Tephra2 is a simulation program capable of estimating the distribution and mass loading of tephra fall deposits based on an analytical solution to the advection-diffusion equation. As this code includes a vertical column model, application of inversion techniques, such as the downhill simplex method, to model observed variation in tephra deposits has shown the code's potential as a tool for reconstruction of ancient eruptions. Previous studies show that column reconstruction seemed to successfully model the simple vertical plume of the 1992 eruption of Cerro Negro, Nicaragua (<8km high); however, the model failed to uniquely constrain the column height for a larger eruption, the 2450 BP eruption of Pululagua, Ecuador (36-20km high). This discrepancy reflects that fallout during energetic eruptions takes place from the base of a horizontally spreading umbrella cloud rather than from a rising vertical column, as shown in studies based on gravity current models. We have modified the Tephra2 code to include fallout from the umbrella region by defining a new parameter, sigma-plume, to represent the characteristic radius of the umbrella cloud. In addition, the total grain size distribution of the deposit can be uniquely specified. These modifications to Tephra2 will improve its use as a tool for reconstructing eruptions by improving the interpretation of eruption dynamics, specifically column height and plume geometry, inferred from field observations and examination of the thickness and granulometry of mapped tephra fallout deposits.