



# Freeze/Thaw Protection during Construction of Recompacted Soil Liners and Recompacted Soil Barrier Layers

## Applicable Rules

- MSW: OAC 3745-27-08(D)(8)(h)  
OAC 3745-27-08(D)(21)(h)  
ISW: OAC 3745-29-08(D)(8)(h)  
OAC 3745-29-08(D)(21)(h)  
RSW: OAC 3745-30-07(C)(1)(I)  
OAC 3745-30-09(F)(3)(a)  
Tires: OAC 3745-27-72(C)(1)(I)  
OAC 3745-27-72(C)(4)(d)

DMWM Cross Referenced guidance document:

#599 *Use of Shredded Tires in Landfill Construction*

## Purpose

This document provides suggestions on meeting the requirement to protect the recompacted soil liner (RSL) and recompacted soil barrier layer (RSBL) in the composite cap system from damage due to freeze/thaw cycles.

## Detailed Discussion

Many researchers have observed an increase in the permeability of recompacted soil due to the effects of freeze/thaw damage. In laboratory studies, this increase has been up to two orders of magnitude. In field studies, this increase was observed to approach one order of magnitude. Geosynthetic clay liners are not as susceptible to the effects of freeze/thaw damage due to the unique "healing" properties of hydrated bentonite.

Frost penetration records indicate an average in Ohio ranging from 10 inches to 25 inches. Extreme frost penetration depths in Ohio range from 20 inches to 40 inches. The depth of frost penetration depends primarily on the duration and degree of freezing temperatures, available solar radiation, and the thickness and type cover on the liner. The degree of freeze/thaw damage depends primarily on the number of freeze/thaw cycles (damage occurs in the first freeze/thaw cycle and continues to increase until about the 3rd to 5th cycle). Conditions which increase damage include low overburden pressure, a slow freezing rate, and a supply of moisture that keeps the soil saturated through multiple freeze/thaw cycles.

At times, owners and operators are unable to place the select waste layer above the RSL or complete construction of the composite cap system before freezing temperatures are expected. If this is the case, then the owner or operator may need to provide other means of frost protection. The rules do not prescribe a deadline for placement of the freeze/thaw protection nor do they specify properties or thickness of the protection material. As a result, the owner or operator has the flexibility to assess the site specific conditions and weather patterns and decide when to apply the protective measures, what material to use, and how much protection to apply. If damage does occur to the RSL or RSBL, the owner or operator is in violation of the requirement to maintain the integrity of the engineered components.

## WHEN:

The onset of freezing temperatures is variable and irregular. DMWM recommends the owner or operator review and assess local weather history. Available from the Midwest Regional Climate Center at: <http://mcc.sws.uiuc.edu/>, in the station almanac, are city-specific historic climate summaries showing temperature norms and extremes and the number of days with maximum and minimum temperatures below freezing. Available from the Ohio Agricultural Research and Development Center at: <http://www.oardc.ohio-state.edu/newweather/> are records of soil temperature data (depths of 5 cm (two inches) and 10 cm (four inches)); however, parts of the state are not monitored. The Natural Resources

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Conservation Service at: <http://www.wcc.nrcs.usda.gov/scan/> has two soil climate monitors in Ohio that have deeper soil temperature probes. The state climatologist may also be of assistance (link is available through the MRCC website listed above).

## WHAT:

A variety of materials may be used to provide frost protection. These include shredded tires, soil, straw, and solid waste. These materials are effective in trapping air (a good insulator) when dry, but they more readily transfer heat out of the RSL and RSBL when water, liquid or frozen, fills the voids. Solid waste can only be used on RSLs if the construction has been certified and concurred with by Ohio EPA.

Straw can be used if measures are taken to keep it in place and to keep it dry, and all straw can be removed. Straw can be left in place only if its presence will not interfere with continued construction of the landfill components. Straw must be removed if above the RSL or RSBL because the RSL and RSBL must be free of debris, foreign material, and deleterious material. DMWM recommends removing straw above the drainage layer so the fines created from decomposition of the straw will not clog the layer.

If shredded tires are used above FML, the same FML protective measures need to be employed when placing the shredded tires as indicated in DMWM guidance #599 *Use of Shredded Tires in Landfill Construction*. DMWM also does not recommend removing the shredded tires, in this case, due to the likelihood of causing damage to the FML. If the shredded tires are placed directly above the RSL or RSBL, they must be completely removed. Note: if removal of the tires damages the RSL or RSBL and if other engineered components requiring intimate contact are to be placed above the RSL or RSBL, the RSL or RSBL will need to be repaired and recertified prior to placement of the overlying engineered component.

