



Comparison of Hydrograph Rise Times for Streams in Rural and Urban Mid-Atlantic Watersheds

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I. Problem

The response to a storm event is important for water management, hazard management, environmental research, and infrastructure design. Urbanization has influenced this response through increasing impervious cover in watersheds and channelizing stream channels. Using lag time relationships, the construction of hydrographs shows the effect of urbanization on peak discharge from a storm of given intensity (Leopold, 1991).

Lag times versus basin area

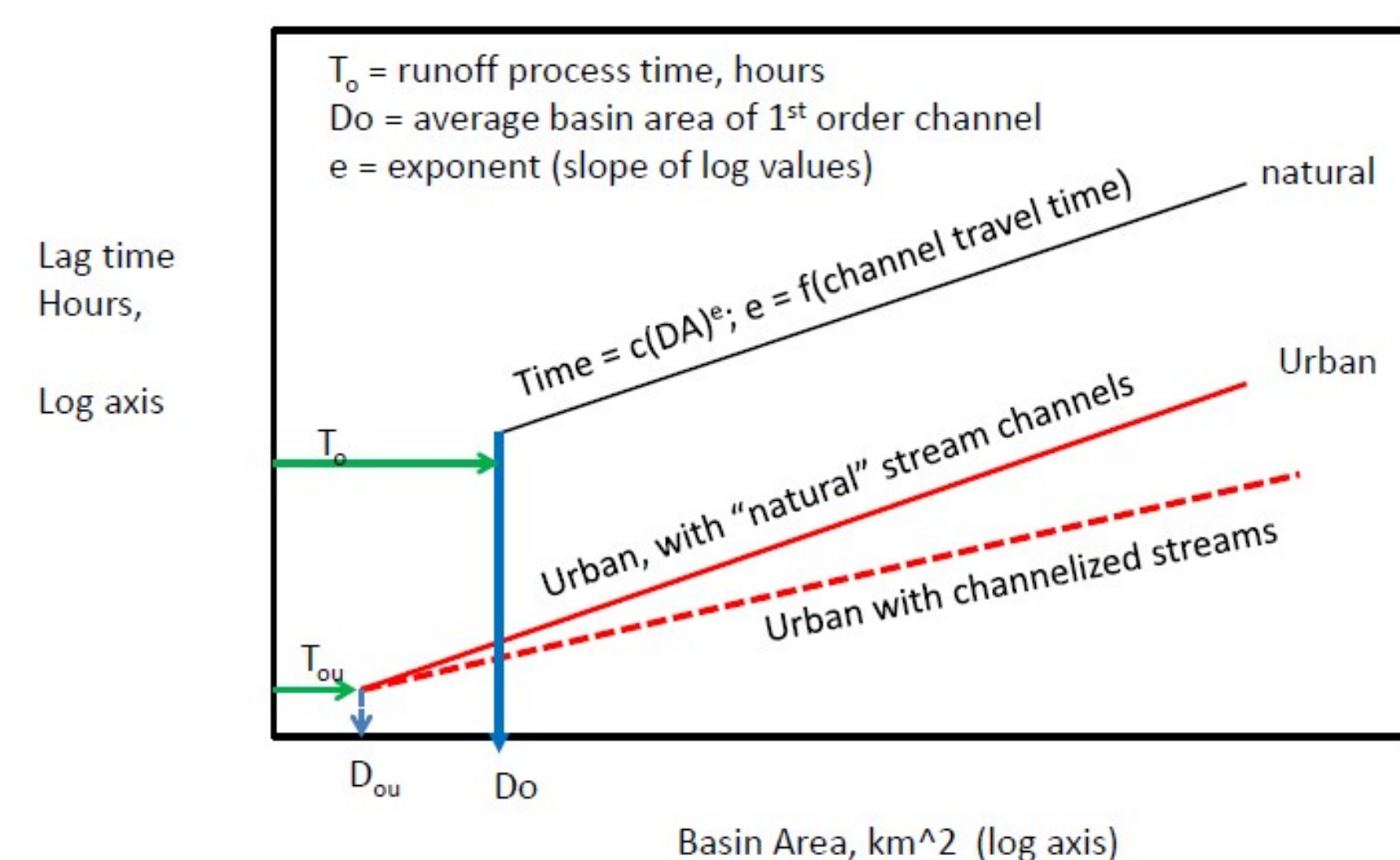


Fig. 1: Schematic diagram that illustrates the effects of urbanization on runoff process time (delivery of water from hillslopes to stream channels) and in-stream travel times (related to the flow resistance and velocity of stream channels).



