Evapotranspiration Covers for Landfills

An Online Continuing Education Course for Engineers

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Evapotranspiration (ET) Landfill Cover Systems are increasingly being considered for use at waste disposal sites. These include municipal solid waste (MSW) landfills, hazardous waste (HW) landfills, and isolated arid waste sites when equivalent performance to conventional final cover systems can be demonstrated. Conventional cover system designs use barrier layers consisting of materials with low hydraulic conductivity (e.g., clay, geosynthetic clay liners, or geomembranes) to minimize the percolation of water from the cover to the waste. ET cover systems use water balance components to minimize percolation. These cover systems rely on soil properties (e.g., soil texture and associated soil water storage capacity) to store water until it is either transpired through vegetation or evaporated from the soil surface. This course provides a summary of ET technical issues, including design considerations, performance monitoring, cost, and potential imitations on use. It is intended to provide basic information about these potential design alternatives.

Background

Final cover systems often are used at landfills; abandoned dumps; some hazardous, low-level, and mixed low-level waste sites with conducive environmental conditions; hazardous waste containment facilities; sites with surface contamination; and other types of waste disposal sites.

There are a number of reasons for using them, including to control moisture and percolation, manage surface water runoff, minimize erosion, prevent direct exposure to waste, control gas emissions and odors, prevent occurrence of disease vectors and other nuisances, and meet aesthetic and other end-use purposes. Final cover systems are intended to remain in place and maintain their functions for periods of many decades to hundreds of years. Cover systems may be used alone or, if warranted, in conjunction with other technologies (for example, slurry walls and groundwater pump and treat systems) to contain waste or leachate.

The design of cover systems is site specific and depends on the intended function of the final cover–cover designs can range from a single layer of soil to a complex multi-layer system that includes synthetic materials. To minimize per collation, conventional cover systems typically use low-conductivity barrier layers. These barrier layers are often constructed of compacted clay, geomembranes, geosynthetic clay liners, or combinations of these materials. Depending on the material type and construction method, the saturated hydraulic conductivities for these barrier layers are typically between 1x10-5 and 1x10-9 centimeters per second (cm/s). In addition, conventional cover systems generally include shallow-rooted plants and additional layers, such as surface layers to prevent erosion; protection layers to minimize freeze/thaw damage; internal drainage layers; and gas collection layers (Environmental Protection Agency [EPA] 1991; Hauser, Weand, and Gill 2001b).

The design, construction, and maintenance of cover systems may be subject to statutory and regulatory requirements under various federal and state programs; some of these requirements also may come into play in cleanup programs.

For example, with regard to municipal solid waste facilities, regulations under the Resource Conservation and Recovery Act (RCRA) for the design and construction of final cover systems are based on using a low-conductivity barrier layer (conventional cover system). Under RCRA Subtitle D (40 CFR 258.60), the minimum design requirements for final cover systems at municipal solid waste landfills (MSWLF) depend on the bottom liner system or the natural subsoils, if no liner system is present. The final cover system must have a permeability less than or equal to that of the bot- tom liner system (or natural subsoils) or a permeability no greater than 1x10-5 cm/s, whichever is less. This design requirement was established to minimize the "bathtub effect," which occurs when the landfill fills with liquid because the cover system is more permeable than the bottom liner system. This bathtub effect greatly increases the potential for generation of leachate.

Until March 2004, the equivalent reduction language provided the statutory underpinning for proposing an alternative cover at an MSWLF. On March 22, 2004, 40 CFR 258 was amended to allow for research, development, and demonstration permits (40 CFR 258.4). These permits are issued for three years with up to three renewals (12 years total). The regulation states, "The director of an approved state may issue a research, development, and demonstration permit for a new MSWLF unit, existing MSWLF unit, or lateral expansion, for which the owner or operator proposes to utilize innovative and new methods which vary from the final cover criteria of §258.60(a)(1), (a)(2) and (b)(1), provided the MSWLF unit owner/operator demonstrates that the infiltration of liquid through the alternative cover system will not cause contamination of groundwater or surface water, or cause leachate depth on the liner to exceed 30 cm."

