The Real Cost of Terraces on Landfill Slopes

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Many landfill designers continue to incorporate terraces on the outside slopes of landfills, but not always for sound reasons. Sometimes, terraces are necessary to maintain landfill slopes in stable condition, due to low shear strength of the foundation soils, or when required according to the specific state or local solid waste rules.

Some designers continue to propose terraces on slopes to collect and convey surface water runoff from a landfill's higher slopes to a low point on the terrace where the downchute system is located. On paper, it is very easy to show nicely sloping terraces toward a low point, with transverse slopes toward the landfill slope, to control surface water. However, terraces cause significant operational issues for landfill operators. Some of these problems are very apparent, and some are realized when a portion of the landfill slope is scheduled to receive a permanent final cover. Consider these factors during permitting and design.

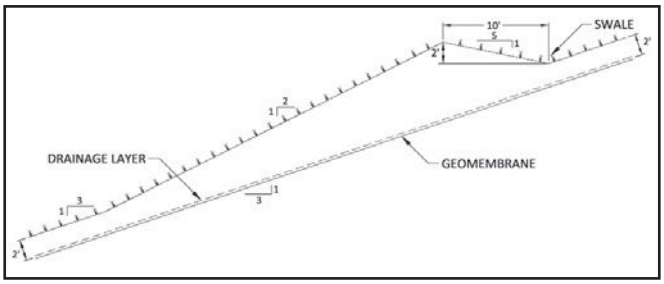

Diagram 1 - Tack-on berm and swale on landfill slope.

Photo 1 - Grading of tack-on berm and swale during construction.

1. It is difficult to shape sloping terraces during waste placement operations; terraces can end up formed horizontally. When it is time to close the landfill's side slope, significant amounts of soil are placed along the terrace to make it slope toward a low point where the downchute system is located. Normally, permit drawings do not include sufficient details to illustrate these technical issues, and the operator would not have the specific knowledge of such issues at the time of closing the slope.
2. During waste placement, difficulties arise for the equipment operator (dozer pushing waste and compactor compacting and shaping surfaces) to shape the breaklines and compress waste properly to form the terrace. Lack of compaction near the outside breakline of the terrace makes it susceptible to excessive settlement and can cause the terrace to change shape over time.
3. Operators shape the transverse slope of the terrace either horizontally or sloping away from the landfill slope to manage surface water during the landfill's operational phase. In either case the slopes could end up formed differently, or in opposite direction of the slopes in the permit drawings. Closure of the landfill slope requires special attention along with large quantities of soil to shape the terrace similar to what is in the permit drawings. Again, the landfill operator would not have knowledge of the additional work and the soil quantities necessary to fix the terrace transverse slope properly.
4. Settlement in waste causes previously shaped terraces, at a certain elevation, ending up lower than the originally shaped terraces. Over time, the terrace originally constructed at a certain elevation and in accordance with the permit documents, ends up lower in elevation due to waste settlement. Continuously occurring settlement can cause the misalignment of terraces formed at different intervals. At the time of closing, the terrace misalignments become a major problem for the engineer and contractor to meet elevations and shapes previously permitted.
5. Downchute pipes extend from the highest terrace to the lowest terrace, and to the surface water management system at the perimeter of the landfill. The downchute pipes are designed to cross the width of each terrace and pickup surface water from each terrace. However, the pipe alignments, complicated by the terrace transverse slopes toward the landfill slope, cause construction complications and increase the risk of failing to properly collect surface waters at the low point. This particular risk can become drastic when considering waste settlement changes the surface geometry at the inlets to the downchute system, causing costly repairs.
6. Over the terrace surface, the geocomposite drainage layer in the final cover follows the transverse slope toward the landfill slope and across the width of the terrace. Water in the geocomposite from the higher slope and from the terrace reach the inside edge of the terrace, with nowhere to go except to follow the longitudinal slope of the terrace along the interior edge. Geocomposite is not designed to carry such a large quantity of water along the interior edge for the entire length of the terrace. Inevitably, problems arise, and potential failures

can occur. The solution is to install a toe drain along the interior edge of the terrace that collects and conveys water in the geocomposite layer to the low point in the terrace. This toe drain adds another complication to the design of piping system at the low point of the terrace, where the down chute system is located. Additionally, the cost of the toe drain construction goes up significantly due to logistical complications along the terrace in the middle of the slope, including the placement of gravel around the toe drainpipe before the geomembrane and geocomposite are covered with the overlying soil.