Fig. 2: Channelized urban stream (USFWS photo)

III. Research Design

To test effects of urbanization on lag time urban and non-urban stream gauge sites have been selected. This study will focus on streams in Maryland, DC, and Virginia, with basin areas between 6 and 100 mi². Storms of different magnitude and duration have been investigated on streams with similar basin areas with differences in the amount of urbanization.

Total hydrograph volume and time to centroid can be obtained from the cumulative hydrograph (fig. 4).

To determine the velocity associated with the peak discharge and the average hydrograph discharge, the channel measurement data will be obtained from the USGS and these data will be analyzed to determine the relationship between channel discharge and velocity. This relationship will be used to estimate peak velocity and average velocity for each hydrograph. The relationship between discharge and velocity for Bennett Creek is shown in fig. 5.

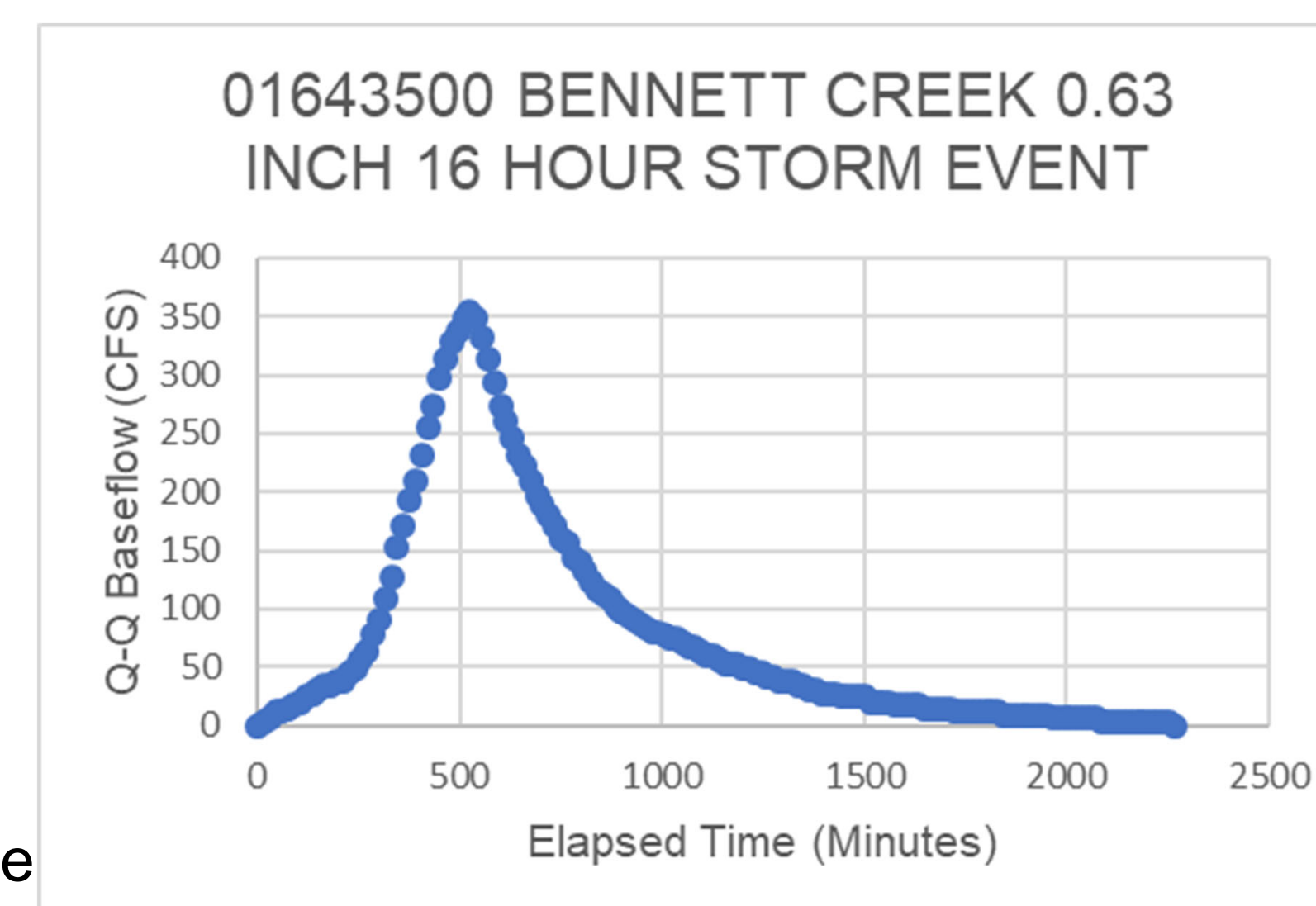


Fig. 4. Example of a storm hydrograph

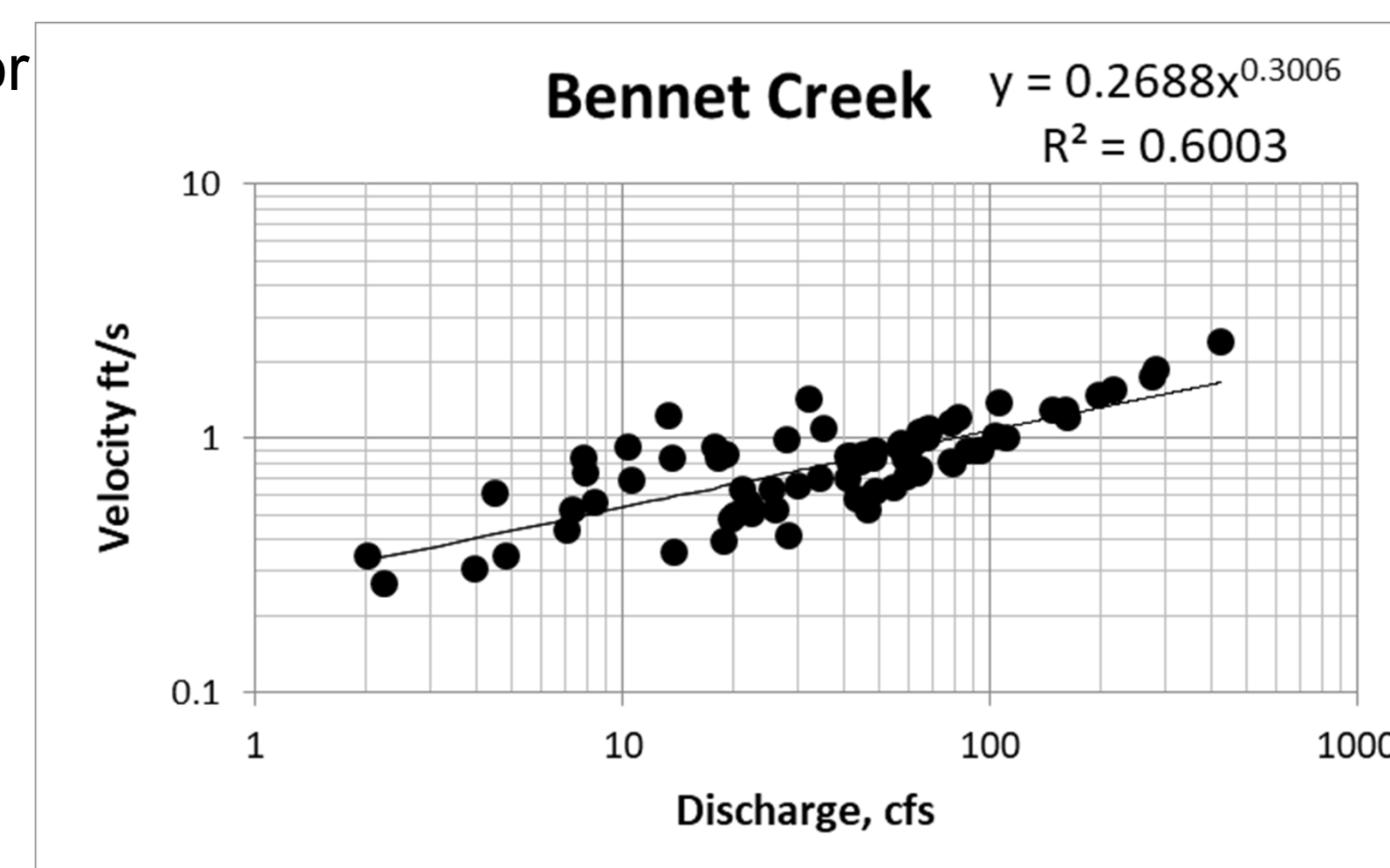


Fig. 5. Relationship between discharge and velocity for Bennett Creek.

