CIVIL ENGINEERING DEPARTMENT

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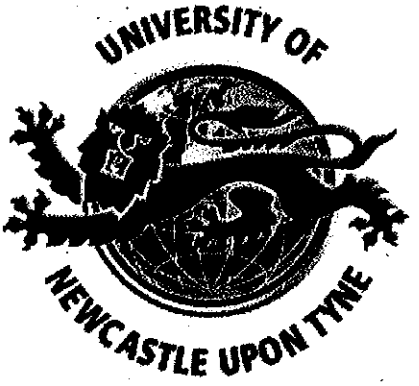

Economic Planning and Operational Control of an Irrigation Project

By

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ABSTRACT

This Thesis is concerned with the development and application of mathematical control models and the optimisation methods in the operation of an irrigation project. The proposed models and algorithms are believed to be widely applicable and their use is demonstrated in the control of water supply systems with objectives including aspects of economic operation. An application for the ElSalam Irrigation Project in Egypt is introduced, since the project is very important, politically and economically, to the country. Moreover, the overall uses of this research, allow an assessment of the hydraulic and operational performance of the project's main irrigation channel, and introduce the best control method to be used. In the meantime, the research identifies the factors critical for sustained economic benefits for the two main resources in the project, land and water.

The water supply pattern for the irrigation scheme in space-time is used to run the hydraulic simulation model based on the Global Elimination Method (GEM). The model was written in the PASCAL language using DELPHI 4 programming techniques [written by Kutija, 1994 and modified by Water Resources Group at Newcastle University, 1999]. To produce the control profile of the channel, the Proportional Integral (PI) controller model is developed. The two classical control methods are demonstrated (i.e. upstream or downstream water level control). The channel's boundary conditions are adjusted according to the estimated discharge changes to the controlled structure in order to produce the water supply hydrograph for each control method that ensures the fulfilment of the target water levels.

A new methodology for a downstream control algorithm for on-demand water delivery operation of the irrigation channel system is developed. The concepts within this method are achieved by maintaining the downstream end water level of the channel's pool at a target setpoint by manipulating the upstream gate openings in real-time. This control algorithm is suitable for the case of irrigation channels with low bank decks. The effectiveness of the method is presented using a simulation model that is based on the de. St.-Venant equations and the implicit Preissmann scheme. The control model is developed using the MATLAB-Simulink programming technique to facilitate the use of the feedback Proportional Integral Differential (PID) controller and also for the power of the graphical interface. The results of the simulations show that the proposed control algorithm is able to provide an effective control of the flow and cope with rapid variations of water demand and unknown disturbances. When the target is to operate the system under a given demand pattern hydrograph for the downstream nodes of the channel, the model performs well for self-tuning the controlled upstream gate.

The expected actual economic returns of the project are estimated using the designed Linear Programming (LP) model based on the ENFIN software optimisation package. The underlying approach is to maximise the economic returns to water and land by a choice of the best cropping patterns subject to water and land availability. The constraints on water supply and water levels are represented in the LP model through water availability. Seven different operational strategies are presented for the short and long-term. The expected marginal benefit curves are introduced as a sensitivity analysis for different water resources availability; moreover, the shadow prices and the reduced costs for the model's decision variables are examined.