

TEST REPORT #4: Field-Scale Hydraulic Conductivity of a Typical Freshwater AquaBlok Formulation

Background and Purpose of Testing

Results of bench-scale AquaBlok™ testing indicate that, under controlled laboratory conditions and using standard testing procedures, typical freshwater AquaBlok formulations tested under saturated conditions display very low hydraulic conductivity when permeated with freshwater (Test Report #3). The relatively impervious nature of saturated AquaBlok contributes to its ability to minimize flux of sediment-borne contaminants into adjacent surface or ground-water bodies through minimizing advective pore-water flow. As also discussed in Test Report #3, contaminant flux reduction is considered to be an important function of in-situ remedial sediment caps.

The purpose of this test was to determine the hydraulic conductivity (permeability) of a typical hydrated freshwater AquaBlok formulation on a large (field-equivalent) scale using a recognized and accepted procedure developed for evaluating the efficiency of clay based landfill caps and liners.

Test Method Background and Procedures

The field-scale permeability of hydrated AquaBlok was determined using the Two-Stage Borehole Field Permeability Test developed by Soil Testing Engineers, Inc. – a procedure also commonly known as the Boutwell Permeability Test. The Boutwell Test is a standardized field procedure used for quantitatively evaluating the permeability of rainfall through clay based landfill caps and liner systems. The Boutwell Test is widely recognized and accepted by U.S. EPA, U.S. Army Corps of Engineers, and many state regulatory agencies.

In theory, the Boutwell Test is based on the concept that when the three-dimensional geometry of a substrate's wetted zone is varied

systematically, the vertical and horizontal permeabilities also vary in a calculable manner. That is, during "Stage I" of this permeability test, the bottom of a test hole augered into a substrate is positioned flush with the bottom of the cased (and water-filled) hole, allowing for primarily vertical flow from the casing into the substrate. In contrast, "Stage II" of the test involves advancing the test hole several inches beyond the bottom of the water-filled casing, thus allowing for significant horizontal flow through the substrate.

The Boutwell Test has associated with it a number of boundary condition requirements that must be met in order for the test to be considered valid. As described in detail by Boutwell (1992), such requirements range from a minimal thickness of material below the bottom of the test hole during Stage II (8 inches) to a minimum horizontal distance between test holes (20 inches). Personal communication with Dr. Gordon Boutwell confirmed that these and other requisite assumptions and conditions (Boutwell, 1992) were met through conducting our particular permeability test using AquaBlok.

The Boutwell Test was performed outside in two large, (1000-gallon capacity) plastic testing vessels, each equipped with valving and drainage along perimeter sides and bases to allow for gravity drainage from each vessel (in order to meet boundary condition requirements).

Quantities of AquaBlok, similar in composition to the 4060 FW formulation (see Test Report #1), were added and hydrated incrementally in 4- to 6-inch lifts (Photo 1), with approximately one-day hydration time between lifts. The final, cumulative hydrated AquaBlok thickness in each vessel was approximately 3.5 feet (Photo 2). At this point, the AquaBlok-filled vessels were ready for installation of the testing devices.

A total of seven permeameters and one TEG (temperature effect gauge) unit were installed in the hydrated AquaBlok, to total depths of about twenty inches below the material's surface (Photo 3). A hand auger was used to drill the 4.5-inch diameter holes to the required depth, into which each test device was installed.



Photo 1. Addition of AquaBlok to testing vessels



Photo 2. Hydrated AquaBlok prior to instrument installation



Photo 3. Instrumented Boutwell testing vessels

Permeability testing involved collecting data in two different stages, as described above: Stage I of the test, during which vertical permeability has the greatest affect, was conducted over a period of sixteen days. Once the permeability values for Stage I had apparently stabilized (which took approximately two weeks), Stage II was conducted over a period of ten days. Visual and manual inspection of hydrated (but pretested) AquaBlok removed from augered test holes indicated that the bentonite-rich material may not have been fully hydrated during the initial portion of Stage I monitoring. (continued on back)

Table 1. Calculated vertical and horizontal permeability through hydrated AquaBlok (n=7 samples)

Calculated Vertical Permeability ¹			Calculated Horizontal Permeability ¹		
All values in units of cm/sec					
Value Range	Arithmetic Mean	Geometric Mean	Value Range	Arithmetic Mean	Geometric Mean
5.70 x 10 ⁻⁹ to 1.12 x 10 ⁻⁸	8.65 x 10 ⁻⁹	8.41 x 10 ⁻⁹	2.84 x 10 ⁻⁸ to 3.96 x 10 ⁻⁸	3.26 x 10 ⁻⁸	3.23 x 10 ⁻⁸

¹Variability (standard deviation) among replicates for the respective calculated values was small, less than 18 percent.

Results and Observations

Results of large-scale AquaBlok permeability testing using the Boutwell test method are summarized in Table 1. For comparison, see Table 1 of Test Report #3 for AquaBlok permeability values determined on a bench scale in the laboratory.

As can be seen in Table 1, calculated mean permeability values for vertical and horizontal flow through hydrated AquaBlok on a field scale are quite low, on the order of 10⁻⁸ to 10⁻⁹ cm/sec. If, in fact, the AquaBlok had been fully hydrated during Stage I, the actual vertical component would likely have been lower. Furthermore, AquaBlok permeability on a field scale is comparable to values determined under controlled conditions in the laboratory, which ranged from 3.9 x 10⁻⁹ to 5.9 x 10⁻⁹ cm/sec for different product formulations (see Test Report #3).

Conclusions

Results of this large-scale field permeability test indicate that AquaBlok - once in place and hydrated in the field - can form not only an effective physical barrier between contaminated substrate and the adjacent environment, but also an effective hydraulic barrier between such ecosystem components. Whether considering a landfill, deepwater, or wetland application scenario, such characteristically low permeabilities would help protect against the downward migration of dissolved contaminants into underlying ground water resources, as

well as upward migration of contaminated pore waters into an overlying water column.

References

Boutwell, G.P., 1992. The STEI Two Stage Borehole Field Permeability Test. Presented to "Containment Liner Technology and Subtitle D" seminar sponsored by Geotechnical Committee, Houston Branch, ASCE, Houston, Texas - March 12, 1992.



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