Assignment on flood frequency analysis

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ASSIGNMENT ON FLOOD FREQUENCY ANALYSIS

1 OVERVIEW

Objectives

The learning objectives of this modelling exercise are:
- to get familiarise with different existing approaches on flood frequency analysis
- to carry out a flood frequency analysis of a small catchment using different approaches and compare different results

Reading material

The following reading material are needed:
- Slides on flood frequency analysis (from Biswa Bhattacharya) – available on eCampus
- Manuals:
    - HEC-HMS – Technical Manual (available on eCampus)
    - Bulletin 17B (US manual on flood frequency analysis using Log Pearson Type III) (available on eCampus)
- Data: File FloodFrequencyAssignment-Data.xlsx (available on eCampus)
- Further reading material:
    - Van Te Chow, David Maidment and Larry Mays (1988). Applied Hydrology (available at IHE library, also online at http://ponce.sdsu.edu/Applied_Hydrology_Chow_1988.pdf)

Tools required

- MS Excel
- Not needed but if you wish you can use HEC-SSP

Assessment

- You must submit a PDF report (upload to eCampus). The task constitutes to 10% of the module mark.

2 CATCHMENT DATA

Catchment Malgudi is a small catchment with the following data:

Catchment area	A	250	km2
Landuse:			
Cover type	Hydrologic condition	Soil type	Area (km2)
Pasture, grassland or range	Good	B	190
Row crops (Straight row (SR))	Poor	A	40
Developing urban areas: Newly graded areas		A	20

Catchment hydrologic properties (based on large number of past hydrographs):

Peak direct runoff per unit km2 (per 25 mm excess rainfall)	qp	4.35	m3/s/km2/mm
Baseflow per km2 (assumed to be constant over time)	qb	0.195	m3/s/km2

At *Hogsmeade*, which is located near the outlet of the catchment, the stage is measured every day and discharge is estimated from a calibrated rating curve using the measured stage. From the daily discharge data the annual maximum discharge data has been selected and shown below:

Year	Annual Max disharge (m3/s)
1913	112
1914	80
1915	91
1916	141
1917	99
1918	229
1919	69
1920	74
1921	178
1922	95
1923	63
1924	278
1925	65
1926	78
1927	293
1928	167
1929	108
1930	109
1931	73
1932	61
1933	62
1934	68
1935	78
1936	75
1937	184
1938	70
1939	86
1940	80
1941	138
1942	54
1943	64
1944	85
1945	131
1946	74
1947	56

A rain gauge is located at Hogwarts, which measures hourly rainfall. The dominant storm duration in the catchment is 5 hours. The 5-hourly annual maximum rainfall for the study period is presented below.

RAINFALL DATA	
Annual max 5-hr duratior	
Year	Rainfall (cm)
1913	2.49
1914	3.35
1915	1.83
1916	2.95
1917	2.08
1918	2.39
1919	3.76
1920	2.69
1921	3.86
1922	2.90
1923	4.06
1924	3.35
1925	3.45
1926	3.45
1927	3.30
1928	4.47
1929	2.49
1930	1.68
1931	4.88
1932	4.78
1933	4.06
1934	3.15
1935	3.61
1936	5.64
1937	3.25
1938	2.64
1939	3.25
1940	1.73
1941	1.56
1942	2.90
1943	4.67
1944	3.35
1945	3.30
1946	3.20
1947	3.05

3 DESCRIPTION OF THE TASK

(a) Using the annual maximum discharge time series carry out a flood frequency analysis using either Log Pearson Type III distribution or Gumbel distribution. Present the design discharge values (in a table and a chart) for the following return periods: 100, 50, 10 and 5.

(b) Using the annual maximum rainfall time series carry out a flood frequency analysis using either Log Pearson Type III distribution or Gumbel distribution. Present the design rainfall values (in a table) for the following return periods: 100, 50, 10 and 5.

(c) Using a conceptual model estimate the design discharge corresponding to the design rainfall values found above.

