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Khadakwasla watershed Modeling using HEC-HMS Modclark Transform

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Abstract
Using a MOD Clark model of WMS 9.1 hydrologic modelling wizard we are able to delineate a watershed, create a grid from the delineated watershed, and compute watershed geometric and hydrologic parameters from geometric, land use, and soil data. And then after using a MODClark model in HMS 3.5 to obtain a hydrograph. And the parameters values can be easily checked and compared.
Keywords: *Modclark, HMS, Hydrograph, Hydrologic modeling*

INTRODUCTION

Rain fall forms very important part of many hydrological scenarios. Estimation of rainfall runoff is important in flood forecast, watershed development, integrated catchment planning. Reliable and accurate estimation of rainfall runoff from land surface into rivers is intricate and time consuming. Conventional models for prediction of river discharge require considerable hydrological and meteorological data (T. R. Nayak et al. 2003). The Khadakwasla area lies at the outskirts of Pune city. The major watersheds are included in this area, namely Khadakwasla, Warasgaon and Panshet and one minor watershed Temghar. This total area is commonly known as Khadakwasla Complex. The main objectives are

- To delineate the watershed and estimation of Hydrologic elements required to run the HEC-HMS Model.
- To identify the runoff at various points in the watershed and to calibrate the watershed by comparing the modeled values of runoff with the observed value at various gauges.

Runoff in HEC-HMS

The U.S. Army Corps of Engineers Hydrologic Modeling System (HEC-HMS) is the Windows-based hydrologic model that supersedes HEC-1 and contains many improvements over its predecessor.

The program underneath HEC-HMS considers that all land and water in a watershed is categorized as **Directly-connected impervious surface.** Directly-connected impervious surface in a watershed is that portion of the watershed for which all rainfall converted to runoff with no infiltration, evaporation, or other hydrological losses.

Loss Model: initial and constant-rate loss model

In this model precipitation loss is found for each provided computation time interval, and is subtracted from the Mean Areal Precipitation (MAP) depth for that interval.

Hydrologic Modeling and Parameter Estimation

There are numerous methods of modeling runoff transformations for each sub watershed. We will present two of the more common method s, the Clark (T_C + R) Unit Hydrograph and the Snyder Unit Hydrograph. Further discussion on both methods is presented in Hoggan (1997) and Bedient and Huber (1992).

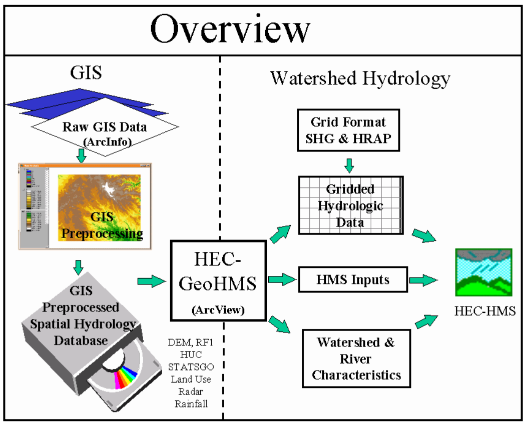


Figure 1: Runoff Process in HEC-HMS

Stream Routing: Muskingum Routing

Muskingum K is the travel time for the reach, and is determined by dividing the mean velocity by the reach length. Velocity can be determined from a hydraulic model, such as HEC-2 or HEC-RAS, or performing a simple open-channel flow calculation using Manning's equation. Muskingum X is the only means represent storage for the routing step using this routing procedure. Muskingum X ranges from 0 to 0.5, where 0.5 is used for smooth uniform channels with a pure translation of the flood wave. A value of 0.2 is generally used for natural streams and a value of 0.45 is used for most improved urban channels. As a rule of thumb, water in a stream can travel 2 mi/hr, although in channelized streams, the rate can increase to 10 mi/hr, or even greater, depending on overland slope and channel roughness. **Figure 3** shows the effect of Muskingum K and X coefficients on the routed hydrographs.

