EFFECTIVE EVALUATION OF WATER DISTRIBUTION SYSTEMS

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INTRODUCTION

The City of Athens operates a water treatment plant which supplies an average of 15.5 million gallons per day (mgd) to the residents and businesses of Clarke County and parts of Barrow, Oconee, Jackson, and Madison Counties. As the rapid growth trends of metro Atlanta push eastward, the need to manage water resources in Athens becomes more evident. An important aspect of water resource management is maintaining a reliable supply of water to the customer. Several computer programs are available to aid the engineer in evaluating the adequacy of water distribution systems. The City of Athens uses one such program, developed by the University of Kentucky (Wood, 1980) and based on the Hardy Cross Method, to evaluate the water system's ability to meet demands and to point out hydraulic deficiencies in the distribution system where improvements are necessary. Historical billing records are used by Athens to help make these evaluations with the aid of LOTUS 1-2-3 and D-base software working interactively with the Hardy Cross computer program.

COMPUTER MODEL

The Hardy Cross computer model involves developing a schematic (node map) of the water system which consists of the major distribution pipes. The two major components of the node map are pipe segments and nodes representing the endpoints of a given pipe segment. Each pipe segment's length, diameter, roughness factor, and minor loss coefficient are defined and entered into the computer model. Demands can occur at the nodes, and inflows into the system such as pumps and reservoirs can be modeled.

Billing records are utilized by the City of Athens to determine the demand assigned to each node. There are 80 billing zones in the City of Athens. D-base is used to determine which customers are using the largest amount of water. These users (approximately the top 70 users) are assigned to specific nodes in the computer model. This accounts for approximately 45 percent of the total water sold in Athens. The remainder of the demand is disaggregated by billing zone. Meter records are sorted in D-base according to billing zone and imported into LOTUS, where the nodes falling within each zone are then assigned weighting factors and the demand is disaggregated accordingly.

WATER SYSTEM EVALUATION

Once the computer model is developed and the demands are disaggregated, the City confirms its accuracy by performing fireflow tests in the distribution system and comparing those actual results to the model's predicted results. Boundary conditions such as elevated tank water levels, pumping flowrates and pressures are recorded at the time the flow tests are performed. The model is calibrated, if necessary, by adjusting parameters such as pipe roughness factors and demands. Up to a 10 percent difference in field measurements and model predictions is considered acceptable for a water system similar in size to Athens (Walski, 1984).

Once the model has been calibrated, peaking demands, such as maximum day demands and maximum hour demands, are applied to predict low pressure in the existing distribution system. The minimum system pressure requirement for the City of Athens is 35 psi under peak day conditions and 20 psi under fireflow conditions. Fireflow requirements range from 500 gallons per minute (gpm) in residential areas to 1,000-gpm in industrial areas.

The City can then model improvements to the distribution system to improve the pressures to acceptable levels. Pipe replacement or rehabilitation can be modeled as well as adding new pumps or storage tanks. With the high processing speed of today's personal computers, several "what if" scenarios can be modeled to obtain the most cost-effective solution.

The Hardy Cross program has also allowed the City of Athens to evaluate requests from developers for future water service. Peaking conditions as well as fireflows are simulated to see if the system can maintain the minimum pressure requirements throughout the distribution system. Once a development is

approved, the City reserves the approved capacity for 12 months after which a sunset clause takes effect and the allotted capacity is revoked for any unbuilt houses.

The City of Athens maintains two computer models at City Hall to perform evaluations on the distribution system, one with only the existing pipes and users and the other with approved developments. The City plans on updating the historical billing records and to check its calibration on an annual basis.

CONCLUSIONS & RECOMMENDATIONS

By maintaining statistical data such as water use records, municipalities can effectively manage their water in the distribution system. Computer models, including the University of Kentucky's Hardy Cross program can readily predict current and future system adequacy when used in conjunction with these records.

The development of such computer models is relatively inexpensive to set up and can be effectively used by engineers to accurately predict actual system conditions and to recommend improvements where necessary. Cities are able to effectively plan the installation of new improvements at the most cost-effective solution. Control of new developments can also be effectively managed by predicting the impact of their presence on the distribution system through computer modeling.

LITERATURE CITED

Wood, Don J., 1980. "Computer Analysis of Flow in Pipe Networks Including Extended Period Simulations, User Manual," University of Kentucky Department of Civil Engineering, Lexington, KY.

Walski, Thomas M., 1984. "Analysis of Water Distribution Systems," Van Nostrand Reinhold Company, Inc., New York.