DESIGN CONSIDERATIONS FOR ALTERNATIVE COVER SYSTEMS

Alternative final cover systems are becoming increasingly popular for waste containment facilities. Less costly than traditional covers systems consisting of geosynthetic barriers such as a geomembrane and/or a GCL, alternative covers rely on the evapotranspiration of moisture through vegetative cover and the moisture storage capacity of soil to mitigate percolation into the underlying waste mass. A USEPA-funded Alternative Cover Assessment Project (ACAP) has shown that these "ET caps" can perform well in certain climates.

In this study, eleven sites were constructed with 10 m x 20 m monitoring sections comprising both conventional and ET cover systems. Albright, et. al. (2006) compiled and summarized the data obtained to date in the ACAP program. Data from the monitoring sections has been collected for the past five years (Table 1).

Table 1. Summary of five-year data from ACAP sites (from Albright, et. al., 2006).

	Average Percolation Rate (mm/yr)	
	Traditional Composite*	Alternative (ET)
Humid Sites	< 3	27 - 207.3
Arid/Semi-Arid/Sub-Humid Sites	< 1	0 - 63.3

*scaled to appropriate hole per area density

In general, composite cover systems consisting of a geomembrane plus clay soil or a GCL allowed significantly less percolation than the alternative covers, despite the fact that the geomembranes in these covers were intentionally compromised with one hole in the center of the test section. But some ET caps did perform as well as the composite covers, indicating that ET principals were successfully applied during the five-year study period. Nevertheless, several additional findings from the ACAP research program indicate a variety of limitations and concerns with ET caps, as discussed below.

Climatic Limitations. ET caps are not appropriate for humid regions, generally any sites in the eastern half of the USA plus those in coastal or otherwise temperate regions of the West as well as those with significant snowpack. Because moisture is stored in the soil of an ET cap for later evapotranspiration by vegetation, the local climate must achieve a long-term excess of evapotranspiration over evaporation. Sites with precipitation (P) at a net 75% of potential evapotranspiration (PET) are defined as humid and are generally not suitable for ET caps. The ET caps installed in Georgia, Iowa, and Nebraska accordingly did not perform well in the ACAP study.

Gas Control. ET caps involve the use of permeable soil with high porosity for water storage. These soils are not barriers to liquid and therefore are not barriers to landfill gas that may continue to be generated for 20 years or more within the underlying waste mass. ET caps would not be suitable for sites where gas control is required. Even if an active gas extraction system exists at the site, an ET cap would not prevent the intrusion of air into the gas collection system, posing efficiency and safety problems.

Erosion. Soil erosion on landfills is common. While the hydraulic performance of composite covers is far less likely to be affected by soil loss, the moisture storage capacity of an ET cap would be severely affected. The frequency and quality of maintenance for such caps must ensure that erosion is limited or altogether eliminated during the post-closure period.

Biotic Separation. Landfill covers play the important role of isolating the waste mass from constituents potentially harmful to animals and plants. ET caps provide little protection for burrowing animals and deep-rooted plants, which not only may be threatened by the waste but also may degrade the performance of the cap by creating flow pathways into the waste. It should be noted that a textile root barrier was installed under the soil layer in the ACAP test sections, in order to prevent roots from causing interference with the lysimeter collection system. The effect of the root barrier, which is not included in real-world ET caps, is to reduce percolation by helping to maintain a capillary break under the soil storage layer.

Extreme Weather. ET caps are designed around long-term annual averages for precipitation and evapotranspiration and may be unable to handle "extreme" situations on both ends of the weather spectrum. Drought conditions may kill the vegetative cover, thereby reducing or eliminating site evapotranspiration to the extent that the soil moisture storage capacity is exceeded in subsequent precipitation events. On the other hand, extreme precipitation events will similarly overload the soils with moisture that the vegetation and evapotranspiration cannot remove. The result in each of these situations is excessive percolation into the waste mass.

