ECWS-8
2024
Conference

The 8th International Electronic Conference on Water Sciences

14-16 October 2024 | Online

MDPI

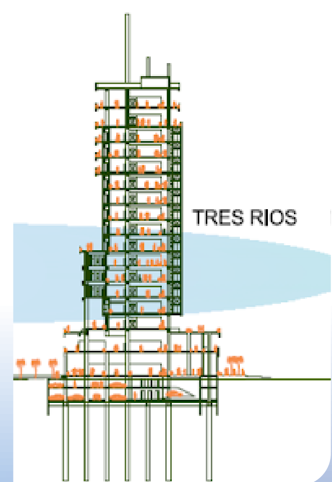
Numerical Models for Groundwater Flows: Key in Construction

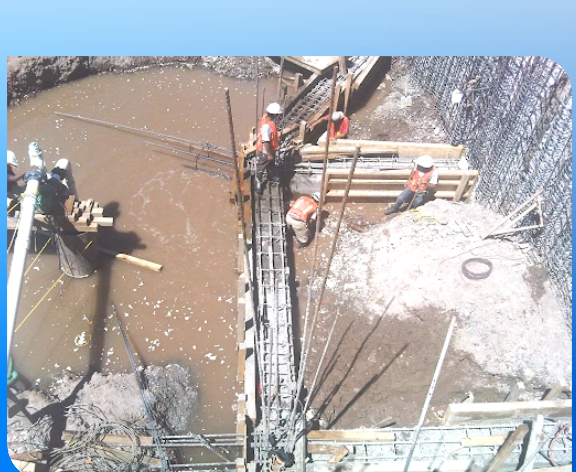
David Beltrán-Vargas[1], Fernando García-Páez[1], Sergio Arturo Rentería-Guevara[1], Manuel Martínez Morales[2]
[1]Department of Civil Engineering, Autonomous University of Sinaloa, 80013 Culiacán, México
[2]Instituto Mexicano de Tecnología del Agua, Paseo Cuauhnahuac 62550, Jiutepec, Morelos, México

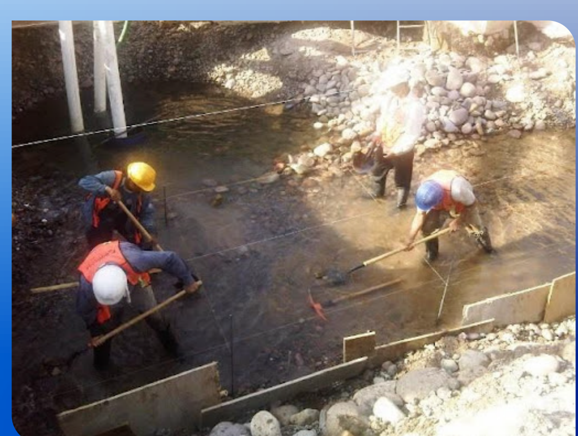
INTRODUCTION & AIM

Controlling groundwater levels is crucial for constructing complex or high-rise buildings, shaping their design and ensuring a safe construction process. Intelligent planning throughout the dewatering process is essential avoiding a simplistic "trial and error" approach. Each project uniqueness demands decisions guided by professionals blending theoretical knowledge with practical experience. In these complex and uncertain projects, flexibility is key to success. Numerical models play an important role in analyzing groundwater flow, offering approximations rather than exact solutions.

"Torre Tres Ríos" (one of the highest towers in Culiacán, Sinaloa, Mexico) is the project to be analyzed. The building is a 21-story structure with commercial areas and office spaces. The project is located at the urban zone called "Desarrollo Urbano Tres Ríos", where Tamazula and Humaya rivers converge to form the Culiacán river. The project involves the controlled dewatering of the groundwater level below the maximum excavation depth.







METHOD

Numerical models do not seek to find the exact solution to the differential equation; instead, they aim to approximate it and transform a differential equation into a set of solvable algebraic equations. This methodology allows for the analysis of any possible scenario and variable conditions. The selection of modeling approach should be proportional to the complexity of the project conditions.

The stages for the modeling process are as follows:

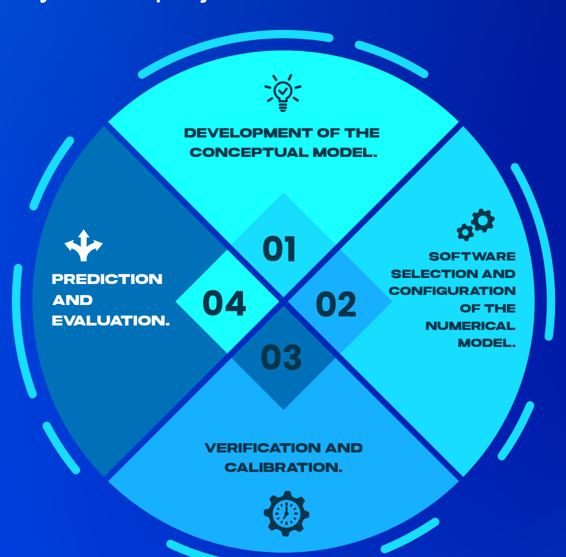


FIGURE 1.
STAGE FOR MODELING PROCESS.

