# MODELING OF SALTWATER INTRUSION FROM BRACKISH CANALS IN SOUTHEAST FLORIDA: DYNAMICS AND MANAGEMENT IMPLICATIONS

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*REFERENCE*: ***Proceedings of the 1997 Georgia Water Resources Conference***, held March 20-22, at The University of Georgia, Kathryn J Hatcher, Editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

ABSTRACT

**Background**

Salt water intrusion has been a major threat to the water supply in south Florida since the 1960's. There are three types of salt water intrusion: ocean, brackish water canal, and remnant seawater. Most salt water intrusion research has been focused on ocean saltwater intrusion and the freshwater lenses of atoll islands. As the population has grown in south Florida, the drainage from land development has significantly lowered the groundwater level, making the salt water intrusion from the canal one of the major forms of intrusion.

**Conceptual Model**

A conceptual model has been developed to study the dynamical characteristics of the groundwater system of brackish water canals. The transient conditions of this system, such as the seasonal changes of the groundwater level, the tidal changes of water level in the canal, the rainfall recharges, and the behavior of the low permeability surface layer are investigated in the conceptual model.

The conceptual model explains the brackish water intrusion process while it is under transient conditions. The groundwater system of brackish water canals cannot be characterized by steady state boundary conditions in which brackish water from the canal either intrudes into the entire aquifer continuously or there is no intrusion at all. It seems that a higher mean head surrounding the canal is needed to stop the intrusion when tidal changes of the canal water level and seasonal changes of the groundwater level are applied to the system.

The tidal condition also creates the smoothest salt front, since the flow direction changes at a high frequency, while a steady state creates the roughest salt front due to steady flow. The combined effect of both tidal and seasonal changes has made intrusion a seasonal phenomenon. The low permeability layer of the ground surface and the canal bottom has a tremendous effect on salt water intrusion for steady state boundary conditions. The effect of this layer is greatly reduced under dynamic conditions due to the changing momentum of the groundwater flow.

The conceptual model with a low permeability layer under dynamic conditions provides a full explanation of the salt water intrusion from the brackish water canal. The salt water starts seeping into the aquifer with the momentum it attains during the dry season. The seepage continues during the early portion of the wet seasons. The brackish water, shaped like a drop of water in the air, sinks into the aquifer with very low speed. The amount of brackish water, or the volume of this drop, depends on the characteristics and length of the dry season. The salt water enters the aquifer, diffuses to a lower concentration because of the high permeability in the Biscayne aquifer, sinks into deeper aquifer due to buoyancy and dynamical effects, and merges with the main salt water body accumulated from previous dry seasons before onset of the next dry season. The shape of salt front and the low salinity (relative to the salinity in the canal) in the numerical model matches the observations.

**Procedure**

Based on our understanding of tidal canal groundwater systems, we analyze the Hollywood wellfield, one of largest wellfields in southeast Florida, which has one tidal canal, the C-10 canal nearby. Our investigation starts with a hydrological, geological data analysis, with special attention to the seasonal changes of groundwater levels, tidal canal water levels, and chloride concentrations from the monitoring wells. The analysis shows that there is intrusion of salt water into the Hollywood wellfield, and that the source of this intrusion is the C-10 canal; the salt front is as close as 0.1 miles from the supply wells.

The purpose of the present investigation is to understand the dynamics of the brackish water problem in the Hollywood wellfield, to determine if water management strategies can prevent further intrusion, and if so, what strategy would be most effective. For this purpose we develop a numerical model to describe the brackish water problem in the wellfield. A cross-section which contains the wellfield, the canal and two monitoring wells is used for the two dimensional variable density system. Boundary conditions of seasonal groundwater levels and tidal canal water levels are assumed to be periodic functions due to lack of available data on departures

from seasonal conditions. The shape of the salt fronts simulated by the numerical model matches the observations.

**Predictions**

The model predicts that the brackish water intrusion of the C-10 canal is a slow process. It appears that one year or a short dry term will not induce serious intrusion if the water level returns to normal conditions. However, long term water level changes due to water management policy may not become evident for years or decades after an undesirable stress is placed on the system.

The water level surrounding the canal becomes the most dominant factor influencing brackish water intrusion, especially during the dry season. Because of high permeability in the area, neither pumpage nor injection affects the water level significantly. It seems that more pumpage from Hollywood wellfield only slightly speeds up the intrusion. On the other hand, as proposed to inject freshwater into the aquifer, is not able to stop the salt water intrusion even when the amount of injection is the same as pumpage. In addition, injection wells are expensive to construct.

The main conclusion of the present study is that to prevent salt water intrusion from the canal, a threshold water level should be maintained in the wellfield area surrounding the canal during the dry season through water management. A huge amount of freshwater needs to be delivered to the area during the period when the hydraulic head surrounding the canal is not high enough to support the denser brackish water. Injection delivers far less water than needed and is not feasible to accomplish, but a fresh water canal placed along side of the brackish water canal could provide water that is required.