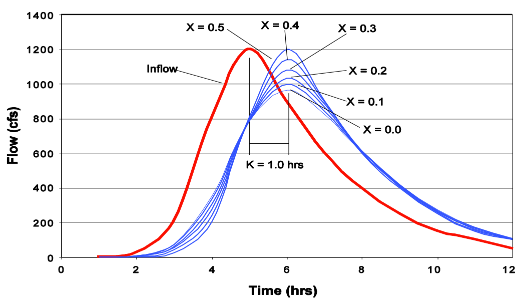


Figure 3: Muskingum Routing

Loss Rates

The loss rate used in Harris County and many other communities is the simple Initial-Constant Loss Method. Under this method, an initial amount of rainfall is "lost," or infiltrates (or evaporates) and a constant rate of rainfall lost per hour. It depend on the degree of urbanization and soil type (Table 2)

	Sandy Soils		**Clay Soils**	
Losses	Rural	Urban	Rural	Urban
Initial (in)	1.00	0.75	1.00	0.50
Constant (in/hr)	0.15	0.10	0.10	0.05

Table 2: HCFCD Recommended loss

MATERIALS AND METHODOLOGY

Satellite image of IRS LISS III, March 2007 was used for presentation purpose. Spatial resolution of the image is 30 m. and Toposheet of SOI of 1:50000 scales is used to generate the soil map. The DEM was first processed in the Archydro tools in ArcGIS 9.3 and then it was processed in the HEC-GeoHMS.HEC-GeoHMS is a set of ArcGIS tools specifically designed to process geospatial data and create input files for the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS). Then the same file is further processed in the HEC-HMS 3.5

ANALYSIS

Using a DEM as shown in the Figure 4 and the catchments in the study area are delineated and were indentified in the following Figure 5.

Further the basins of the different small catmints are merged together to have a large Subbasins as shown in Figure

Hydrological Parameters) River and Basin Auto name: This process names reaches in sequence from upstream to downstream. After this step a new column is added to the attribute table of rivers. The naming convention combines the letter "W" and a number. After naming the HMS schematic is prepared which is as shown in the **Figure 7.**

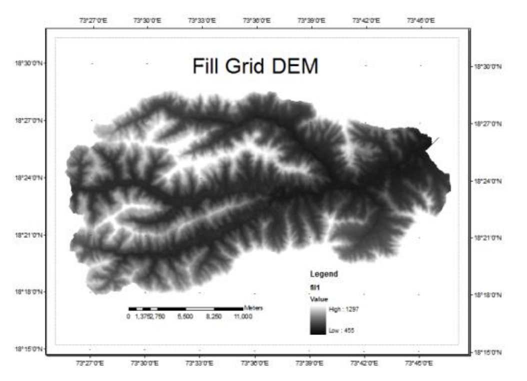


Figure 4: Digital Elevation Model (DEM)

