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A MODULAR GROUND WATER MODELING SYSTEM (GWZOOM)
2. System Implementation

by

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A MODULAR GROUND WATER MODELING SYSTEM (GWZOOM): 2. System Implementation

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ABSTRACT: A modular ground water modeling system, called GWZOOM, was developed at the South Florida Water Management District (SFWMD). This paper presents an example of an application to illustrate the use and effectiveness of GWZOOM. GWZOOM was used to create a small scale model from a regional scale model in Dade County, Florida, in order to analyze a proposed underground seepage barrier (curtain wall). The purpose of the proposed curtain wall is to increase water levels and improve hydroperiods in Everglades National Park (ENP), while reducing the impacts and providing flood protection to adjacent agricultural operations. GWZOOM was used to generate the model grid, to convert regional model data sets to the smaller scale model, and to transfer data from various coverages in a Geographic Information System (GIS) to MODFLOW model coordinates and input files. Many alternative scenarios were also created and simulated. Creation, analysis, and revision of the small scale model was accomplished far more rapidly than previously possible.

KEY TERMS: Ground Water Modeling; Geographic Information System; Resources Planning; Hydrology; Water Resources Management.

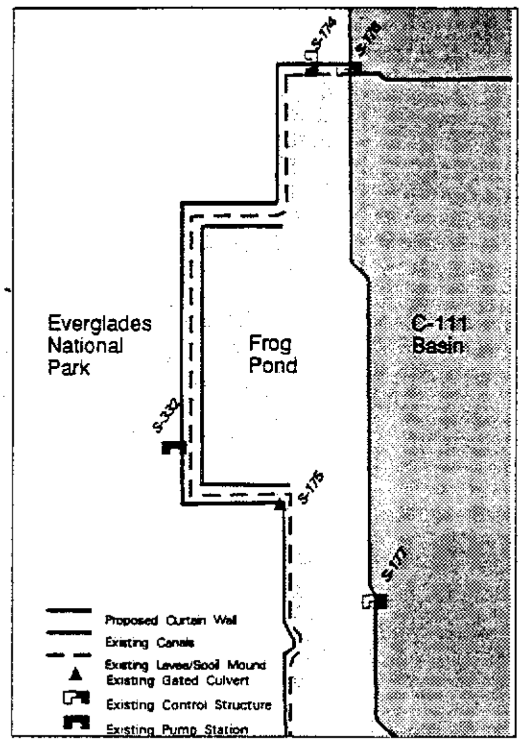

Figure 1. Frog Pond Study Area

INTRODUCTION

Several water management strategies have been proposed for environmental improvement for Everglades National Park (ENP) and Florida Bay. One alternative is to construct a seepage barrier (curtain wall) between ENP and an adjacent agricultural area,

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known as the Frog Pond (Figure 1). Anticipated benefits of the proposed curtain wall include: 1) restoring historical hydroperiods in ENP, 2) delivering additional fresh water to Taylor Slough and Florida Bay, and 3) providing flood protection to the areas east of the proposed curtain wall. To analyze impacts associated with construction of the proposed curtain wall, a localized three-dimensional ground water model flow was developed. GWZOOM described in the first paper (Yan et al., 1995) and an existing regional ground water flow model were used to develop the smaller local scale model (zoom model). The location of, and the relationship between the zoom model and the regional model is illustrated in Figure 2.