Figure 1 (below) shows the minimum recommended requirements for a typical conventional Subtitle D landfill which consist of a 6-inch soil erosion layer, a geomembrane (when the landfill has a geomembrane liner), and an 18-inch barrier layer of soil that is compacted to yield a saturated hydraulic conductivity equal to or less than $1x10^{-5}$ cm/s (EPA 1992).

As another example, for hazardous waste landfills, RCRA Subtitle C (40 CFR 264 and 265) provides certain design specifications for final cover systems. These include the same provision for Subtitle D that the cover system have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present. Figure 1 shows an example of a RCRA Subtitle C cover at a hazardous waste landfill (EPA 1989).

The design and construction requirements, as defined in the RCRA regulations, also may be applied under RCRA corrective action and other cleanup programs (e.g., Superfund or state cleanup programs). At Superfund remedial sites involving on-site disposal, the RCRA regulations for conventional covers usually are identified as applicable or relevant and appropriate requirements (ARARs) for the site. Under RCRA, an alternative design, such as an ET cover, can be proposed in lieu of a RCRA design if it can be demonstrated that the alternative provides equivalent performance with respect to reduction in percolation and other criteria, such as erosion resistance and gas control.

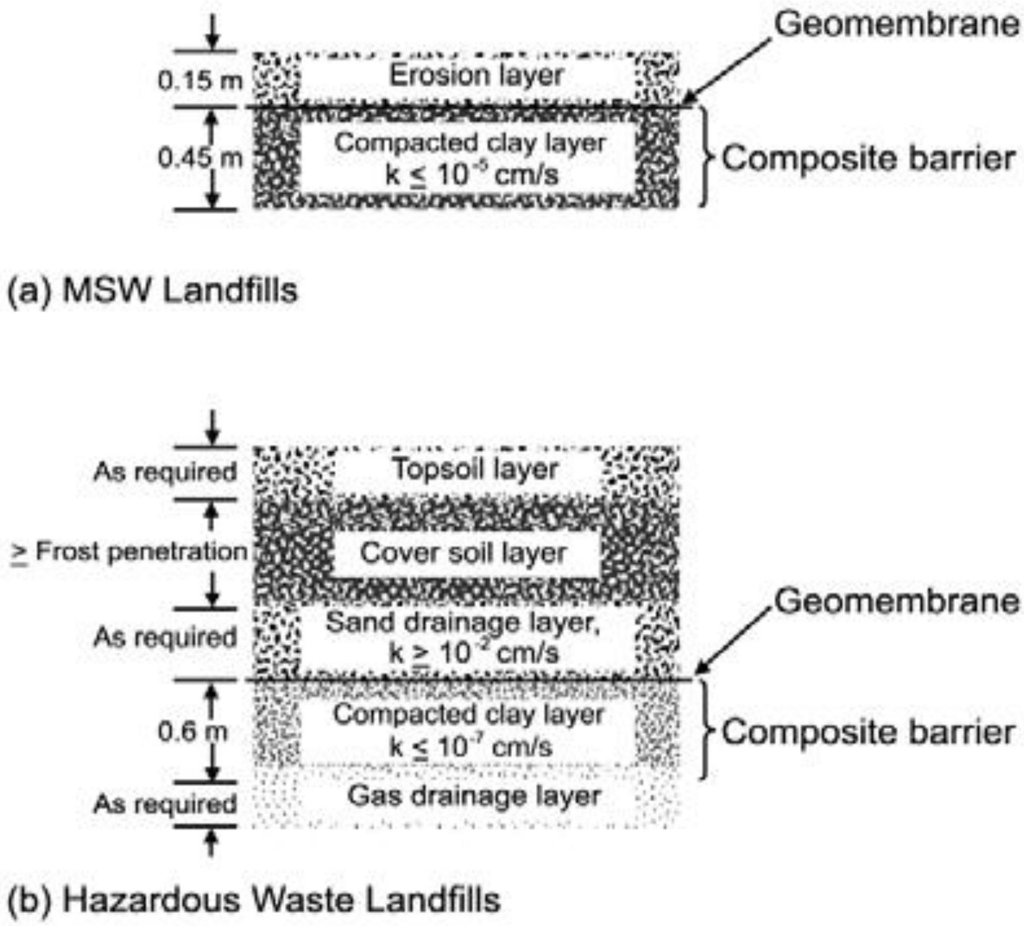

Figure 1: Examples of Subtitle D and C Cover Design

Description

ET cover systems are designed to rely on the ability of a soil layer to store the precipitation until it is naturally evaporated or is transpired by the vegetative cover. In this respect they differ from more conventional cover designs in that they rely on obtaining an appropriate water storage capacity in the soil rather than an as-built engineered low hydraulic conductivity. ET cover system designs are based on using the hydrological processes (water balance components) at a site, which include the water storage capacity of the soil, precipitation, surface runoff, evapotranspiration, and infiltration. The greater the storage capacity and evapotranspirative properties are, the lower the potential for percolation through the cover system.

ET cover system designs tend to emphasize the following (Dwyer 2003; Hakonson 1997; Hauser, Weand and Gill 2001b):

- Fine-grained soils, such as silts and clayey silts that have a relatively high water storage capacity
- Appropriate vegetation for long-term stability and evapotranspiration
- Locally available soils to streamline construction and provide for cost savings

Use of local soils allows the opportunity to utilize natural analogue data for speculating future performance.