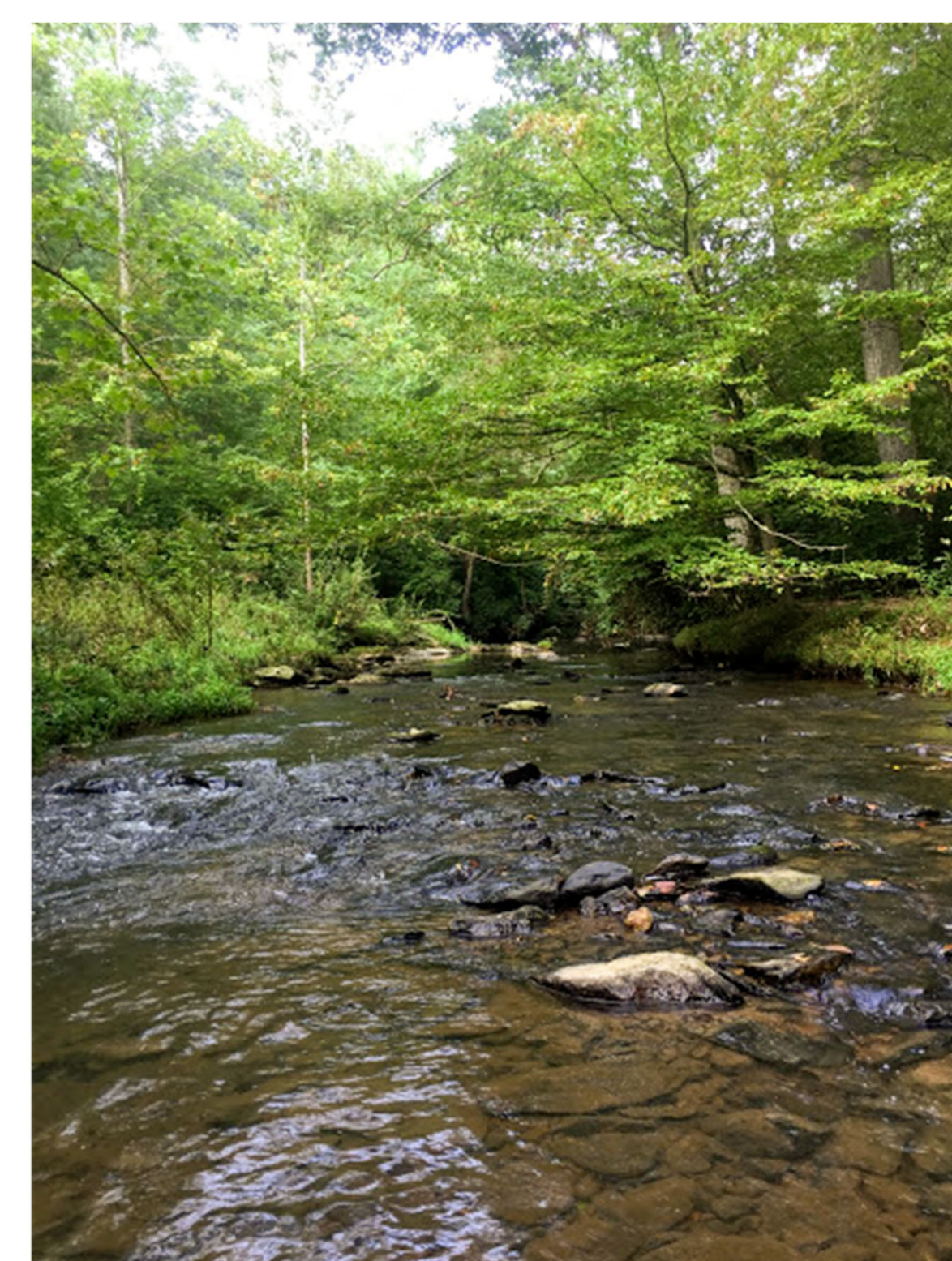


Fig. 6. Picture of Hawlings River taken 2018.