Seasonality Effects. ET caps rely on the combined effects of temporary moisture storage in soils along with the uptake and release of that moisture by vegetation. Both of these processes must occur simultaneously. ET cap performance will decrease when precipitation occurs mainly in the winter months, when evapotranspiration is lowest. In other words, the *seasonal* P/PET ratio must be examined in order to ensure that the ET cap will perform on a year-round basis instead of an average annualized basis. The effects of snowmelt on the seasonal P/PET ratio may also present significant design challenges in this regard.

Long-Term Performance. The performance of geosynthetic cover systems has been well documented for periods up to and exceeding 20 years. The lifetime of these systems is generally accepted to be in excess of 100 years. However, ET caps have little long-term performance data. One arid site has been monitored (with positive results) for 10 years, but the ACAP program has only three seasons of data. Considering the potential for changes in the vegetation quality of these sites and for abnormal weather conditions exceeding the duration of the study period, little conclusive information can be inferred from the field performance of ET caps in the ACAP program.

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Another issue relating to long-term performance is the use of computer water balance simulations over the post-closure period. Benson, et. al. (2004) found that computer-generated percolation rates for ET cover systems under-predicted actual percolation when heavy precipitation events occurred. Thus, the predictive tools used to design and evaluate long-term behavior of ET caps appear to be insufficient. For conventional covers that do not rely on the delicate interrelationship between precipitation and evapotranspiration, such concerns are not applicable.

Construction Quality. The ACAP study is unique in that the soils used in the alternative cover systems were intensely studied in order to derive data pertaining to the relationship between soil type and cap performance. In reality, it is questionable whether soils are assessed with the same rigor, and whether the quality of the soils in terms of their moisture storage capacity is controlled to the extent necessary to produce desired results. Smith (2004) found a 40% difference in moisture storage capacity among soils used in one ET cap. Moreover, Albright found that the moisture storage properties of soils in the laboratory exceeded those properties in-situ, and recommends that the design soil moisture storage value should be only 70% of the laboratory value. With little control over the selection, screening, and placement of ET cover soils on the field scale, the caps may not perform to their design requirements.

Performance Criteria. The ACAP study used site-specific criteria at most sites to assess whether the alternative cover being considered was "equivalent" to the conventional cover required by regulation. For composite-lined landfills, Subtitle D requires a composite cover or equivalent. For composite barriers their criteria was a percolation rate of 3 mm/yr. However, the EPA has not yet recommended a design percolation rate for alternative covers. The EPA may establish more stringent criteria than those used in the ACAP study.

Conclusions. An ET cap may perform acceptably in certain climatic regions, where there is enough precipitation to maintain healthy vegetative cover but not so much that moisture storage and evapotranspiration capacities are exceeded. While such conditions may exist in certain arid or semi-arid regions, ET caps do not appear to be suitable in humid regions. Moreover, with the potential for seasonal or other short term extreme weather events such as heavy precipitation, snowmelt and drought, the percolation into an ET cap can exceed that from a conventional cover system. A designer must be keenly aware of these design considerations and limitations before committing to an ET cap system for a waste containment facility. Due to lack of long-term performance data, lysimeters should be installed in all alternative covers.

References

Albright, W.H., Benson, C.H., Gearhart, N., Gross, B., Rock, S.A. and Valceschini, R. (2006) Alternative Covers for Landfills, Waste Sites, and Mine Sites; Design, Modeling, Construction and Monitoring Workshop, Desert Research Institute, Reno, NV.

Benson, C.H., Bohnhoff, G.L., Aptinwantragoon, A., Ogorzalek, A.S., Shackleford, C.D., and W.H. Albright (2004) "Comparison of Model Predictions and Field Data for ET Cover," *Tailings and Mine Waste '04,* Taylor and Francis Group, London, pp. 137-142.

Smith, G.M. and W.J. Waugh (2004) "Influences of Construction Subtleties on the Hydraulic Performance of Water-Balance Cover," *Tailings and Mine Waste '04,* Taylor and Francis Group, London, pp. 143-150.