7. The access road to the top of the landfill normally crosses several terraces located on the landfill slope. The slope surface geometry at the intersection of the access road with the terraces becomes complicated, affecting the alignment of the access road at each intersection point.

8. Leachate seeps can potentially appear at breaklines on landfill slopes. The inside edges of a terrace are considered a breakline in the landfill slope and are highly susceptible to leachate seeps appearing on the surface. Unfortunately, leachate ponding from the seeps can easily mix with surface water runoff on the terrace. It is then carried to the landfill perimeter surface water management ditches and detention/detention areas.

9. Significant leachate seeps at terraces may require a leachate toe drain system below the final cover geomembrane along the entire length of the terrace. This adds cost and another level of complication at the low point of the terrace where the downchute system is located. The leachate in the toe drain system needs to drain to another system at the low point of the terrace in order to discharge to the landfill leachate collection system or another liquid management system.

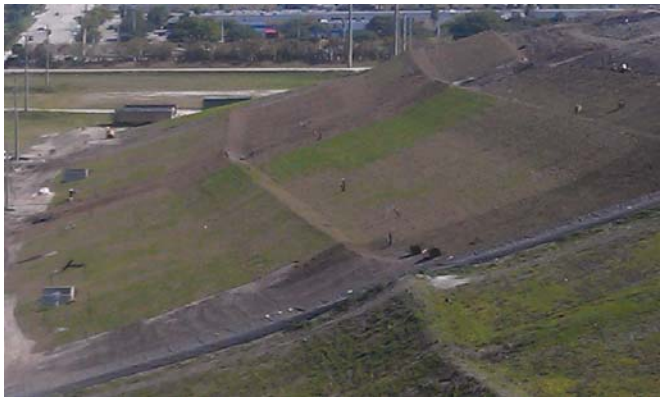

Photo 2 - Tack-on berms and swales on landfill final cover.

Photo 3 - Discharge points of downchute pipes.

To simplify operations, more landfills are designed without terraces on the slope. Before slope closure, management of the surface water runoff is achieved by temporary tack-on berms on the slope (see Diagram 1, Photos 1 and 2) and temporary downchute pipes (see Photo 3) that are easily constructed and maintained. After closure, the surface water management is achieved by permanent tack-on berms at certain spacing on the slope. The swale on the upper side of the tack-on berm conveys surface water runoff from the higher slopes to the low point of the swale on the slope.

The downchute system at the low point of the tack-on berms is simple to construct. These downchutes connect to lateral pipes from lower level swales collecting surface water from these swales before discharging to the perimeter surface water management system. The aforementioned design does not require significant maintenance.

Maximizing Airspace

Terraces decrease potential airspace within the permitted footprint of the landfill. Wasted airspace on landfill slopes is substantial and can be in the order of tens of millions of dollars depending on the size of the landfill. Owners/Operators request airspace loss calculations to emphasize the financial impact of terraces to their bottom line.

One recent evaluation for a 170-acre, 250-ft tall landfill with seven terraces lost approximately 7,500,000 cubic yards of air space. The tipping fee of $80 per ton results in an estimated value of $64 per cubic yard of compacted waste. Therefore, the estimate value of the airspace loss due to the terraces at this landfill site is estimated to be $480,000,000—nearly half-a-billion dollars of the bottom line.

This author, with more than 30 years of landfill design and construction for municipalities and private firms, has witnessed the high level of satisfaction and cost-effectiveness of no-terrace systems by landfill operators. Many of whom changed their permits to eliminate terraces to take advantage of the airspace and operational benefits.

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