

DEVELOPMENT OF A CELL BASED MODEL FOR STREAM FLOW PREDICTION IN UNGAUGED BASINS USING GIS DATA

P.B. HUNUKUMBURA AND S.B. WEERAKOON

Department of Civil Engineering, Faculty of Engineering, University of Peradeniya

A cell-based model, which is capable of stream flow prediction in hydrologically ungauged basins using physical properties of the basin, was developed and it was applied to the Upper Kotmale basin. The model uses spatial data of the basin derived from geographical information systems (GIS).

The basin was divided in to several grids and the total time taken to flow water from each grid cell to the basin outlet was calculated. The S-curve for the basin was developed using the total travel time distribution of the basin and hence the unit hydrograph of the basin was derived. Then the direct runoff hydrograph for a given effective rainfall time series was obtained using the unit hydrograph of the basin. It is assumed that the basin direct runoff consists of two types of flows; overland flows and canal flows. Grid cells of the basin first produces overland flow from the effective rainfall and after collecting sufficient number of cells it produces a canal flow. The flow velocity through each grid cell was calculated using kinematic wave equation and thereby the flow velocity grid for the basin was obtained. The flow travel time through each grid cell was calculated from the slope distance and the flow velocity of the grid cell. The flow path to the basin outlet was identified based on the flow direction grid and the total travel time for the direct runoff generated in each grid cell to the basin outlet was calculated.

For the basin, it is required to obtain the slope, flow accumulation, flow direction and land use raster grids to calculate the flow velocity and the total travel time grids for the basin. The slope, flow accumulation and flow direction grids were prepared using the digital elevation models. The land use raster grid for the basin was prepared using land use and land cover maps. The roughness coefficients for grid cells were selected based on the land use and land cover types. A new cell based model was developed for stream flow prediction in ungauged basin using basin's physical properties and the rainfall data. Computer software with user-friendly graphical user interface was developed using Visual Basic programming language.

The model was tested using hourly data collected from the mountainous Upper Kotmale basin, which is the upper most basin of the Mahaweli River. The area of the basin is 304 km² and the elevation varies from 1200 m to 2500 m above mean sea level. The basin is situated in the wet zone of the country and the average annual rainfall of the basin varies from 2200 mm to 2600 mm. The basin is under varying land use and land cover types comprise of tea (44 %), forest (36 %), build up land (7 %), grass (5 %), water bodies (1 %) and other crops (7 %) with roughness coefficients of 0.17, 0.8, 0.011, 0.24, 0.01 and 0.17, respectively.

It was found that the observed yield and the model predicted yield of the basin for the period from April to September 2003 was 84.66 MCM and 82.53 MCM respectively. The model predicts hourly stream flow at the basin outlet to a reasonable accuracy with Nash coefficient of 0.50. The model, which requires only the basin rainfall, topographical and land use data is a useful tool for stream flow prediction in ungauged basins.