# Translating CFC-based piston ages into probability density functions of ground-water age in karst

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## Abstract

Temporal age distributions are equivalent to probability density functions (PDFs) of transit time. The type and shape of a PDF provides important information related to ground-water mixing at the well or spring and the complex nature of flow networks in karst aquifers. Chlorofluorocarbon (CFC) concentrations measured for samples from 12 locations in the karstic Madison aquifer were used to evaluate the suitability of various PDF types for this aquifer. Parameters of PDFs could not be estimated within acceptable confidence intervals for any of the individual sites. Therefore, metrics derived from CFC-based apparent ages were used to evaluate results of PDF modeling in a more general approach. The ranges of these metrics were established as criteria against which families of PDFs could be evaluated for their applicability to different parts of the aquifer. Seven PDF types, including five unimodal and two bimodal models, were evaluated. Model results indicate that unimodal models may be applicable to areas close to conduits that have younger piston (i.e., apparent) ages and that bimodal models probably are applicable to areas farther from conduits that have older piston ages. The two components of a bimodal PDF are interpreted as representing conduit and diffuse flow, and transit times of as much as two decades may separate these PDF components. Areas near conduits may be dominated by conduit flow, whereas areas farther from conduits having bimodal distributions probably have good hydraulic connection to both diffuse and conduit flow.

**Keywords:** Karst aquifer; Carbonate aquifer; Age dating; Age distributions; Chlorofluorocarbons; CFC; Ground-water tracers; Probability density functions