Unit Hydrograph Analysis

Purpose: The purpose of the UHG is to characterize quantitatively the relationship between rainfall and runoff for a particular basin. The UHG is used to synthesize streamflow hydrographs resulting from multi-intensity storms of variable duration. The synthesized hydrograph is a prediction of the streamflow anticipated in the basin and is useful for water resources planning, or flood control.

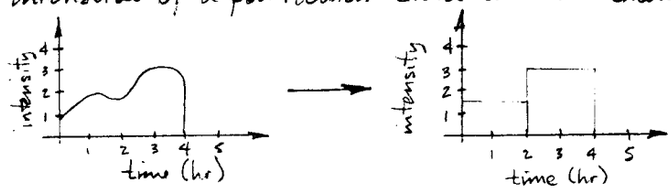
Derivation: The UHG is derived from a streamflow hydrograph having a direct runoff (DR) component equivalent to approximately one unit of effective rainfall over the basin area.

Parameters: The UHG is defined only by the storm duration from which it was derived.

Basin Linearity: An assumption of time invariance of basin response characteristics with respect to runoff.

Synthesizing Hydrographs from the UHG:

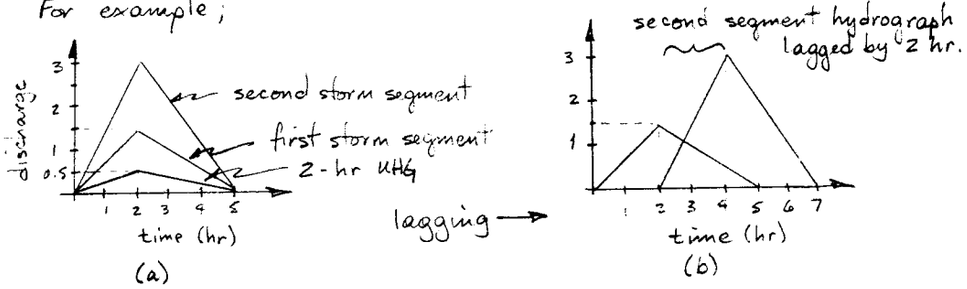
(1) decompose the multiple intensity storm into average effective intensities of a particular duration. For example;



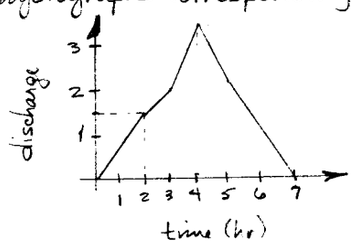
(2) obtain the UHG corresponding to the storm duration of the segments of the decomposed rainfall record. In the example above we need the 2-hr UHG.

(3) multiply the ordinates (y-axis) values of the UHG by the ratio of the storm segment intensity to the UHG intensity. For this example, the ratios would be $\frac{1.5}{0.5} = 3$ and $\frac{3}{0.5} = 6$, respectively.

(4) Lag the hydrographs obtained in (3) by the number of hours corresponding to the beginning of the next storm segment. For example;



(5) to obtain synthesized hydrograph for the multiple intensity storm of (1), sum the discharges for each time of the lagged hydrographs corresponding to each storm segment (b) above.



Synthesizing a UHG of different storm duration: Use superposition.

(1) the t-hr storm duration UHG is lagged by t hr and the two hydrographs are summed (steps 4 & 5 above).

(2) the resulting hydrograph is for 2 units of runoff for a storm lasting $2t$ hours.

(3) the $2t$ - hr UHG is obtained by dividing the hydrograph ordinates of (2) above by two. Note that the rainfall intensity is now half of the original intensity but for twice the duration.

(4) this procedure can be extended by repeated superposition of UHG's.

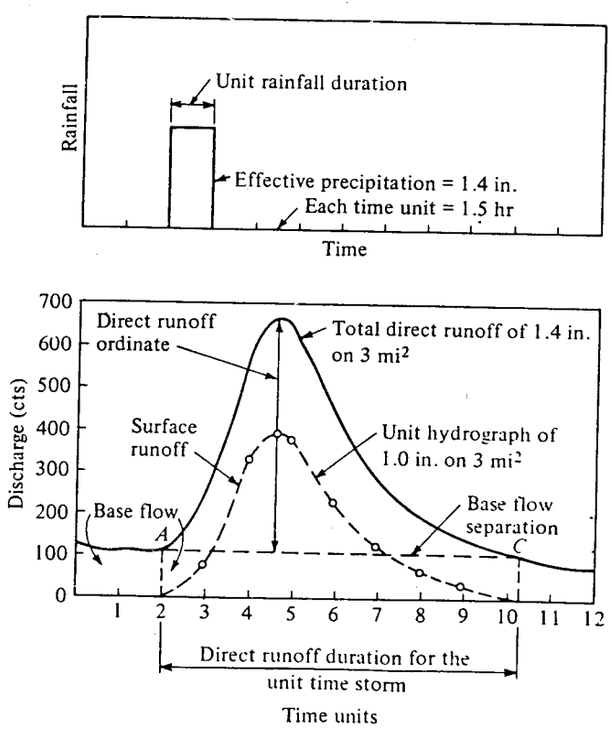
Table 4-6

Interval	*DR* (cfs)	Δt (hrs)	Direct Runoff (ft³) $DR \times \Delta t \times 3600$
2–3	60	1.5	324,000
3–4	290	1.5	1,566,000
4–5	550	1.5	2,970,000
5–6	435	1.5	2,349,000
6–7	255	1.5	1,377,000
7–8	120	1.5	648,000
8–9	70	1.5	378,000
9–10	20	1.5	108,000
			$\sum(DR \times \Delta t) = 9{,}720{,}000$ ft³

$$\text{Total direct runoff} = \frac{9{,}720{,}000}{3 \times (5280)^2} = 1.4 \text{ in.}$$