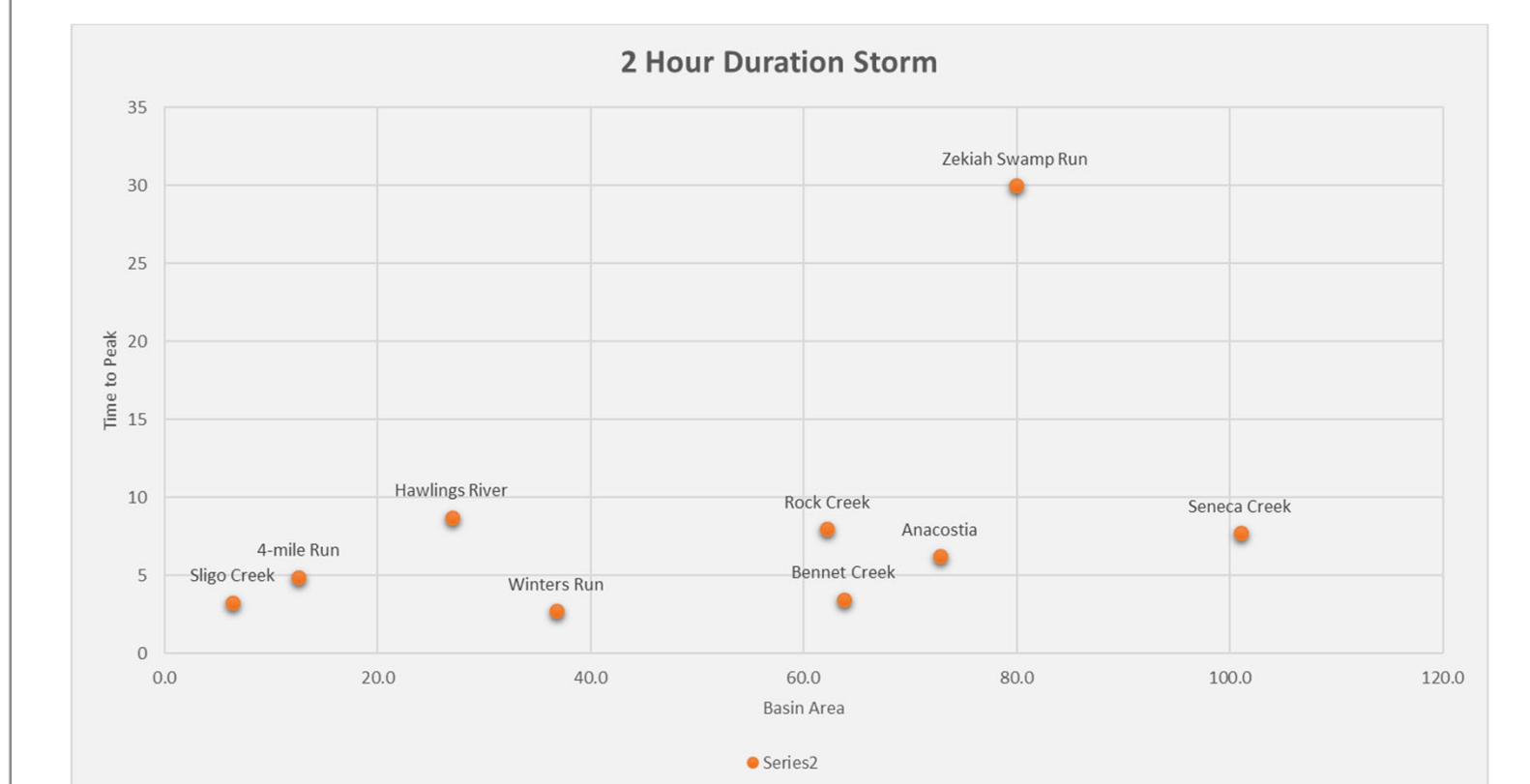