The comparison of calibrated and modified loads was performed using two methods:

- the Mean Absolute Error (MAE) and.
- the Standard Deviation

USGS U.S. Geological Survey
ModelMuse

RESULTS & DISCUSSION

The project in the study area involves the controlled dewatering of the groundwater level below the maximum excavation depth (6.5 m). In July, the water-table was at 33 meters above sea level (masl), which was initially considered not to pose a problem for construction processes. By October, it had risen to 35.74 masl, indicating a recharge period. By November, it had dropped to 35.20 masl as the aquifer entered a discharge process.

The study area was characterized to develop the conceptual model and transition to numerical modeling, as shown in the following figures and tables:

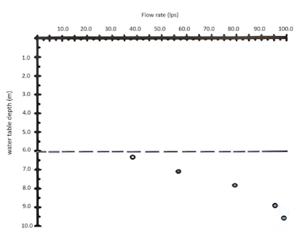


FIGURE 2.
PUMPING TEST

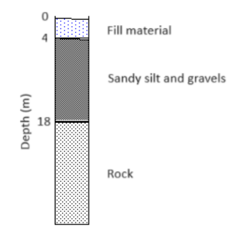


FIGURE 3.
STRATIGRAPHY

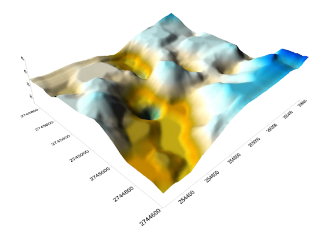


FIGURE 4.
SURFACE MODEL

	JAN	FEB	MAR	APR	MAY	JUN	**JUL**	**AUG**	**SEP**	OCT	NOV	DEC
Temperature (°C)	19.62	20.53	21.74	24.36	26.87	29.86	30.15	29.55	29.22	27.71	23.76	20.7
Average rainfall (mm)	1.952	1.222	0.583	0.2	1.952	2.548	**15.36**	**21.00**	**13.08**	5.074	1.787	3.013

TABLE 1. REPRESENTATIVE CLIMATIC DATA

WELL ID: Torre Tres Ríos

INPUT

Construction:	
Casing dia. (d_c)	22 Inch
Annulus dia. (d_w)	22 Inch
Screen Length (L)	16.5 Meter
Depths to:	
water level (DTW)	6.05 Meter
Top of Aquifer	6 Meter
Base of Aquifer	22.5 Meter
Annular Fill:	
across screen -- Gravel	
above screen -- Open Hole	
Aquifer Material -- Sand and Gravel Mixe	
FLOW RATE	99.52 liters/s

Date: 19/12/2009
Time: 06:00

COMPUTED

Aquifer thickness = 16 Meter

Slope = 1.02623799 Meter/log10

Input is consistent.

K = 28 Meter/Day
T = 470 Meter²/Day

Reduced Data

Entry	Time,	Water Level Meter
1	6:00:00	6.05
2	8:00:00	6.32
3	12:00:00	7.11
4	16:00:00	7.92
5	20:00:00	8.84
6	0:00:00	9.50

TABLE 2. COOPER-JACOB METHOD - HYDRAULIC PARAMETERS

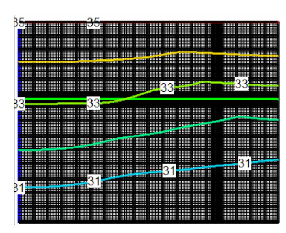


FIGURE 5.
STEADY-STATE FLOW MODEL

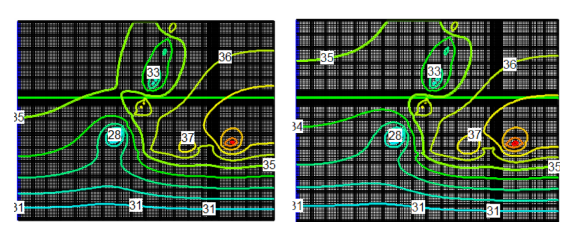


FIGURE 6-7.
TRANSIENT-STATE FLOW MODEL (AUGUST AND SEPTEMBER)

The following results were obtained through the observational method, based on sensor-derived measurements:

Month	Observed water table (masl)	Modeled water table (masl)	Residual
October	35.74	35.676	0.064
November	35.2	35.438	-0.238

TABLE 3. OBSERVED WATER TABLE - MODELED WATER TABLE

The model calibration has a mean absolute error of 0.15 m and a standard deviation of 0.174, these results reproduce the groundwater flow behavior in a congruent and consistent manner

CONCLUSIONS

- The analysis of the numerical model indicates that the main recharges are induced by the constant load of the water table in the area, as well as the influence of the Tamazula River and precipitation. Additionally, the main discharges include the river and the same constant load of the water table.
- The configuration of the water table suggests that the contribution of the Tamazula River discharges into the Humaya River and is influenced in the area where the project was carried out.
- Although the results have been satisfactory, the model is an interpretation of the functioning of the aquifer, and therefore the results should not be accepted as unique. The model should be used as a support tool for management and decision making, but always based on knowledge. The control system must be flexible and capable of incorporating corrective measures for possible singularities.

FUTURE WORKS / REFERENCES

- There are many applications where the methodology can be useful to determine infiltration processes by natural or induced recharge and discharge, also to achieve strategic objectives such as management, use and analysis of groundwater. Furthermore, the recovery of exploited aquifers.

"THE FUTURE PROMISES EVEN MORE EFFICIENT AND SUSTAINABLE SOLUTIONS; WE MUST BE PREPARED TO FACE THE CHALLENGES THAT LIE AHEAD."

davidbeltranvargas.fic@uas.edu.mx