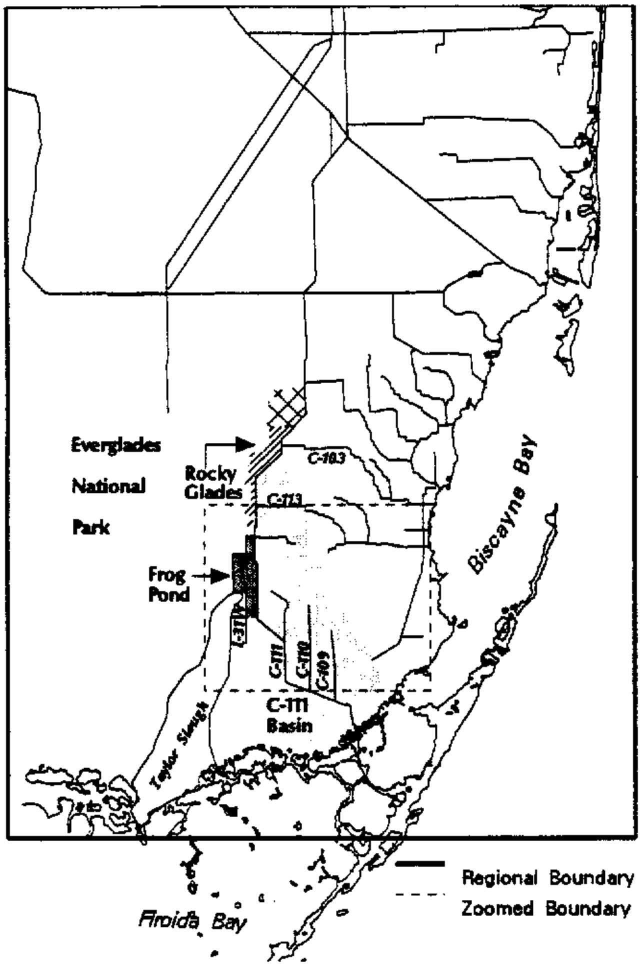

Figure 2. Location Map and the Relationship between the Zoom Model and the Regional Model

MODEL DESCRIPTION

The regional model (called the Dade model) is one of a series of regional ground water flow models developed by the South Florida Water Management District to support planning and regulatory activities. The model grid consists of 132 rows and 100 columns with a uniform cell size of one-half mile by one-half mile. The model grid has four layers representing (in descending order) the Biscayne aquifer (Miami Oolite Formation), the Biscayne aquifer (Fort Thompson Formation), the low permeability layer (Tamiami Formation), and the gray limestone aquifer (Tamiami Formation). The zoom model (called the Frog Pond model) has 150 rows and 200 columns with a uniform cell size of 500 feet by 500 feet. The layering of the Frog Pond model is identical to the Dade model. Boundary conditions for the Frog Pond model were defined as general head boundaries, with the head values interpolated from the regional model for each one-month stress period. This approach provides the Frog Pond model with fine scale simulation capability for the study area while maintaining consistency with the hydrologic conditions of the regional flow system as simulated by the Dade model. The computer code used for both models is the U.S.G.S. Modular Three-Dimensional Finite-Difference Ground-Water Flow Model (McDonald, 1988), also known as MODFLOW.

ZOOM MODEL CREATION

To support the GWZOOM modeling system, regional model datasets need to be developed or converted to a format compatible with GIS. Options included in the GWZOOM program can assist in this task. Major GIS coverages for the regional models (including the Dade model) are listed in Table 1. The canal stage data were assembled into an ASCII file with identical control structure names as those in the canal GIS coverage for linking the static data with temporal data. The Dade model was run to generate hydraulic head values for establishing boundary conditions of the local model.

Table 1. GIS Coverages for Spatial Database

Coverage name	Brief Description	Cov. Type
Land-use	Land use map in level 3 detail	Polygon
General-soils	Soil types and hydraulic parameters	polygon
Land-surface	Topographic land surface	line or point
Base-map	Major roads, canals, political & hydrologic boundaries	Polygon & line
Canals	Canal location, width, bottom elevation, associated control structures, river or drain classification, and other attributes	line
Layer-Bottom	Bottom elevations of model layers	TIN
Conductivities	Hydraulic conductivity parameters	TIN
Transmissivity	Transmissivity parameters	TIN
Storage-Coeff	Storage coefficients	TIN
Vcont	Vertical conductance	TIN
Rain-station	Location, ID, and Static data	point
Grid	Grid coverage coincident with model grid	polygon