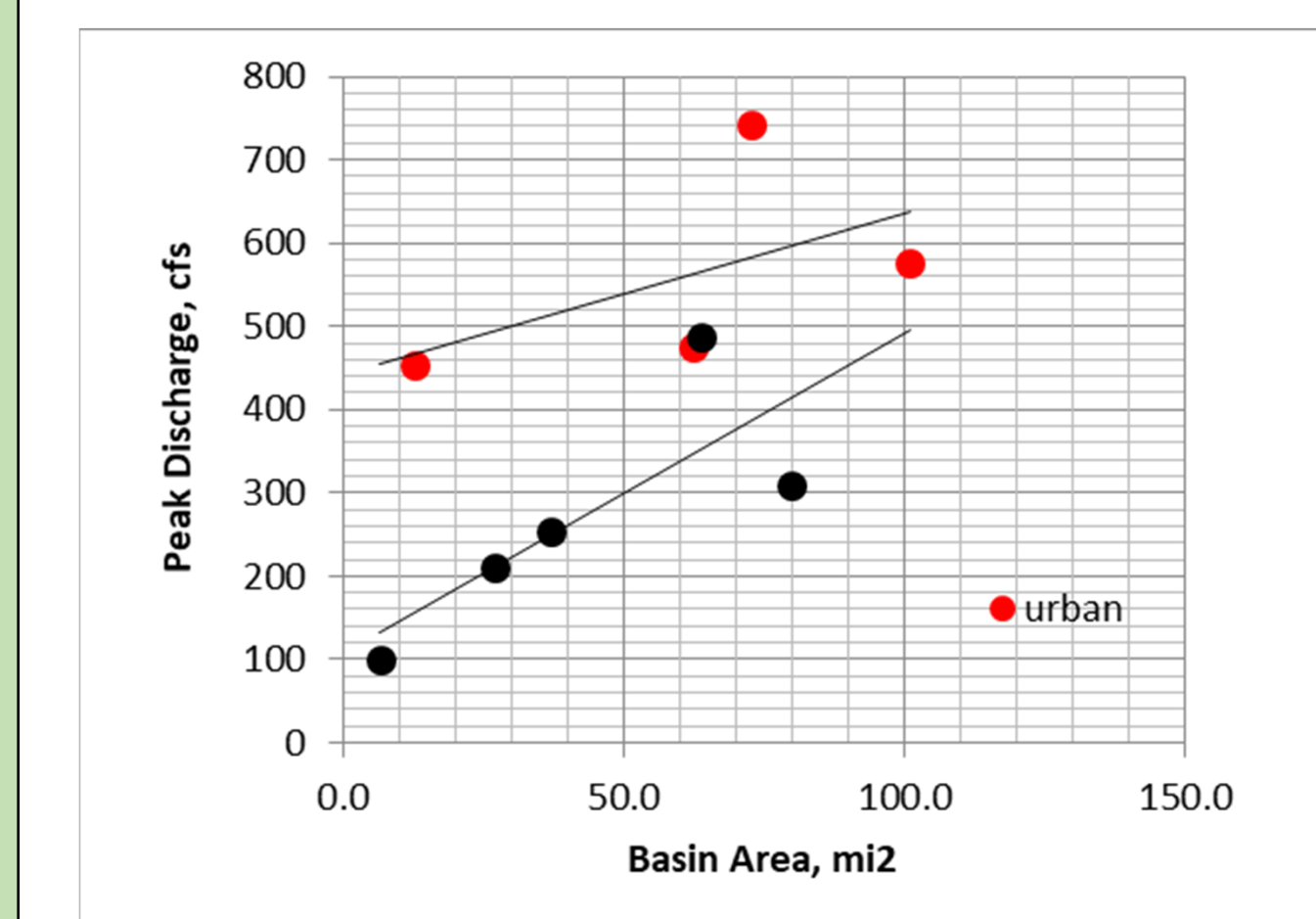


