THESIS

MODELING OVERLAND FLOW AND RUNOFF FROM FLAT GRAVITY IRRIGATED FIELDS HAVING DIKES

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ABSTRACT

Drainage and evacuation of surface runoff generated from severe and intense rainstorm is essential for prevention of crop damages. The amount and flow rate of drainage water that will be evacuated from the area must be known for the proper design of surface drainage system. Sufficient knowledge of rainfall-runoff processes at field and farm level is usually not available for flat canal irrigated areas of Pakistan. Accurate prediction is the key in designing the efficient drainage system. The present study was conducted to develop a two dimensional field scale overland flow and runoff model for flat canal irrigated areas and to simulate the model for various conditions of soils, rainfall events and farmer's drainage responses.

A fully hydrodynamic overland flow and runoff model was developed on the basis of St. Venant equations and modified Kostikove's infiltration equation and MacCormack's finite difference scheme. Model code was written in Java Language and input to the model was through Graphical User Interface (GUI). The model was found to be capable of simulating drainage outflow from a single field having dikes and very flat slopes for various soils, rainfall events and drainage modes\interventions while maintaining mass balance within acceptable limits. The present model is based on simplified conditions in terms of field geometry, levels, rainfall and infiltration parameters. The model was simulated for drainage outflow from a 0.4 hectare (1.0 acre) field with clay, clay loam and silty loam soils for rainfall of 50, 75 and 100-mm/hr intensity and one hour duration under free, delayed and restricted drainage modes.

The outflow hydrograph has a steep rising limb, a sharp peak and a flatter falling limb. The time to peak flow coincided with the rainfall duration. For most conditions the water surface becomes level in the whole field sometime after the start of the rainfall and remains so thereafter. This causes the outflow hydrograph to be different than typical hydrograph for a large area.

Under free drainage conditions, the time taken by the water to evacuate from the field under a rainfall event of 100 mm/hr was 3.73 hrs for silty loam, 5.23 hrs for clay loam and 9.38 hrs for clay soil fields. The corresponding peak flow rates was 20.4, 23.8 and 27.4 l/s/ha and volume of outflow as a percent of rain was 21.96, 32.93 and 58.36% for silty loam, clay loam and clay soil fields, respectively. Under delayed drainage, the time taken by the water to evacuate from the field under a rainfall event of 100 mm/hr was 4.0 hrs for silty loam, 5.27 hrs for clay loam and 9.79 hrs for clay soil. The corresponding peak discharges were 22.7, 26.8 and 32.6 l/s/ha and percent outflow was 17.93, 29.40 and 56.51% for silty loam, clay loam and clay soils, respectively. Under restricted drainage, the time taken by the water to evacuate from the field under a rainfall event of 100 mm/hr was 2.43 hrs for silty loam, 3.48 hrs for clay loam and 7.63 hrs for clay soil. The corresponding peak discharges were 6.5, 9.1 and 13.0 l/s/ha and percent outflow was 3.57, 7.9 and 22.32% for silty loam, clay loam and clay soils, respectively.

The peak flow rate, the volume of outflow (as a % of rainfall) and time required to evacuate the drainage water depend directly on rainfall intensity and soil type. Fine soils were found to generate large outflows with consequent larger peak flow rates and the

base time than coarser soils due to smaller infiltration rates for all drainage modes. The peak flow rate, drainage volume and base time was found to increase almost linearly with rainfall intensity.

The drainage mode has a largest effect on drainage outflows. The peak flow rates with free drainage are 10 to 12% less as compared with delayed drainage. However the outflow volume decreases with delayed drainage by 3 to 18 %. The restricted drainage results in much smaller peak flow rates and outflow volumes (55to 85% of free drainage). The evacuation time is 0.5 to 6% more in delayed drainage and 18 to 34% less in restricted drainage as compared with free drainage conditions. This trend remains same for all soil types.