Use of Analog Models in the Arkansas and Verdigris River Valleys, Oklahoma[1]

HARRY H. TANAKA, U.S. Geological Survey, Oklahoma City

Electrical analog models are being used by the U.S. Geological Survey in cooperation with the U.S. Army Corps of Engineers to determine ground-water surface in the alluvium after construction of navigational improvements on the Arkansas and Verdigris rivers. The construction of five navigation locks and dams in Oklahoma will change the natural gradient of the rivers to a series of stairstep reservoirs. The changes in the river-stage profile resulting from these structures will obviously cause related changes in the ground-water surfaces and evapotranspiration rates in the aquifer. The analog model was used to project the postconstruction ground-water surface because it provides a convenient method to miniaturize the physical dimensions of the hydrologic system and to apply certain controlled changes on this system.

Basically, the analog model consists of a resistor network, a direct-current power source, and a voltmeter. The principle of operation is based on the analogy between the flow of water in a ground-water system (Darcy's law) and the flow of electricity through an electrical circuit (Ohm's law). In this analogy the transmissibility in a ground-water system is represented by resistance in an electrical system, pressure or head of water is represented by voltage, and rate of water flow by amperes (Robinove, 1962).

The basic grid, consisting of a network of resistors, is scaled to the dimensions of the real aquifer. The resistance values are scaled to the transmissibility of the aquifer. The transmissibility of the aquifer was determined at several hundred test-hole locations by correlating the grain size of samples with permeability.

Changes in evapotranspiration become particularly significant when ground-water levels are projected near land surface. Evapotranspiration control on ground water is determined by a relation of the rate of upward flow of water (capillary flow) and the depth to the water table. This relation is computed and is incorporated in the model by adding resistors with appropriate values to the network junctions of the basic model so that current equivalent to the change in the rate of evapotranspiration flows through the resistor.

The natural (prior to construction of navigational structures) ground-water surface is the average of water levels measured at regular intervals during an 8-year period. The natural ground-water surface is the datum from which the postconstruction groundwater surface is projected. The postconstruction water-level surface is projected on the basis of the change in the river-stage profile and the change in evapotranspiration attending the change in ground-water level. The changes in the water level are determined by analysis of the analog and superimposed on the natural ground-water surface to obtain the postconstruction ground-water surface.

Electrical analogs have been constructed for alluvial areas bordering the Arkansas River in Oklahoma from the State line to Muskogee and for the Verdigris River valley from its mouth to Catoosa. Analogs in the Arkansas River valley have been analyzed and the analog of the Verdigris River valley is currently being analyzed. The projected ground-water

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maps, prepared with the aid of the analogs, are used by the Corps of Engineers in their planning and construction phases of the Arkansas River Multiple Purpose Project.

LITERATURE CITED

Robinove, Charles J. 1962. Ground-water studies and analog models. USGS Circ. 468, 12 p.