The zoom model grid is created using the "Model Grid" option of GWZOOM. Once the model grid is created, the "Model Data" option is used to create data files for each MODFLOW package. The following example is provided to describe the operations. To create the data file for hydraulic conductivity of layer 1, the zoom model grid and the TIN of hydraulic conductivity of the regional model are used. On the "Model Data" menu (Figure 3), the user inputs the name of the GIS workspace containing the zoom model grid, the name of the modeling workspace to write MODFLOW files to, and the model run. Then, the user selects the BCF package (which is a matrix-based package), parameter "hyc" (for hydraulic conductivity), model layer 1, and clicks on the "create/edit" button. A new menu appears, giving the user four choices for creating a "GWZOOM" coverage for matrix data (Figure 4), one of which is to "Spot an existing TIN". The user clicks on the "Spot an existing TIN" button, then specifies the name of the TIN; GWZOOM creates a "GWZOOM coverage" called "g-hyc-1-1a" according to a systematic naming convention developed for

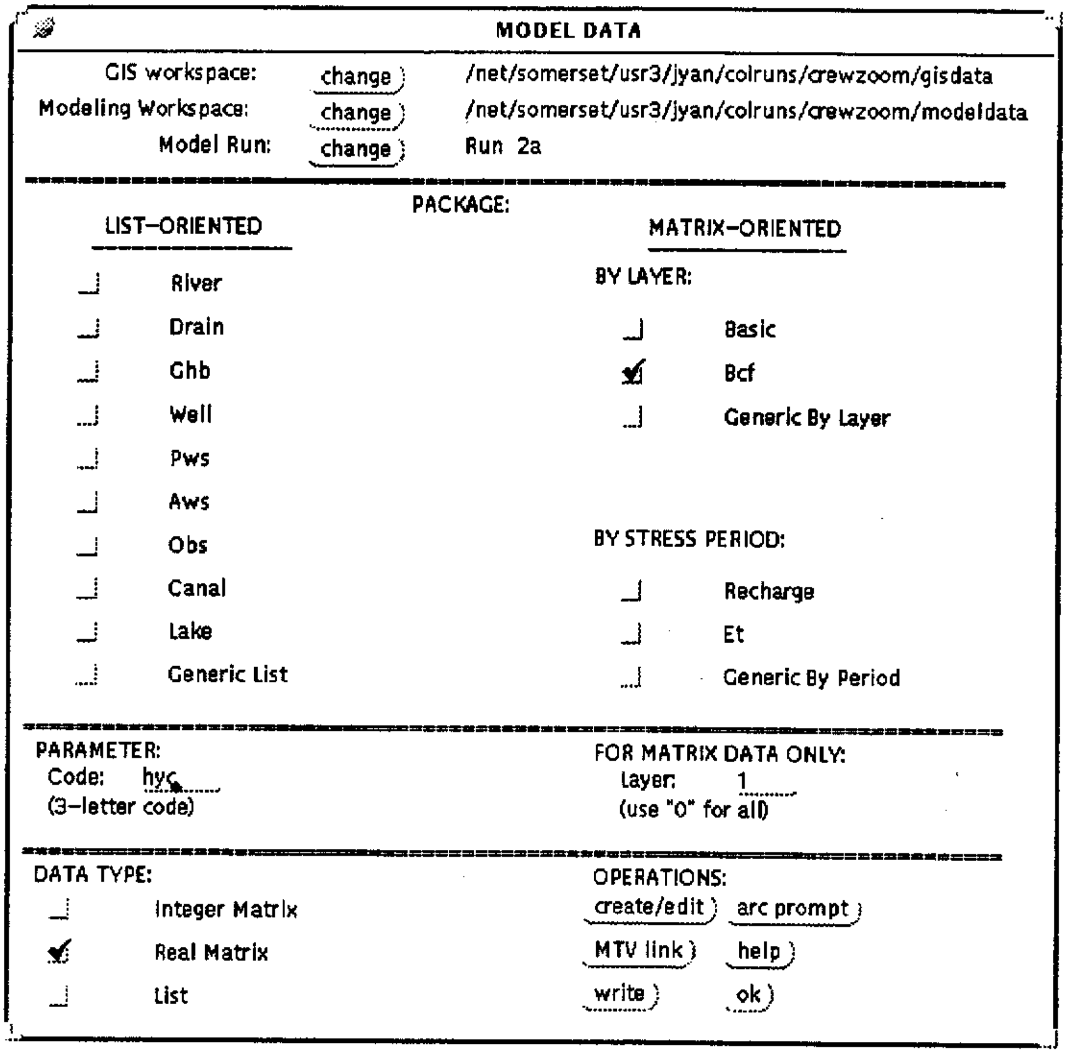

Figure 3. Model Data Menu

GWZOOM. The "GWZOOM coverage" for matrix data is always a point coverage with one point at each model grid center, with attributes identifying the model row and column. After the "GWZOOM coverage" is created, the screen automatically go back to the "Model Data" menu. The user then clicks the "write" button and GWZOOM writes an ASCII file named "hyd-1-1a.mod from the coverage "g-hyd-1-1a". This file contains the hydraulic conductivities of layer 1, run 1a, in a matrix format readable by MODFLOW. Following the same procedure, all data files can be quickly created for a zoom model.

SIMULATIONS AND RESULTS

