WATER RESOURCES RESEARCH GRANT PROPOSAL

TITLE: AN IMPROVED CHARACTERIZATION OF A ERACTURED- ROCK AQUIFER BY THE TRANSIENT FLOWMETER TEST

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STATEMENT OF CRITICAL REGIONAL WATER PROBLEMS:

Efficient management and/or remediation of groundwater resources polluted by *point and nonpoint* sources in general and *pesticides and* nitrates in particular, depend directly on reliability of groundwater-flow and contaminant-transport mod els. In addition, allocation of water resources as well as water quality of public water supply reservoirs of North Carolina depend to a certain degree on these models. The groundwater-flow and contaminant-transport models in turn need accurate knowledge of aquifer parameters including specific *storativfty* (or storativity) and *hydraulic conductivfty* (or transmissivity), which are known to vary significantly even within the same geologic formation. The lack of detailed information on the dist ribution of aquifer parameters at scales compatible with model grid scales is a major barrier to successful deterministic or stochastic forecasting of the fate of groundwater contamination. This is especially true in aquifers of complex fractured rock sys tems such as in North Carolina Piedmont plateau *[Evans,* 1995]. In fact. *Evans* [199.5] noted that "[u]understanding the hydrogeology of fractured rock systems remains a particularly challenging aspect of groundwater hydrology." One of the mos t efficient and economical ways for obtaining information about hydraulic properties of aquifers is through the single-borehole tests and, in particular, through the flowmeter test.

Although developed initially for wells in alluvial aquifers, the flowmeter test also finds applications to the fractured rock aquifers of both high and low permeability (*Hufschmied. 1983:*83: *Hess. 1986: et al.. 1988:* Tsang et al.. 1990). The current theory of the flowmeter test (Motz et al.. 1989, 1990: *Rehfeldt et al.,* (1989) evaluated recently by *Rund and Kabala* (1996) requires that the borehole be pumped at a constant pumping rate until a quasi steady stare is reached bef ore the flowmeter test can be performed. This allows one to estimate *only* the downhole distribution of the hydraulic conductivity (or related transmissivity). It does not provide enough information to estimate the downhole specific storativity dist ribution, which plays a key role in transient flows. In the flowmeter test, specific storativity is usually assumed to be constant and its value is estimated from a pumping rest on a fully penetrating well *[Molls et al.,* 1989, 1990], or its value i s assumed based on literature *[Tsang' et* al., [990]. The only way to measure specific storativity is in a transient rest. Bur the theory of the transient flowmeter test has nor yet been developed nor applied in subsurface hydrology. In addition, pr olonged pumping to reach

steady state may increase the spread of hazardous contaminants at critical sites such as tee Gate 11 Duke Forest Site located near the eastern edge of the North Carolina Piedmont plateau *[Medina et* al., 1995: *Cassiani and Medina,* 1996]. A transient flowmeter rest would permit more rapid and more accurate measurements.

STATEMENT OF THE RESULTS, BENEFITS AND/OR INFORMATION:

The objectives of the proposed research are to i) develop a theory of the transient flowmeter test, ii) develop a new related transient flowmeter rest interpretation methodology, iii) evaluate the new transient flowmeter rest in synthetic numerical exp eriments, iv) evaluate the new test in the field at the Gate 11 Duke Forest Sire located at the edge of the North Carolina Piedmont plateau, v) measure downhole distributions of fracture transmissivity in a number of the 15 monitoring wells surrounding th e Gate 11 Duke Forest Site. and vi) measure the downhole distributions of fracture *storativity* in a number of the 15 monitoring wells surrounding the Gate 11 Duke Forest Sire.

We will relax the *traditionally invoked assumption* of steady pumping rare for each borehole segment measured in the flowmeter test (note that *Ruud and* Kampala [1996, 1997] provided a realistic numerical counter example in which even in th e case of constant total pumping rate, the flow-rare contributions of each measured segment were *transient).* The revised theory and the new interpretation methodology will find immediate applications in characterization of nor only fractured rock a quifers but also alluvial aquifers in North Carolina and beyond. Consequently, the results of the proposed research will have a positive impact on the management and remediation of groundwater resources of North Carolina polluted by point and *nonpoint sources. in* addition the project will generate valuable data for modeling the fate of *paradioxane* and other hazardous contaminants including derivatives of the low-level radioactive waste buried at the Gate11 Duke Forest Site between 1961 and 1 970. Since the site is located at the edge of the North Carolina Piedmont plateau these results could possibly be extrapolated to similar sites in the plateau.