1. **Safe Management for Regional Groundwater Sustainability**.

**ABSTRACT**

The indiscriminate and sometimes excessive use of groundwater has led to questions regarding its sustainability. To what extent can groundwater be exploited unduly without compromising the principle of sustainable development?. The sustainability of groundwater utilization must be assessed from an interdisciplinary perspective, where the hydrology, ecology, geomorphology, and climatology play an important role. Generally, groundwater does not recycle as fast as the surface water, with rates of groundwater turnover varying from years to millennia, depending on aquifer location, type, depth, properties, and connectivity. Excessive pumping can lead to groundwater depletion, where groundwater is extracted at a rate faster that it can be replenished. The purpose of this paper is to develop and demonstrate a methodology based on fuzzy set theory to incorporate imprecise data into transient groundwater flow simulation and uses that methodology for management considering sustainability of groundwater for Bahr Al- Najaf region (which lies in Iraq). Modeling transient groundwater flow requires the knowledge of various hydrogeological parameters such as transmissibility, storage coefficient, and aquifer thickness. In the modeling process, parameter uncertainty is one of the major barriers to reliable prediction of groundwater system response. In order to consider a different type of parameter imprecision; one that results from measurement interpretation which is often influenced by expert judgment and subjective information, a fuzzy set approach is presented. Linkage of finite element techniques with fuzzy number operations resulted in numerical models that were considered to simplify flow fields. Fuzzy number operations (α – level cuts) are used to solve the resulting fuzzy groundwater flow model and are extended to consider the dependencies among hydraulic head coefficients. With the fuzzy number inputs, the transient fuzzy groundwater flow model provides a direct measure of hydraulic head uncertainties in the time domain. For management and sustainability, for Bahr Al- Najaf region the proposed model was used in three scenarios for operation of wells to test the durability of groundwater in the study region: 1- remaining the number of original wells and its capacities constant with time 2- increasing the capacities of original wells and remains its number constant 3- adding new wells in the study region. A conclusions from the three scenarios were obtained for management of pumping wells which leads to Sustainable development.