AN EVAPOTRANSPIRATION COVER FOR CONTAINMENT AT A SEMIARID LANDFILL SITE[1]

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Abstract: The Resource Conservation Recovery Act (RCRA) requires that regulated landfills have hydrologic barrier covers that comply with prescribed design criteria or an alternative with equivalent performance. In arid and semi-arid climates, alternative covers rely on soil water storage, establishment of vegetation, and soil water loss through evapotranspiration to restrict deep drainage. The design and performance monitoring of a 6.1 ha evapotranspiration landfill cover (ETLC) within a U.S. Army facility located in central Colorado are described. A numerical water balance model, UNSAT-H, predicted that annual drainage through a 122-cm thick clay loam cover, based on four continuous years of high annual precipitation (53 cm), was near or less than 0.1 mm. A soil survey of the borrow area was conducted to inventory soil horizons that were suitable based on hydraulic and plant productivity characteristics. Construction of the ETLC was completed in August 2000. Native prairie grasses were planted in October. Management practices to establish the permanent plant cover included incorporation of biosolids, soil fertilization, straw mulching, and use of erosion blankets. Soil water storage and vertical water flux rates are being assessed by lysimeter, neutron-moisture probe, and thermocouple psychrometer measurements. Transect methods will be used to assess cover vegetation.

The RCRA regulations allow for an alternative to the prescribed landfill cover if hydrologic performance is equivalent. Alternative landfill covers are attractive because the design and construction costs can be substantially less than those for prescribed RCRA Subtitle C or D covers. This report describes a 6.1 ha, 122-cm thick Subtitle C evapotranspiration landfill cover (ETLC) that was constructed in August 2000 at the U.S. Army facility at Fort Carson near Colorado Springs, Colorado. The cost of the ETLC was about \$240,000 dollars ha^{-1} less than a prescribed RCRA Subtitle C cover. The performance of an ETLC is dependent on many variables including climatic conditions, soil and vegetation characteristics, and cover thickness. The cover stores water in the soil during the plant dormant period and removes the stored water during the growing season through evaporation and plant transpiration. The development of the Fort Carson cover required water balance model simulations, soil characterization (physical, chemical, hydrologic), soil and vegetation management plans, and performance monitoring plans.

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The hydrologic model, UNSAT-H (Fayer 2000), was used to assess the potential hydrologic performance of cover configurations that were representative of in-situ borrow-area soils and borrow-area soils compacted to 75 and 85 percent of the maximum Proctor density. Model simulations were conducted using Colorado Springs daily climatic data from an average year (1983) with 40 cm of precipitation and also a year with the historical near maximum precipitation (1984) at 53 cm. All model simulations were conducted for a 4-year period. The model input parameters were representative of a prairie grass with 50 percent cover, a leaf area index range from 0.5 to 1.5, a root density distribution based on literature data (Weaver 1958), and root depth to 89 cm. The model predicted that annual water loss through evapotranspiration exceeds annual precipitation. For all simulations the predicted annual drainage through the base of the ETLC with in-situ and compacted soil was 0.1 mm or less.

Soil profiles throughout the borrow area were described to a depth of at least 152 cm using U.S. Department of Agriculture (USDA) soil description terminology (USDA 1998). Soil samples were collected from each soil horizon and physical, hydraulic, and fertility parameters were determined from laboratory analysis. This information was used to inventory soils suitable for ETLC construction, to identify soils that were best suited for topsoil, to determine soil amendment requirements, and to establish a construction target bulk density. The texture for most soil horizons is a clay loam (USDA Soil Classification System). The dry bulk density for in-situ borrow area soils are between 1.10 g cm^{-3} and 1.25 g cm^{-3}. The saturated hydraulic conductivity is between 10^{-3} and 10^{-5} cm s^{-1}. The dry bulk density and hydraulic conductivity values for borrow area soil samples compacted to 75 percent of the maximum Proctor density were similar to those of in-situ soils. The dry bulk density at 85 percent of the maximum Proctor density, however, approached 1.45 g cm^{-3}. Soil compaction may affect plant productivity that is required for the cover performance. Bulk densities above 1.45 g cm^{-3} in a clay loam may affect plant growth because of soil resistance to root penetration (Brady and Weil 1999, Daddow and Warrington 1983). Thus the target compaction range for construction of the ETLC was established between 1.10 g cm^{-3} to 1.30 g cm^{-3}. A field test was conducted to estimate the water storage capacity of the cover profile using a 2,839 L-polyethylene tank that was developed into a lysimeter (147 cm height by 152 cm diameter). The lysimeter was packed with soil that was representative of the 122 cm cover profile and then saturated with water. The water storage in the soil profile, based on volumetric water content measurements obtained 13 days after no drainage was observed, was 43 cm of water.

The upper 30 cm of the ETLC was constructed with borrow area upper soil horizons because these soils have higher organic matter content and more favorable soil structure for plant growth than lower soil horizons. During cover construction, soil was placed in 0.30 m lifts and each lift was tilled to achieve the target bulk density. Some of the soil samples collected from the cover following construction had bulk densities greater than 1.3 g cm^{-3}, presumably due to compaction associated with construction activities. A mix of native warm- and cool-season grasses was seeded in October 2000. These prairie grasses provide an extended growth and transpiration period, the grasses develop shallow and deep root systems for erosion control and soil water removal, and the grasses tolerate adverse environmental conditions. The management practices to establish the vegetation included incorporation of biosolids at about 313 dry Mg ha^{-1} to increase organic matter and provide a slow release of nitrogen for plant growth and use of straw mulch or erosion mats for temporary cover. Weeds that establish on the cover will be controlled through mowing.

A recording weather station was installed to monitor climatic conditions. The hydrologic performance of the ETLC is based on monthly soil water monitoring at eight locations. Lysimeters, with dimensions described previously, were installed 30 cm below the cover to measure drainage. Neutron probe access tubes were installed both within and external to lysimeters to measure the soil water content throughout the cover profile using a portable neutron probe. Thermocouple psychrometers were installed external to lysimeters in a vertical plane at depths of 61 cm, 91 cm, and 122 cm to measure soil water potentials. The water potential data is used to estimate vertical water flux rates in the cover. Soil water monitoring data has been collected monthly since September 2000. Soil water content has ranged from 0.13 g cm^{-3} to 0.31 g cm^{-3} and water potential has ranged from -0.4 MPa to -2.1 MPa. As of April 2001 there has been no drainage from lysimeters.

Transects to monitor vegetation will be established in the future at three locations. Each transect will extend 61 m and include four 1 m^2 quadrants. Vegetation data will be collected in the spring and fall. The data will include plant species, plant species height, estimated leaf area index, total composition of each species, and the percent bare area. Aerial color and color infrared photographs will be obtained each year in July to document vegetation cover.

References

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