Table 4-4 *Determination of a Unit Hydrograph from an Isolated Storm*

1	2	3	4	5
Time Unit	*Total Runoff (cfs)*	*Base Flow (cfs)*	*Total Direct Runoff, (2) − (3) (cfs)*	*Unit Hydrograph Ordinate, (4) ÷ 1.4 (cfs)*
1	110	110	0	0
2	122	122	0	0
3	230	120	110	78.7
4	578	118	460	328
4 7	666	116	550	393
5	645	115	530	379
6	434	114	320	229
7	293	113	180	129
8	202	112	90	64.2
9	160	110	50	35.7
10	117	105	12	8.6
10.5	105	105	0	0
11	90	90	0	0
12	80	80	0	0



(b)

Fig. 4-16. *(a) Dimensionless unit hydrograph; (b) illustration of i rivation of a unit hydrograph from an isolated storm.*

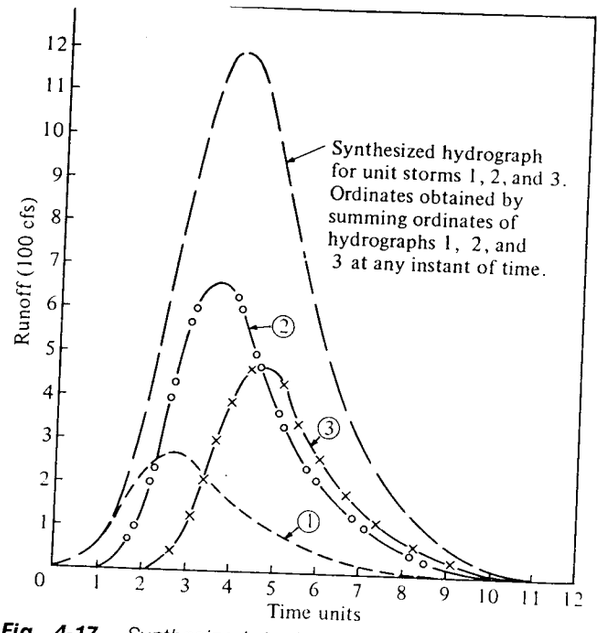


Fig. 4-17. *Synthesized hydrograph derived by the unit hydrograph method.*

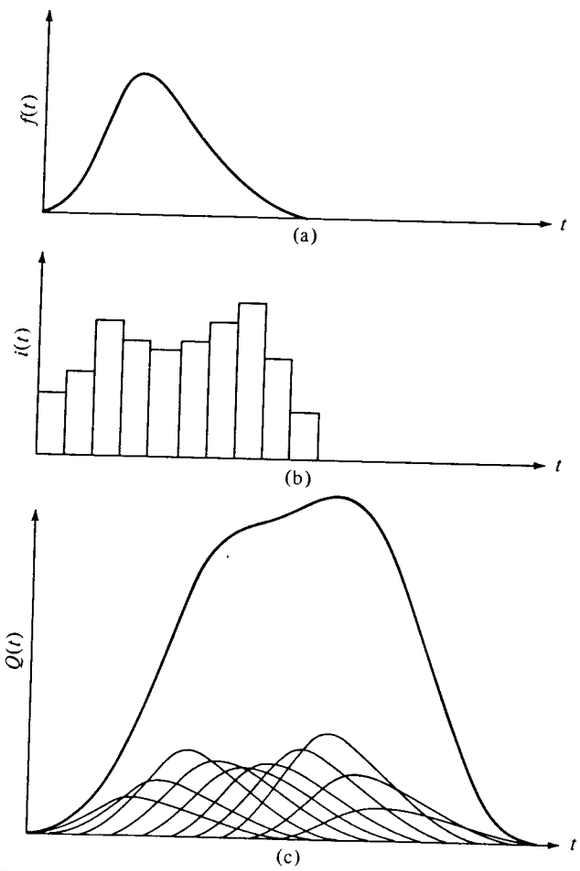


Fig. 4-18. *Unit hydrograph description of the runoff process. (a) Unit hydrograph; (b) a sequence of 1-min storms; (c) superposition of runoff hydrographs for each of the 1-min storms. (After John C. Schaake, Jr., "Synthesis of the Inlet Hydrograph," Tech. Rept. No. 3, Department of Sanitary Engineering and Water Resources, Baltimore, Md., 1965.)*