Both steady-state and transient simulations were created for the Frog Pond model.

The transient simulation covers the period from January 1988 through December 1988, which includes both average and wet conditions. Figure 2 shows that there are two major canals in the area, the L-31W borrow canal and the C-111 canal. The L-31W levee and its western borrow canal separate ENP from the eastern developed areas, while serving to provide flood protection during the wet season. Water is pumped from the borrow canal and delivered to the head of Taylor Slough using the S-332 pump station. This water then drains to the south by gravity. A proposed function of S-332 under consideration will be to deliver water to Taylor Slough to increase the hydroperiod of wetlands in the ENP area. S-332 will be used to make scheduled releases to ENP not only for flood protection but also for environmental restoration.

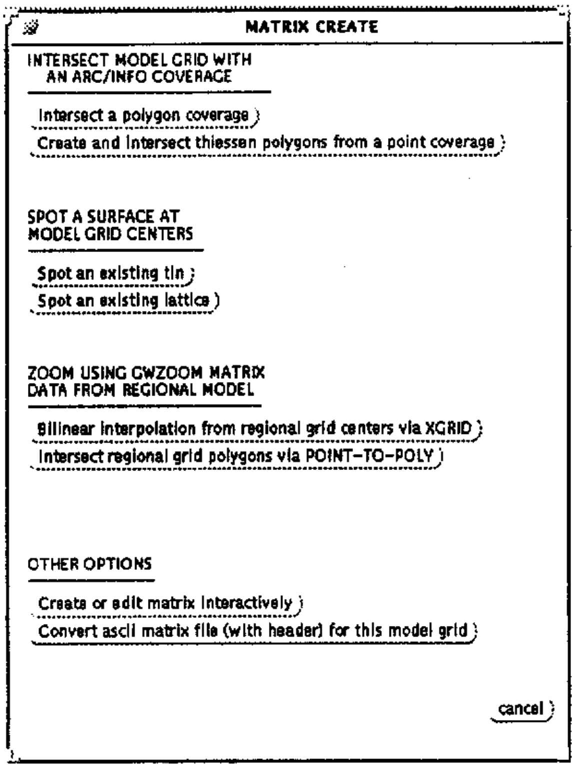

Figure 4. Matrix Create Menu

The historic ground water table in the area has a northwest to southeast gradient with water table elevations similar to canal stages. The historical (1933-1947) canal stages at S-332 vary from about 1.9 feet to 5.6 feet. Since 1947, the canal stage was maintained between approximately 2.7 feet to 4.0 feet to facilitate flood protection and water supply. For purposes of environmental restoration, it has been determined that canal stages and ground water levels should return to historical levels (1933-1947). However, the agricultural interests in the area need a relatively stable ground water level during the growing season. Extremely high or low water levels have a negative impact to the agricultural areas to the east. The curtain wall concept is proposed to solve these problems by hydraulically separating the two areas.