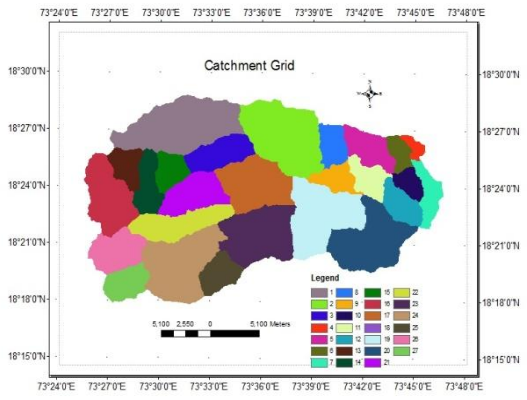


Figure 5: Catchment Deliniation

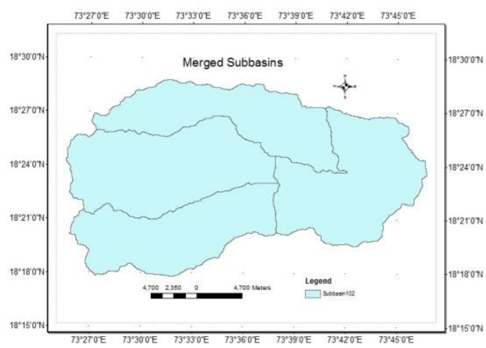


Figure 6: Merged Basins

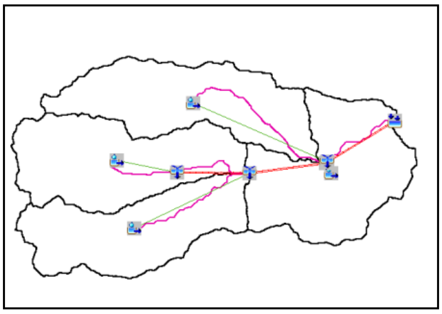


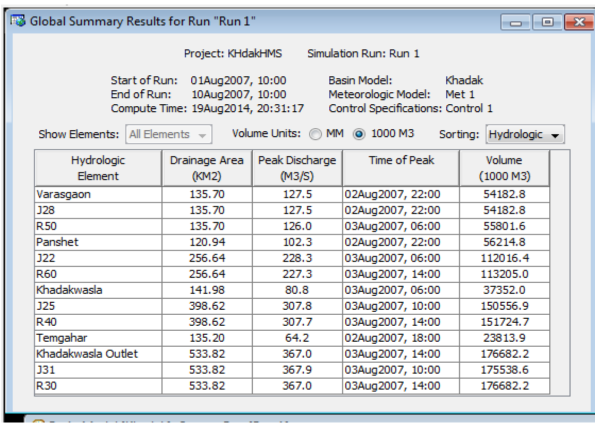
Figure 7: HMS schematic

Processing in HEC-HMS 3.5:

In HEC HMS by setting a new project parameters values are added along with the time series data and the gauge weight data. Meteorological model for the present data is prepared with the inclusion of all Subbasins in the watershed. Control specifications for the first run with the date and time interval of the analysis is set and the run was performed

RESULTS

A variety of tabular and graphical results are available after a simulation is run. Results can be visualized as graphs, summary tables and time series tables. The global summery table of the Run is shown in the **Figure 8.**Summary table for Junctions comprise of Peak Outflow, Date/Time of Peak Outflow and Total Outflow. Following table indicates these results for each junction in the basin model. The results are shown differently for junctions, rivers and Subbasins which are shown in the **Table 3,5,6.**



Global Summary Results for Run "Run 1"

Project: KHdakHMS   Simulation Run: Run 1

Start of Run: 01Aug2007, 10:00   Basin Model: Khadak
End of Run: 10Aug2007, 10:00   Meteorologic Model: Met 1
Compute Time: 19Aug2014, 20:31:17   Control Specifications: Control 1

Show Elements: All Elements   Volume Units: MM 1000 M3   Sorting: Hydrologic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
Varasgaon	135.70	127.5	02Aug2007, 22:00	54182.8
J28	135.70	127.5	02Aug2007, 22:00	54182.8
R50	135.70	126.0	03Aug2007, 06:00	55801.6
Panshet	120.94	102.3	02Aug2007, 22:00	56214.8
J22	256.64	228.3	03Aug2007, 06:00	112016.4
R60	256.64	227.3	03Aug2007, 14:00	113205.0
Khadakwasla	141.98	80.8	03Aug2007, 06:00	37352.0
J25	398.62	307.8	03Aug2007, 10:00	150556.9
R40	398.62	307.7	03Aug2007, 14:00	151724.7
Temgahar	135.20	64.2	02Aug2007, 18:00	23813.9
Khadakwasla Outlet	533.82	367.0	03Aug2007, 14:00	176682.2
J31	533.82	367.9	03Aug2007, 10:00	175538.6
R30	533.82	367.0	03Aug2007, 14:00	176682.2

Figure 8: Global Summery table for the HEC-HMS Run

Junction	Peak Outflow (M^3/S)	Date/Time of Peak Outflow	Total Outflow (MM)
Junction 28	127.5	02Aug2007, 10:00	399.28
Junction 25	307.8	03Aug2007, 10:00	377.70
Junction 22	288.3	03Aug2007, 10:00	436.47
Junction 31	367.9	03Aug2007, 10:00	328.83
Outlet	367.0	03Aug2007, 10:00	330.98

