

# Effects of Turbulence on Hydraulic Heads and Parameter Sensitivities in Preferential Ground-Water Flow Layers

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## Abstract

The U.S. Geological Survey created a Conduit Flow Process (CFP) (Shoemaker and others, 2008) for the Modular Finite-Difference Ground-Water Flow Model, MODFLOW-2005. An application of the CFP on the Biscayne aquifer in southern Florida is described that examines (1) the potential for turbulent groundwater flow, and (2) the effects of turbulent flow on hydraulic heads and parameter sensitivities. Turbulent flow was spatially extensive (Figure 1) in preferential groundwater flow layers with mean void diameters equal to about 3.5 centimeters, groundwater temperature equal to about 25 degrees Celsius, and critical Reynolds numbers less than about 400. Turbulence either increased or decreased simulated heads from laminar altitudes. Specifically, head differences from laminar altitudes ranged from about -18 to +27 centimeters, and were explained by the magnitude of net flow to the finite-difference model cell. Turbulence also influenced the sensitivities of model parameters. Specifically, the composite-scaled sensitivities of horizontal hydraulic conductivities decrease by as much as 70% when turbulence is removed. Resultant hydraulic head and sensitivity differences due to turbulent groundwater flow highlight potential errors in models which assume laminar flow in an equivalent porous-media having uniformly distributed void spaces.

[http://water.usgs.gov/software/ground\\_water.html](http://water.usgs.gov/software/ground_water.html)

## REFERENCES

Shoemaker, W.B., Kuniansky, E.L., Birk, Steffen, Bauer, Sebastian, and Swain, E.D., 2007. Documentation of a Conduit Flow Process (CFP) for MODFLOW-2005: U.S. Geological Survey Techniques and Methods 6-A24.

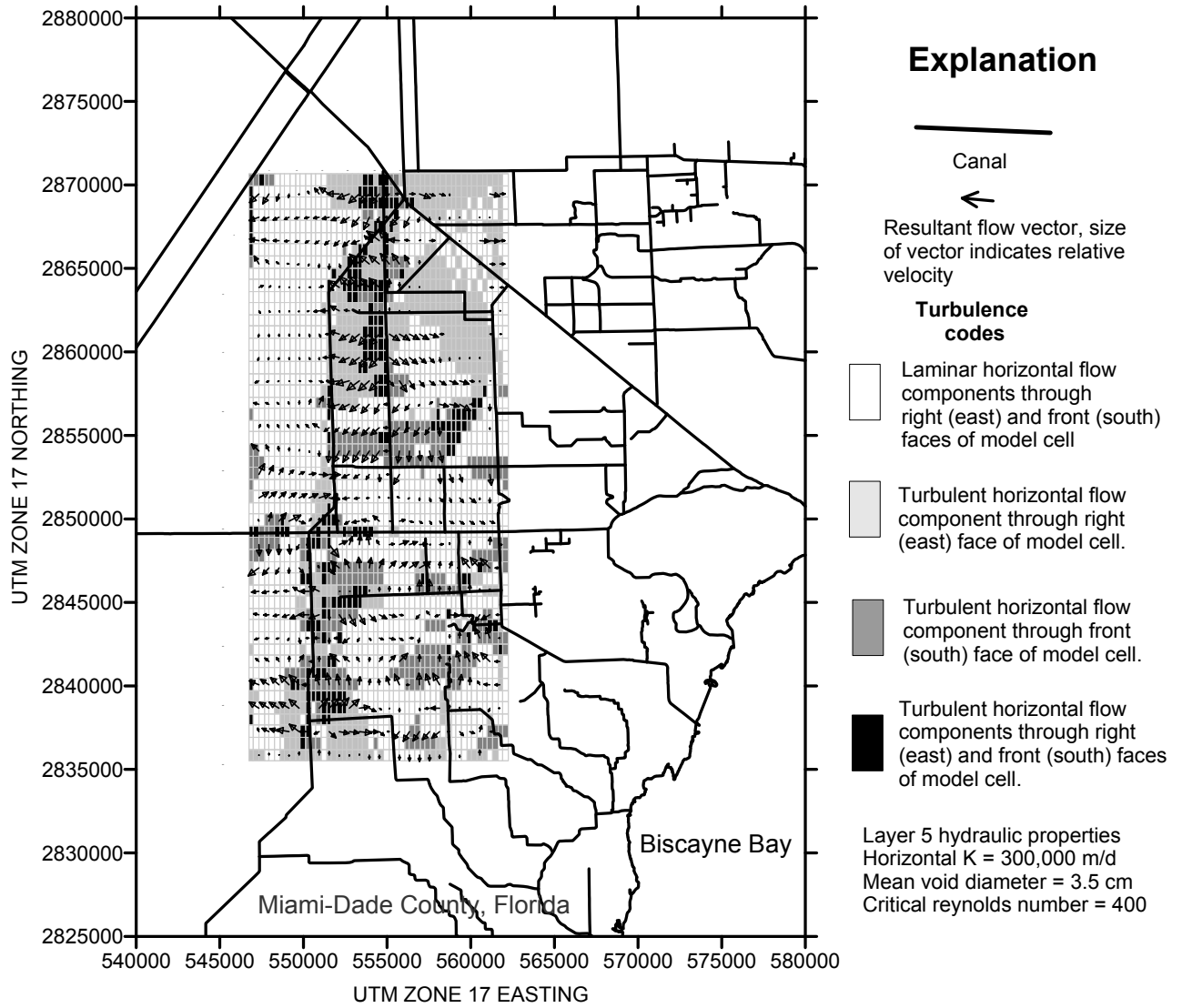


Figure 1. Extent of turbulence in preferential ground-water flow layer 5.