Fig. 7. Picture of Little Bennet Creek taken on April 13th

IV. Preliminary Results

2 Hour Storm Duration			Basin Area	Storm	Baseflow	Peak Discharge	Q Peak-Q Baseflow	Basin	Q/Qbaseflow	Time to Peak ttp	Peak Velocity
Site Name	Site #	% Imp.	mi ²	Date	Qbf, cfs	Q Peak, cfs	cfs	area		Hours	ft/s
Hawlings River	1591700	7	27.0	3/10/2019	58.3	210	151.7	27.0	210	8.75	2.24
Rock Creek	1648000	21	62.2	3/10/2019	90.4	475	384.6	62.2	475	8	1.80
Seneca Creek	1645000	12	101.0	3/10/2019	263	577	314	101.0	577	7.75	2.91
Sligo Creek	1650800	6	6.5	3/10/2019	8.32	99.6	91.28	6.5	99.6	3.3	2.20
Winters Run	1581750	25	36.8	3/10/2019	129	253	124	36.8	253	2.75	0.79
Bennet Creek	1643500	1	63.8	3/10/2019	205	487	282	63.8	487	3.5	1.73
Anacostia	1649500	35	72.8	3/10/2019	89.6	742	652.4	72.8	742	6.25	3.79
Zekiah Swamp Run	1652500	7	79.9	3/10/2019	206	308	102	79.9	308	30	1.00
4-mile Run	1660420	15	12.6	3/10/2019	14.7	454	439.3	12.6	454	4.91	2.55