In addition to being called ET cover systems, these types of covers have also been referred to in the literature as water balance covers, alternative earthen final covers, vegetative landfill covers, soil-plant covers, and store-and-release covers.

ET cover systems are constructed using a monolithic soil barrier. Monolithic covers also referred to as monofill covers, use a single fine-grained soil layer to retain water and support the vegetative community (Albright et al. 2010 and Hauser 2009). Figure 2 shows an example of a mono- lithic ET cover. Exhibit 1 provides an example of a full-scale monolithic cover at a MSW landfill.

Exhibit 1. Monolithic Cover at Lopez Canyon Sanitary Landfill
Site type: Municipal solid waste landfill

Cover design: The ET cover was installed in 1999 and consists of a 3-foot silty sand/clayey sand layer, which overlies a 2-foot foundation layer. The cover soil was placed in 18-inch lifts and compacted to 95 percent with a permeability of less than $3x10^{-5}$ cm/s. Native vegetation was planted, including artemesia, salvia, lupines, sugar bush, poppy, and grasses. In 2001, fifty 30-KW micro turbines that use landfill gas as fuel were installed at the site. They provide sufficient electricity to power 1,500 homes.

Regulatory status: In 1998, Lopez Canyon Sanitary Landfill received con... al approval for an ET cover, which required a minimum of two years of field pe... date the model used for the design. An analysis was conducted ... ry approval of the ET cover. The cover was full... Water Quality Control Board - Los Angeles Reg...

Performance data: Two m... osal Area A and one at Disposal Area AB+ in May... stem has two stacks of time domain reflectometry ... to a maximum depth of 78 inches, and a station fo... ata, there is generally less than a 5 percent chang... tom of the cover compared to nearly 90 perc... the water infiltrating the cover is being removed ... f the cover.

Modeling: The numerical mo... ulative percolation through the cover. The mode... and weather data. Following calibration, UNSAT... ET cover and 95 cm for a conventional cover over... lation of approximately 0 cm for both c... the simulation, the model predicted less annual p... er.

Maintenance activities: During ... establish the vegetation. Once or twice a ye... Department regulations. Prior to the rainy season, an inspection ... and clear debris basins and deck inlets. No mowing activities or fertilizer app... have been conducted or are planned.

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Cost: Initial costs were estimated at $4.5 million, which includes soil importation, revegetation, quality control and assurance, construction management, and installation and operation of moisture monitoring systems.