Many scenarios were simulated under steady state and/or transient conditions. One of the steady-state scenarios is presented in this paper. This scenario assumes that the curtain wall would be built east of the borrow canal along the L-31W levee. The water level in the borrow canal was assumed to be held at 6.0 feet between S-174 and S-175. The water level in C-111 was held at 3.5 feet between S-176 and S-177. Figure 5 shows the simulated ground water level contours with the proposed curtain wall. Figure 6 shows the water level contours simulated without the proposed curtain wall. The two figures indicate that the water levels in the Frog Pond area are reduced slightly by the wall. Apparently, only the 3.44 feet contour line is moved north about one mile. This simulation reveals that the curtain wall is not very effective under these assumed conditions.

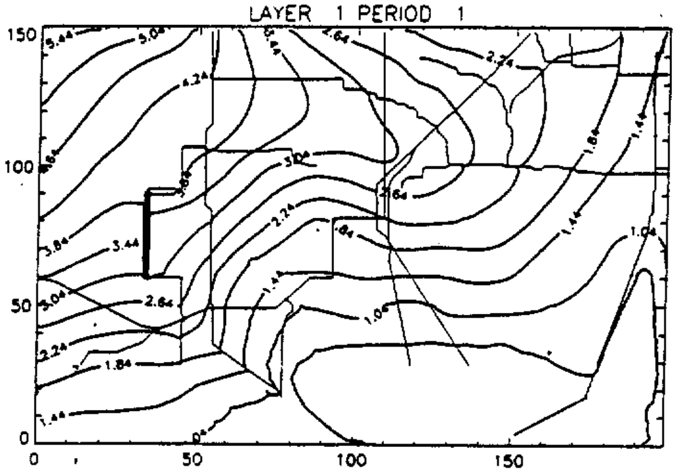

Figure 5. Water Level Contours Simulated with the Curtain Wall

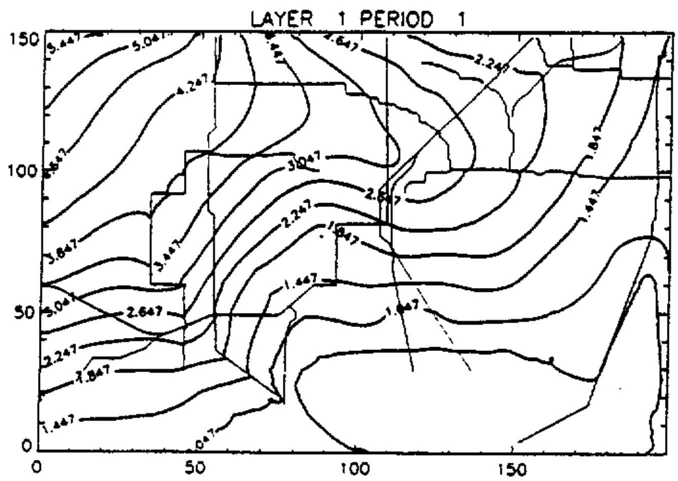

Figure 6. Water Level Contours Simulated without the Curtain Wall

CONCLUSIONS

The implementation of the GWZOOM modeling system provides several advantages: 1) the graphical interface allows the user to easily create and apply a local scale model based on a regional model, 2) the system makes it simple to understand and prepare model components, 3) the generic structure of the system allows it to be used for different study areas or different MODFLOW models, and 4) the modular structure of the system makes it easy to enhance by adding additional modules. Although full implementation of the system requires converting datasets for existing regional models into GIS compatible formats, this can also be quickly and easily accomplished using options included in the GWZOOM modeling system.

REFERENCES

McDonald, M.G., and A.W. Harbaugh, 1988. A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model. Techniques of Water-Resources Investigations of the United States Geological Survey, Book 6.

Yan, J. J., and K. Smith, 1995. A Modular Ground Water Modeling System (GWZOOM): 1. Concept and System. This proceeding.