Table 3: Summery table for the Junction Flow

Reach	Peak Inflow (m^3/s)	Date/Time of Peak Inflow	Peak Outflow (m^3/s)	Date/Time of Peak Outflow	Total Inflow (MM)	Total Outflow (MM)
Reach 50	127.5	02Aug2007, 10:00	126.0	02Aug2007, 10:00	411.21	399.28
Reach 60	228.3	03Aug2007, 10:00	227.3	03Aug2007, 10:00	441.10	436.47
Reach 40	307.8	03Aug2007, 10:00	307.7	03Aug2007, 10:00	380.62	377.70
Reach 30	367.9	03Aug2007, 10:00	367.0	03Aug2007, 10:00	328.83	330.98

Table 4: Summery table for the River Flow

Subbasin	Peak Discharge (m^3/s)	Date/Time of Peak Discharge	Total Precipitation (MM)	Total Direct Runoff (MM)	Total Loss (MM)	Total Baseflow (MM)	Total Excess (MM)	Discharge (MM)
Warasagaon	127.5	02Aug2007, 10:00	66.36	54.52	11.84	344.76	54.52	399.28
Panshet	102.3	02Aug2007, 10.00	58.42	47.02	11.40	417.80	47.02	467.82
Khadakwasla	80.8	03Aug2007, 10.00	54.54	43.46	11.08	219.62	43.46	263.08
Temgahr	64.2	02Aug.2007, 10.00	58.42	47.02	11.40	129.12	47.02	176.14

Table 5: Summery table for the Subbasin Flow

The similar results can also be viewed though the Graph and the Time-Series table for the each subbasin and the outlet of the study area separately. These gives the discharge at each point in the watershed and can be compared with the actual observed values. Following is the graph for the first run of Khadakwasla Subbasin with computed discharge and gauged measured discharge.

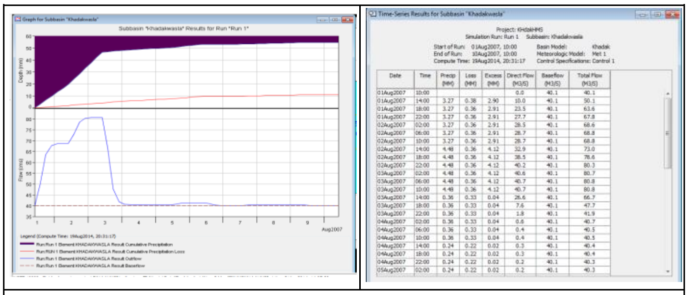


Figure 9: Graph and the time series table for the Khadakwasla Subbasin

CONCLUSION

Optimization trials are done for the estimation of parameter from the regular run process. Here we compare the parameters with the observed values to check the accuracy of the simulated results Optimization trials are done herewith for the peak flow and the volume of the discharge.

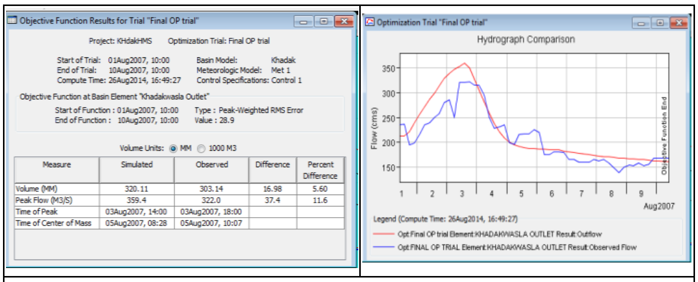


Figure 10: Hydrograph comparison of Khadakwasla outlet

Watershed parameters are computed from the Arc-hydro component of Geo-HMS in ArcGIS environment. Automatic watershed delineation for 30m DEM at 30 km^2 area threshold; which automates the tedious process of delineation of watershed and the stream computations defining a proper steam definition. Rainfall run off model was calculated using Clark's method. The reach routing was done by Muskingum method with K as 0.6 and X as 0.2 with 3 reaches. Lastly it can be concluded that the maximum flow calculated through the simulations is almost matching to the observed flow at the particular gage. Hence this method help to identify the flow and the losses by evaporation and also the precipitation addition to the flow.

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