Hydrogeology and Simulated Water Budget of the Rio Cobre and Rio Minho-Milk River Basins, Jamaica, West Indies

by

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(**ABSTRACT)**

An investigation was undertaken to better understand the hydrogeologic framework of the Rio Cobre and Rio Minho-Milk river basins, Jamaica, West Indies. A quasi three-dimensional finite-difference groundwater flow model was used to conceptualize flow conditions and establish a hydrogeologic budget of the region.

The Rio Cobre and Rio Minho-Milk river basins lie on the Clarendon Block, an area with a complex geologic history. The geologic history includes: 1) the intrusion of calc-alkaline granites, 2) morphotectonic sedimentation, 3) three episodes of deformation by transpressional and transcurrent tectonics, 4) the deposition of a highly-permeable, Tertiary carbonate platform, and 5) the development of near surface karst oriented with the major NNW-SSE fault trend in the basins. Since deposition, compression, faulting, and solution have modified the distribution and thickness of carbonate rocks impacting the ground-water flow of the region. The most notable features are the older NNW-SSE trend dip-slip faults and the younger E-W trend strike-slip faults, notably the South Coast Fault (SCF) formed during the Laramide Orogeny. The White Limestone aquifer is the principal aquifer of the Rio Cobre and Rio Minho-Milk river basins in the parishes of St. Catherine, Clarendon, and partly in Manchester. It is characterized by intercalated sequences of permeable rubbly and micritic carbonate rocks. The age of the rocks range from Late Cretaceous (Maastrichtian) to Recent.

The permeability of the South Coast fault and the high hydraulic conductivity value associated with the Tertiary carbonate platform (480 m/d) in the Lower Rio Minho-

Milk River basin control the gradient of the potentiometric surface and ground water flow in that region The agreement between the measured and the simulated hydraulic heads obtained for this steady-state model suggests that the values assigned to the hydraulic properties that characterize the ground-water flow of the White Limestone aquifer are reasonable. Recharge to the area occurs as net recharge in addition to upland subsurface inflow across the general head boundary in the northern part of the study area. Comparisons of calculated and observed values of head indicate that simulated groundwater flow field generally agree with field conditions.

Several simplifying assumptions were made for the conceptualization and simulation of flow in the basins: 1) during the 1998 water year, ground-water in the basins was considered at steady-state, 2) pumping does not significantly affect the level of hydraulic heads; therefore pumping wells are not simulated, 3) Net recharge from precipitation varies spatially, 4) karstification and aquifer heterogeneity impact on the distribution of hydraulic conductivity, 5) Darcy's law is applicable to flow through the fractures and solutions openings in a karst region, 6) flow in the White Limestone aquifer occurs in the uppermost 650 m and vertical flow is assumed to be controlled by intervening units, 7) evaporation was not explicitly simulated in the model. Recharge rates were considered as 'net recharge,' and 8) submarine discharge occurs from the aquifer along the coast where aquifers are hydraulically connected to the sea.

Ground-water flow in the basins was conceptualized as a quasi three-dimensional flow system in which two model layers were used. The model boundaries selected to represent natural hydrologic boundaries include (1) a no-flow along the western and eastern boundaries, (2) a constant head boundary along the freshwater/saltwater interface; (3) a general head boundary along the northern boundary; and (4) a horizontal-flow barrier boundary along the South Coast Fault; and (5) river leakage boundaries along major rivers draining the coastal basins. The simulated region is an area of 2,550 square kilometers, two-thirds of which is hilly and the remainder, irrigated plains with small swamps draining the area. The model consists of over 337,500 cells and employed a regular grid spacing of 200m x 160m. The model was designed and calibrated to steady-state conditions from data observed/estimated during water year 1998. The Water Resources Authority of Jamaica (WRAJ) will use the results of the modeling study as a predictive tool for long-term management and monitoring of water resources in the region.

The model was calibrated using a manual *trial-and-error* adjustment of parameters. Hydraulic conductivity values in both model layers, hydraulic conductivity at the general-head boundary, and streambed conductance were adjusted during successive simulations until computed head values approximated field conditions. The computed potentiometric surface is an adequate or reasonable match on a regional scale, with the general horizontal hydraulic gradient oriented with the main fault trend NNW-SSE in both basins.

Sensitivity tests of the calibrated model were conducted on net recharge, hydraulic conductivity, hydraulic conductivity assigned along the general-head boundary, and streambed vertical conductance to determine if differences between simulated and observed values were similar to the range of uncertainty in the values of input data and boundary conditions. Based on the results obtained from the sensitivity analysis, it is apparent that the model is extremely sensitive to changes in horizontal hydraulic conductivity and recharge in the form of precipitation. The model is least sensitive to streambed vertical hydraulic conductivity.