepage to rates that will allow the pond to function suitably as intended.

Compacted soil liners for waste storage impoundments shall be designed to reduce specific discharge (unit seepage) to rates suggested in the National Engineering Handbook (NEH), Part 651, Agricultural Waste Management Field Handbook (AWMFH), Chapter 10, Appendix 10D, or rates mandated in State regulations if they are more restrictive. Other, lower specific discharge rates may be used for design at the discretion of the designer.

The AWMFH, Chapter 10, Appendix 10D, provides methods for computing unit seepage rates and includes recommended allowable rates of seepage. Other generally accepted methods for computing unit seepage rates may also be used.

Other Criteria

Compacted soil liners shall be filter-compatible with the sub-grade on which they are compacted to prevent loss of the liner soil into larger openings in the sub-grade material. The National Engineering Handbook (NEH), Part 633, Chapter 26-Gradation Design of Sand and Gravel Filters, provides guidance on filter compatibility.

Liner Thickness. The minimum thickness of the finished compacted liner shall be the greatest of:

1. Required to achieve a specific discharge (unit seepage) design value selected by the designer.

2. Required by State regulations.

3. The water depth to be used in the table is the normal full pool storage depth in the impoundment.

Water Depth (feet)	Liner Thickness (inches)
≤ 16	12
16.1 – 24	18
> 24	24

Liner Protection. The soil liner shall be protected against damage caused by the effects of water surface fluctuations, wave action, rain fall during periods when the liner is exposed, water falling onto the liner from pipe outlets, agitation equipment, solids and sludge removal activity, animal activity, and penetrations through the liner.

Design should include measures to protect against damage to the compacted liner if a seasonal high water table occurs at a level above that of the lowest potential level of liquid in the impoundment. Perimeter drains to lower the water table, maintaining minimum liquid depth in the impoundment, and using liners thick enough to resist uplift water pressures are examples of protective design measures.

The finished liner should be protected against the effects of desiccation during periods when the pond or impoundment is empty. A protective soil cover may be used. For severe conditions, a protective soil cover may not adequately protect the liner from desiccation. Severe conditions include liners constructed with very high plasticity soils that are exposed to long periods of hot, low humidity conditions.

Designs including a geomembrane in conjunction with a cover soil may be considered for severe conditions to protect the liner from desiccation adequately.

Side Slopes. The side slopes of ponds or waste storage impoundments should be 3H: 1V or flatter to facilitate compaction of soil on the slopes if the bathtub method of construction as described in Appendix 10D, AWMFH, is used. Slopes as steep as 2H: 1V may be used if the stair-step method of construction as described in Appendix 10D to the AWMFH is used for constructing the liner. Maintenance requirements should also be considered when selecting side slopes.

CONSIDERATIONS

Consider using a flexible geomembrane or geosynthetic clay liner for sites that have water or waste storage depths greater than 30 feet.

Alternatives to compacted clay liners should be considered for poor foundation conditions such as karstic bedrock.

PLANS AND SPECIFICATIONS

Plans and specifications for compacted soil liners for ponds and waste storage impoundments shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. Plans and specifications shall include such drawings, specifications, material requirements,

quantities, construction requirements, equipment requirements, quality control requirements, and other documents as are necessary to describe the work to be done.

OPERATION AND MAINTENANCE

Maintenance activities required for this practice consist of those operations necessary to prevent and/or repair damage to the compacted soil liner. This includes, but is not limited to, excluding animals and equipment from the treated area; repairing damage to the liner occurring from erosion during initial filling; erosion resulting from wave action after the impoundment fills and erosion caused by agitation, pumping operations, and activities involved in removal of solids and sludge. Damage that might be caused by roots from trees and large shrubs should be prevented by removing such vegetation. If the liner is damaged, any disturbed or eroded areas should be repaired to restore the liner to its original thickness and condition.

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

POND SEALING OR LINING

SOIL DISPERSANT TREATMENT

(No.)

CODE 521B

DEFINITION

A liner for a pond or waste impoundment consisting of a compacted soil-dispersant mixture.

PURPOSE

To reduce seepage losses from ponds or waste impoundments for water conservation and environmental protection.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Soils are suitable for treatment with dispersants.
- Ponds or waste impoundments require treatment to reduce seepage rates and to impede the migration of contaminants to within acceptable limits.

CRITERIA

General Criteria Applicable to All Purposes

Dispersant treated soil liners shall comply with all federal, state, and local laws, rules, and regulations.

Lined structures shall meet all applicable NRCS standards.

Dispersant treated soil liners shall be filter compatible with the natural foundation materials on which they are compacted according to Chapter 26, Part 633, of the National Engineering Handbook, Gradation Design of Sand and Gravel Filters.

The minimum thickness of the finished compacted liner shall be 6 inches.

The dispersant shall be tetrasodium pyrophosphate (TSPP), sodium tripolyphosphate (STPP), or soda ash, unless laboratory tests using other dispersant types are used for design.

When laboratory permeability tests are required to determine application rates, the tests shall be performed using dispersant of the same quality and fineness as that proposed for use.

For protection against dispersant dust, personnel on site during dispersant application and mixing shall wear mask and goggles.

Criteria Applicable to Waste Impoundments

Design. Design of dispersant treated soil liners for waste impoundments shall be in accordance with National Engineering Handbook, Part 651, Agricultural Waste Management Field Handbook, Chapter 10, Appendix 10D, and/or state regulatory requirements.