## HOW THICK:

The depth of frost protection material to apply depends on the insulating properties (thermal conductivity) of the material and the severity of the weather. Formulae and models are available for predicting frost penetration. A simple but conservative approach is to use local building code frost depths, or the composite cap system's cap protection layer thickness. Another simple but less conservative approach is to use the local average frost depth.

Some owners or operators, when unable to place the select waste layer above the constructed liner and leachate collection system before freezing temperatures occur, decide to rely on the granular drainage layer to provide sufficient protection. To confirm the RSL does not freeze, these owners and operators have installed thermocouples and monitored temperatures at various depths throughout the RSL or surrogate test pad. Reminder: Penetrations into the RSL must be repaired using bentonite.

## STEEP SLOPES:

In the case of steep side slopes, protection of the RSL and RSBL can be difficult. One approach is to design the landfill to eliminate slopes that cannot be protected or to develop the landfill in such a way as to eliminate the amount of exposed liner on the side slopes. Another approach is to construct an extra thick RSL or RSBL. If damage does occur, the affected material is removed (so intimate contact with the flexible membrane liner is provided), leaving sufficient thickness of competent material behind to meet the approved design requirement.

## REPAIR:

Due to the variability from year to year in weather conditions, the integrity or behavior of the protective material, and the changes that may occur to the protective material (e.g. erosion, weathering, consolidation), the owner or operator may not have adequately protected the RSL or RSBL from freeze/thaw damage. The National Climate Data Center of the National Oceanic and Atmospheric Administration produces and archives regional climate maps ([http://www.cpc.ncep.noaa.gov/products/analysis\\_monitoring/regional\\_monitoring/usa.shtml](http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/usa.shtml)) which can be used to determine if temperatures have been colder than average. However, temperature alone is not an indicator of damage because other factors, such as duration and degree of freezing temperatures, the amount of sunshine, and the direction of the slope face, can increase or decrease the frost penetration for any given part of a facility.

If damage is suspected, the district office may require the owner or operator to investigate and assess the damage and then make repairs, which can be very expensive and time consuming. If the RSL or RSBL has been damaged, then a violation has occurred and the RSL or RSBL must be repaired. Repair of damage can be very costly if the owner or operator has already placed flexible membrane liner above the RSL or RSBL. If the RSL or RSBL is not repaired, then either: (1) Ohio EPA cannot concur with the construction certification report, in which case, the owner or operator cannot

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begin to fill with waste or cease to maintain financial assurance for final closure as per OAC 3745-27-15(O), or (2) if the construction certification has already been concurred with, the owner or operator may be in violation of the requirement to maintain the integrity of, and to repair any damage to, facility components.

To determine the extent of damage (change in soil structure), an appropriate method should be used. For example, the presence and extent of cracking may be determined by surficial observation, probing, or with a dye test. If damage is suspected to be fairly deep, or if it is desired to determine if permeability of the RSL or RSBL has been affected, field tests (sealed double ring infiltrometer) or lab testing of a block sample may be appropriate. DMWM does not recommend using shelly tubes for determining permeability quantitatively because they sample too small an area to accurately detect damage and the distortion that occurs to the sample as a consequence of pushing the tube may result in inaccurate test results. Damage may also be present immediately below the depth of freezing due to desiccation, which occurs in the underlying soil during freeze/thaw cycles.

An approach DMWM has reviewed and has not recommended is to rely on the weight of the landfill to 'heal' cracks. Although some lab testing has shown that cracks can heal when weight is applied, it has not been supported by field studies. Because the permeability may never reach that of the undamaged state after the healing of the cracks, and because the healing of the cracks cannot be verified, DMWM is unlikely to approve of this approach. Another approach which DMWM has not recommended is to investigate freeze/thaw damage in a test pad or liner run-out area instead of investigating the RSL or RSBL for evidence of damage. This approach is not recommended because the extent of freeze/thaw damage varies across a site due to microclimates that develop (e.g. sheltered vs. unsheltered areas, south facing vs. north facing slopes), so there are few circumstances where testing of a surrogate instead of testing the RSL or RSBL is appropriate.

## Contact

If you have questions regarding this document or would like additional information, please contact:

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