Tech Note: Backfilling Geomembranes

Backfill protects liners from environmental and mechanical damage. Backfill can also help to improve the impermeability of the liner system.

Almost all liner materials can benefit from using a backfill cover. Properly designed backfill systems can extend the life of a geomembrane liner to the maximum extent possible. Some backfilled PVC liners have been in service for over 40 years. This Tech Note will discuss some of the items to consider when selecting and placing backfill.

Backfill can often be selected from locally available fill materials. Processed or natural non-cohesive soils, such as gravelly sand, screened sand, pea gravel and well graded cohesive soils, such as clayey-silt or silty-clay are examples of suitable backfill materials. These fill materials can have some larger stones as long as no crushed or shattered rock fragments are present. The "rule of thumb" for included stones (round) is that the largest stone or maximum size of any of the gravel inclusions, should not be greater than 25 mm (1"). In addition, all gravel inclusions that are angular or have sharp or chiselled edges should be removed from the backfill either at the source or during placement.

The second "rule of thumb" regarding backfilling over a liner is that the soil material(s) used should be able to be compacted or consolidated with light to medium duty smooth drum or vibratory plate compaction equipment and should not require extensive reworking, conditioning, or kneading. Materials that contain lumps, clods, or cemented inclusions that require additional compactive effort to break them down are likely not suitable. Clean or screened sand is the ideal backfill material, however local availability of fill materials, and slope stability requirements will dictate what fill material is to be used. Cohesive backfill materials, such as clay, that are placed directly over the liner can actually improve the performance of the liner system. Studies have shown that when clay is in intimate contact with the liner, the individual performance characteristics of both layers are additive. This means that, from a permeability perspective, the combined system performs better than the sum of the individual elements,

therefore, leakage rates through minor defects in either the liner or the clay backfill are dramatically reduced when compared to each as a stand alone system.

In certain instances, locally available backfill material will contain significant amounts of oversize gravel and/or sharp, angular gravel. Even though these backfill materials can be easily worked and compacted to form a uniform, level backfill surface, the sharp stones and oversized gravel may damage the liner without the earthwork contractor's knowledge. In cases such as these, it may be necessary to protect the liner with a cushion layer of sand. This cushion backfill layer should be in the order of 50 mm to 150 mm (2" to 6") thick, depending on the specifics of the installation, and should be compacted. In locations where sand is not available, a medium to heavy weight geotextile may be used as an alternative.

A final note on the selection of fill materials; large clay lumps, roots (organics), and frozen lumps of fill are to be avoided. The fill must be "free-flowing" and placement methods that push fill onto the liner must be able to "roll" the fill ahead. This becomes very difficult in winter conditions where frozen fill and/or freezing conditions might be encountered. Watch carefully that the fill being placed does not "slip" or shear along the top of the liner. If this type of slippage or shearing occurs, check for damage under the backfill. Ensure that the fill rolls onto the liner so that shear forces are not transmitted to the liner. In the attached table are minimum lift thicknesses for the initial lift of backfill. These minimum thicknesses are given as guidelines. Conditions may vary from site to site and the engineer in charge of the project may authorize different minimums from the numbers given here. Sound engineering practice must be exercised and appropriate equipment and methods must be selected if thinner initial lift thicknesses are to be considered.

Placement of backfill is usually dependant on the equipment used to place the fill rather than the liner material. HDPE is a special case and requires a minimum of 450 mm (18") of backfill due to the height of its slack wrinkles which can reach 150 to 200 mm (6 to 8") high. Each type of equipment has a specific ground pressure and weight that requires a different minimum thickness of backfill for liner protection. The initial lift thickness must be of a minimum to protect the liner from the equipment used. If backfill compaction is required, smaller equipment may be required to place the initial lift. Larger equipment can then be used for the second, and subsequent lifts. The usual method for placing thin backfill is to build a road through the pond of at least 600 mm (24") thickness (depending on the type of backfill material and equipment used, a road up to 1200mm (48"), may be required). Loaded trucks may use this road to deliver the backfill to the correct area. A wide pad Cat (bulldozer), or other small piece of equipment, then operates perpendicular to this road and pushes the backfill off the road to create a thin lift throughout the pond. The Cat operator needs to exercise caution at all times and must ensure that the fill rolls off the bottom of the blade and does not introduce a shearing force along the surface of the liner.

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Minimum Lift Thickness	
Backfill Thickness	**Placement Equipment**
No Backfill	Foot Traffic or a 4 Track ATV vehicle only
150 mm (6") or less	Hand Placement
200-300 mm (8"-12")	D3-D4 LGP Cat
300 mm (12")	Bobcat (Skid-Steer)
300 mm (12")	D4-D6 Style Cat
600 mm (24")	D7-D9 Style Cat
900 mm (36")	Loaded Scrapers, Motor Graders
900-1200 mm (36"-48")<	Loaded Tandem Axle Trucks

Care should be taken during all aspects of backfill placement. A spotter should be in position beside the Cat to monitor the placement and thickness of the backfill on the liner. This spotter can usually identify any problems during placement that the Cat operator may not see. During backfill operations there are a few things to look out for; skid-steer equipment, such as a Bobcat, must not make any sharp skid turns on top of the liner or on top of a thin lift of backfill. Sharp turns with one tread (set of wheels) locked can damage the liner. Skid-steer equipment must make long sweeping turns at all times.

Care must be taken to maintain the appropriate thickness of fill beneath a vehicle. Vehicles should not travel on the unprotected liner at any time (4-track ATV's may be excepted). The ground pressure or tire pressure of the vehicle can be used as a guide to minimum backfill thickness. Wheeled vehicles with tire pressures around 200 kPa (30 psi, such as Bobcats and pickup trucks) can operate on a minimum thickness of about 300mm (12"), however all trucks with tire pressures of 500 kPa (80 psi) or higher should have at least 900 mm (36") of fill beneath their wheels.

Place fill from the bottom to the top of slopes. Standing water should be removed prior to placement of the backfill. Backfill depth can be checked by carefully hand-excavating small test pits as required. Special grade stakes can be manufactured that rest on top of the liner. These stakes, usually an upside down wooden "tee", must be removed prior to backfill. Do not cover grade stakes with backfill. A more effective method of grade control involves the use of laser level survey equipment that eliminates the need for survey stakes. All measurements of grade are to be referenced to the actual liner elevation within the containment area.

The most significant problem when backfilling in cold weather is frozen fill. It may be necessary to heat your backfill stockpile or make provision for heating and hoarding at the backfill location. Contain Enviro can supply large covers suitable for applying heat to a fill stockpile or for hoarding if required. Ice lumps in the backfill can also cause damage. Frost, or a dusting of snow on the liner does not always have to be removed, however, it becomes much more difficult to roll the backfill into place without sliding in these circumstances. Accumulations of snow and ice on the liner should be carefully removed prior to backfilling.