Liner Protection. The liner shall be protected against desiccation cracking, the effects of water surface fluctuations, wave action, surface erosion, erosion from pipe inlets, agitation equipment, animals, or items installed through the liner. Protective measures shall be designed into the system to protect the liner for these cases. As a minimum, at least 6 inches of soil cover shall be placed over the soil-dispersant liner.

Criteria Applicable to Ponds

Application Rate. For ponds, in the absence of laboratory tests or field performance data on soils similar to those to be treated, the minimum application of dispersant per 6-inch thickness of constructed liner shall be:

Dispersant Type	Application rate (lb./ 100 ft^2)
Polyphosphates	7.5
Soda Ash	15

Liner Thickness. In the absence of more detailed testing and analyses, liner thickness shall be according to the following table:

Water Depth (feet)	Liner Thickness (inches)
8 or less	6
8.1 – 16	12
16.1 – 24	18
24.1 - 30	24

CONSIDERATIONS

Flattening the slopes of ponds or waste impoundments to facilitate compactive efforts during construction should be considered. The stair-step method of construction as outlined in Appendix 10D may be considered in lieu of slope flattening.

A protective compacted soil cover should be considered for protecting the soil-dispersant liner for ponds.

Consider using a flexible membrane liner for sites that have water depths greater than 24 feet.

PLANS AND SPECIFICATIONS

Plans and specifications for dispersant treated soil liners for ponds and waste impoundments shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. Plans and specifications shall include such drawings, specifications, material requirements, quantities, construction requirements, equipment requirements, and other documents as are necessary to describe the work to be done.

OPERATION AND MAINTENANCE

Maintenance activities required for this practice consist of those operations necessary to prevent damaging the treated soil liner. This includes, but is not limited to, excluding animals and equipment from the treated area, protection of the liner during initial filling, agitation, or pumping

operations, and repair of disturbed or eroded areas.

REFERENCES

ASTM Standard Test Method D5890

NRCS. National Engineering Handbook, Part 633, Chapter 26.

NRCS. National Engineering Handbook, Part 651, AWMFH, Chapter 10, Appendix 10D

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

POND SEALING OR LINING
BENTONITE SEALANT

(No.)

CODE 521C

DEFINITION

A liner for a pond or waste impoundment consisting of a compacted soil-bentonite mixture.

PURPOSE

To reduce seepage losses from ponds or waste impoundments for water conservation and environmental protection.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Soils are suitable for treatment with bentonite.
- Ponds or waste impoundments require treatment to reduce seepage rates and to impede the migration of contaminants to within acceptable limits.

CRITERIA

General Criteria Applicable to All Purposes

Bentonite treated soil liners will comply with all Federal, State, and local laws, rules, and regulations.

Lined structures will meet all applicable NRCS standards.

Bentonite treated soil liners will be filter compatible with the natural foundation materials on which they are compacted according to Chapter 26, Part 633, of the National Engineering Handbook, Gradation Design of Sand and Gravel Filters.

The minimum thickness of the finished compacted liner will be 6 inches.

The bentonite will be a sodium bentonite with a free swell of at least 22 milliliters as measured by ASTM Standard Test Method D5890, unless laboratory tests using other bentonite types are used for design.

When laboratory permeability tests are required to determine application rates, the

tests will be performed using bentonite of the same quality and fineness as that proposed for use.

For protection against bentonite dust, personnel on site during bentonite application and mixing will wear mask and goggles.

Criteria Applicable to Waste Impoundments

Design. Design of the bentonite treated soil liners for waste impoundments will be in accordance with National Engineering Handbook, Part 651; Agricultural Waste Management Field Handbook, Chapter 10, Appendix 10D; and/or State regulatory requirements.

Liner Protection. The liner will be protected against desiccation cracking, the effects of water surface fluctuations, wave action, surface erosion, erosion from pipe inlets, agitation equipment, animals, or items installed through the liner. Protective measures will be designed into the system to protect the liner for these cases. At least 6 inches of compacted soil cover will be placed over the soil-bentonite liner.

Criteria Applicable to Ponds

Application Rate. For ponds, in the absence of laboratory tests or field performance data on soils similar to those to be treated, the minimum application of finely ground bentonite per 1-inch thickness of constructed liner will be:

Pervious Soil Description	Application Rate (lb./ft.^{2})
Silts (ML, CL-ML)	0.375
Silty Sands (SM, SC-SM, SP-SM)	0.5
Clean Sands (SP, SW)	0.625

Liner Thickness. In the absence of more detailed testing and analyses, liner thickness will be according to the following table:

Water Depth (feet)	Liner Thickness (inches)
8 or less	6
8.1 – 16	12
16.1 – 24	18
24.1 - 30	24

CONSIDERATIONS

Flattening the slopes of ponds or waste impoundments to facilitate compactive efforts during construction should be considered. The stair-step method of construction as outlined in Appendix 10D may be considered in lieu of slope flattening.

A protective compacted soil cover should be considered for protecting the soil-bentonite liner for ponds.

Consider using a flexible membrane liner for sites that have water depths greater than 24 feet.

PLANS AND SPECIFICATIONS

Plans and specifications for bentonite treated soil liners for ponds and waste impoundments will be in keeping with this standard and will describe the requirements for applying the practice to achieve its