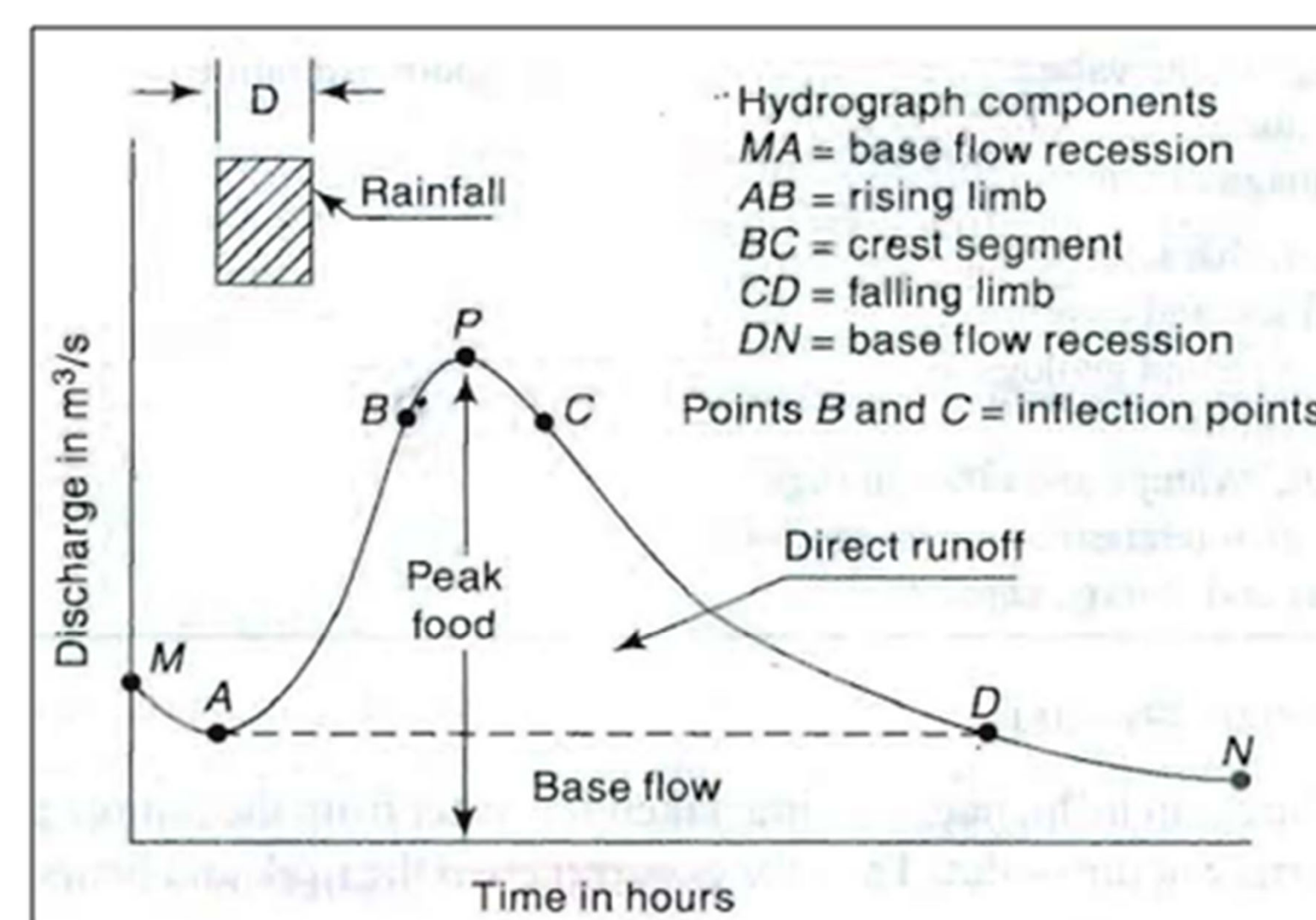
12 Hour Storm Duration			Basin Area	Storm	Baseflow	Peak Discharge	Q Peak-Q Baseflow	Basin	Q/Qbaseflow	Time to Peak ttp	Peak Velocity
Site Name	Site #	% Imp.	mi ²	Date	Qbf, cfs	Q Peak, cfs	cfs	area		Hours	ft/s
Hawlings River	1591700	6.86	27	3/21/2019	1264.4	1390	125.6	27.0	1.10	13	6.69
Rock Creek	1648000	21	62.2	3/21/2019	67.1	1930	1862.9	62.2	28.76	17	4.01
Seneca Creek	1645000	12	101	3/21/2019	532	3330	2798	101.0	6.26	10	6.23
Sligo Creek	1650800	6.45	6.45	3/21/2019	70.6	607	536.4	6.5	8.60	4.08	8.43
Winters Run	1581750	25	36.8	3/21/2019	137	2240	2103	36.8	16.35	12.5	0.98
Bennet Creek	1643500	1.2	63.8	3/21/2019	128	482	354	63.8	3.77	8.75	1.72



Concept of Lag Time

Once a hydrograph has been created, rise time can be measured from the start of rise of the hydrograph to the peak discharge. On the elements of a hydrograph figure 3, this is the time in hours between point A and point P.

Fig. 3: Elements of a hydrograph. (Subramanya, 2008)



II. Hypotheses

Hypotheses:

- H1: The rise time of urban streams (impervious surface area more than 10%) will be lower than non-urban streams with similar basin area.
- H2: Stream channelization and other modifications common in urban watersheds tend to decrease stream flow resistance. Therefore, peak flow velocities will be higher in urban streams than in non-urban streams.
- H3: The total hydrograph volume will increase with peak discharge and will be higher for urban than for non-urban streams.

Null Hypotheses:

- H1₀: Rise times of both urban and non-urban streams with similar basin area will be similar.
- H2₀: Peak flow velocities will increase faster in urban watersheds than rural watersheds.
- H3₀: The total hydrograph volume will increase at a higher rate for urban streams with peak discharge.

V. Conclusions

At this point in the study more data points are needed for analysis. More rural research sites with small basin areas are needed. Data collection has been the main objective for this semester; however, one interesting result is the lack of variance in lag times for both urban and non urban streams with different basin areas. This could suggest that prior to urbanization processes effecting the channel already had an effect on lag time.

VI. References

- Leopold, L. B. (1991). Lag times for small drainage basins. CATENA, 18(2), 157–171.
- Subramanya (2008) Engineering Hydrology. 7 West Patel Nagar. Tata McGraw-Hill, New Delhi