In order to complete Step (c) you need to do the following:

(i) *Estimate the precipitation loss*

You can estimate the precipitation loss using the Soil Conservation Service (SCS) Curve Number (CN) method (among several other methods, although this is one of the most popular ones). Use CN Table from Appendix A of HEC-HMS Technical Manual. Find out the CN values for the 3 land use types of this catchment. Compute the composite CN of the catchment using the following formula:

$$CN_{COMP} = \frac{\sum_{i=1}^{n} A_i CN_i}{\sum_{i=1}^{n} A_i}$$

where CN_{COMP} is the composite curve number of the catchment, i is the index of sub-catchment with uniform land use and soil type, CN_i is the curve number for sub-catchment i, A_i the drainage area of sub-catchment i, n is the number of sub-catchments.

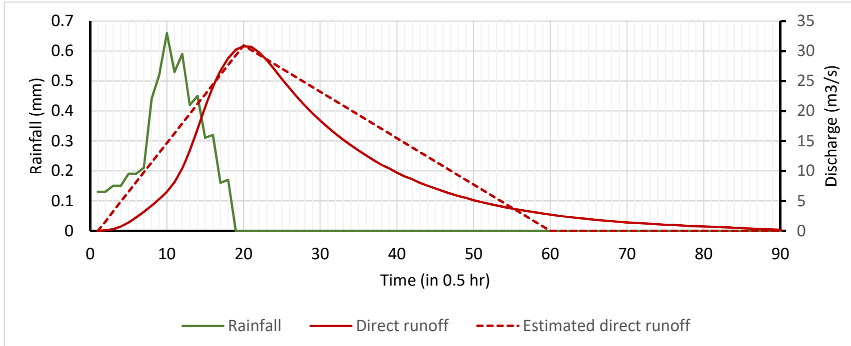
Once you know the CN you can estimate the excess precipitation (P_e) using the following formula:

$$P_e = \frac{(P - I_a)^2}{P - I_a + S}$$

Where: P = total precipitation, P_e = excess precipitation, S = Maximum retention capacity = (25400-254xCN)/CN and I_a = Initial abstraction

(ii) *Estimate the direct runoff*

In this step the excess precipitation P_e (in mm/cm) should be transformed to direct runoff (discharge in m^3/s) using any unit hydrograph. The following unit hydrograph (shown in dotted red line) is suggested for your use. Note that for this task you do not need to compute the ordinates of the hydrograph.



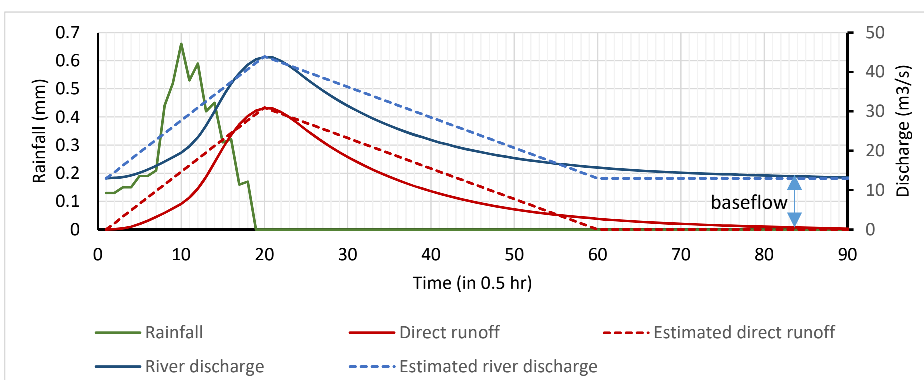
You need to compute the peak discharge (of direct runoff) corresponding to the excess precipitation amount using the value of q_p = maximum peak discharge per unit area (km^2) per unit (25 mm) excess rainfall. This value of a catchment is determined using many observed (maybe simulated as well) hydrographs and is provided to you.

Note that you do not need to create the above figure. This is presented only for illustration.

(iii) *Estimate the baseflow*

Consider constant baseflow. Use the value of q_b = baseflow for per unit area (km^2) to compute the discharge. This value of a catchment is determined using the dry period flow over many years and is provided to you.

(iv) *Combine* the above three components to get the design discharge corresponding to any chosen design rainfall value. Present your results in a table and chart for the following return periods: 100, 50, 10 and 5. The following figure shows the different component of the discharge. Note that you do not have to create the following figure. This is presented just for illustration.



(d) Briefly discuss (indicative 5 lines) about differences in design discharge values due to different approaches and your recommendation about the 100-year return period value.