Unit Hydrograph (UH), UH Derivations and S-Curves, Lecture 7, 04/23/2013

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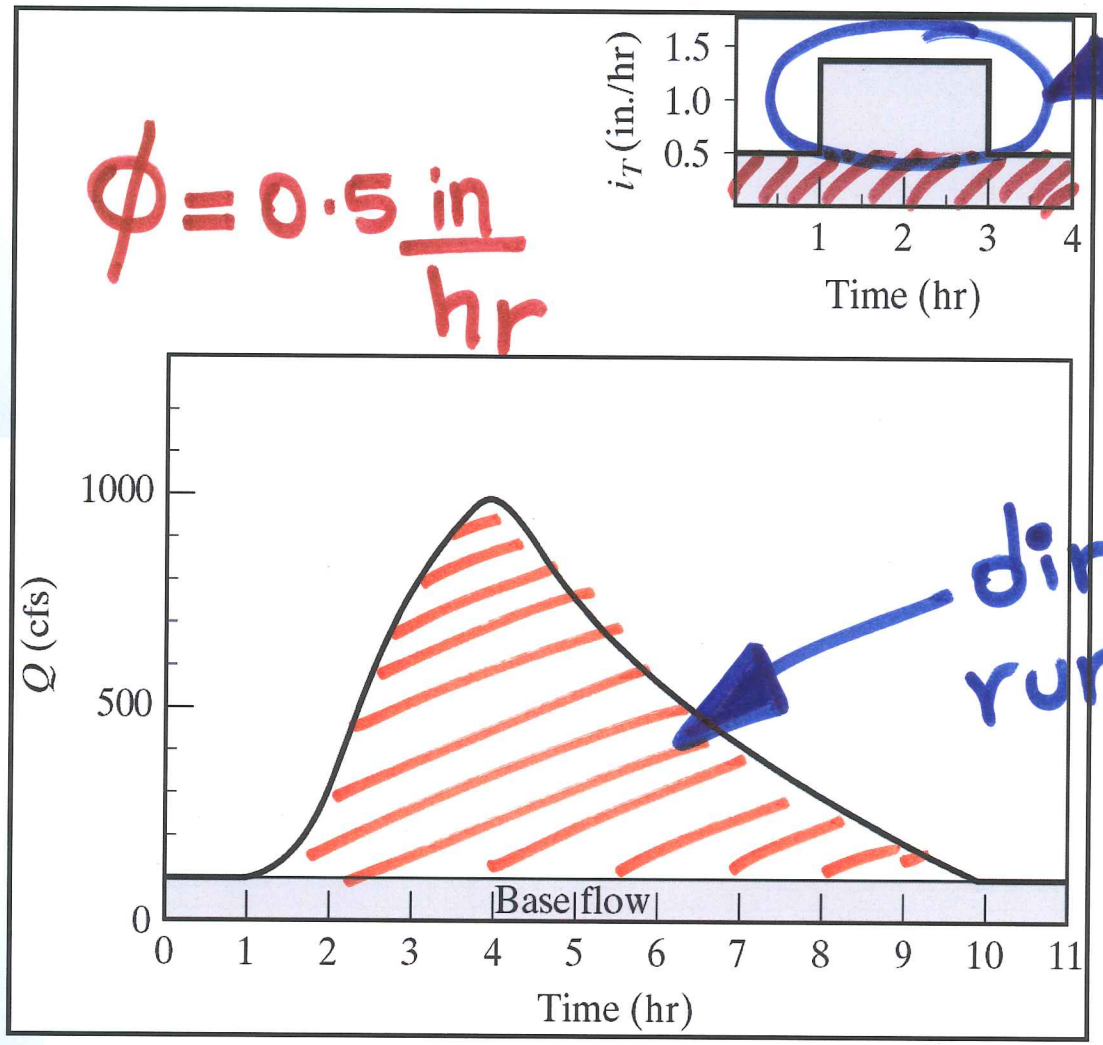
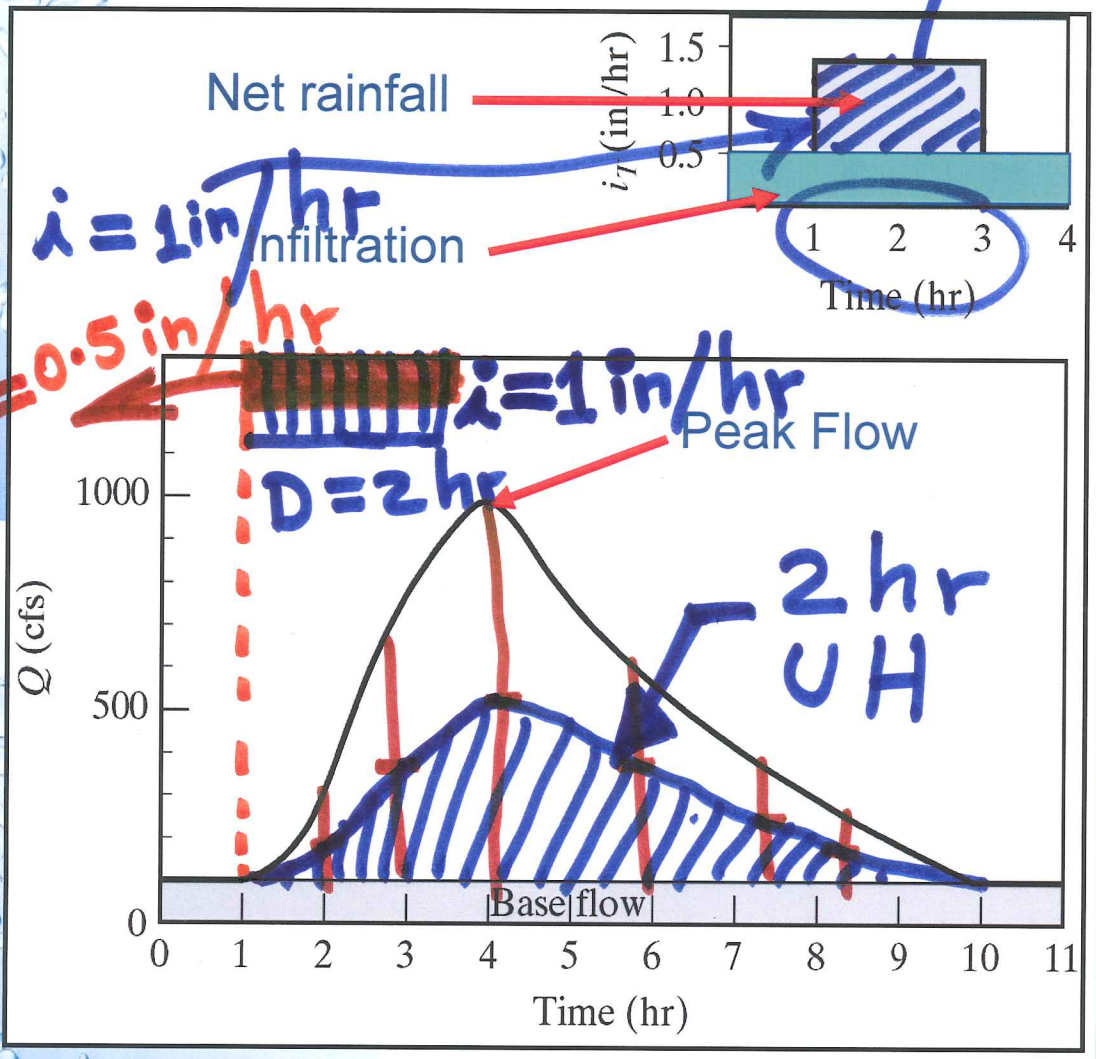
Adapted from textbook and notes of Philip B. Bedient, David Maidment and Areeya Rittima

Measured Hydrograph Adjusted for Net Rainfall (RF)



Base Flow and Infiltration



D = 2 hr

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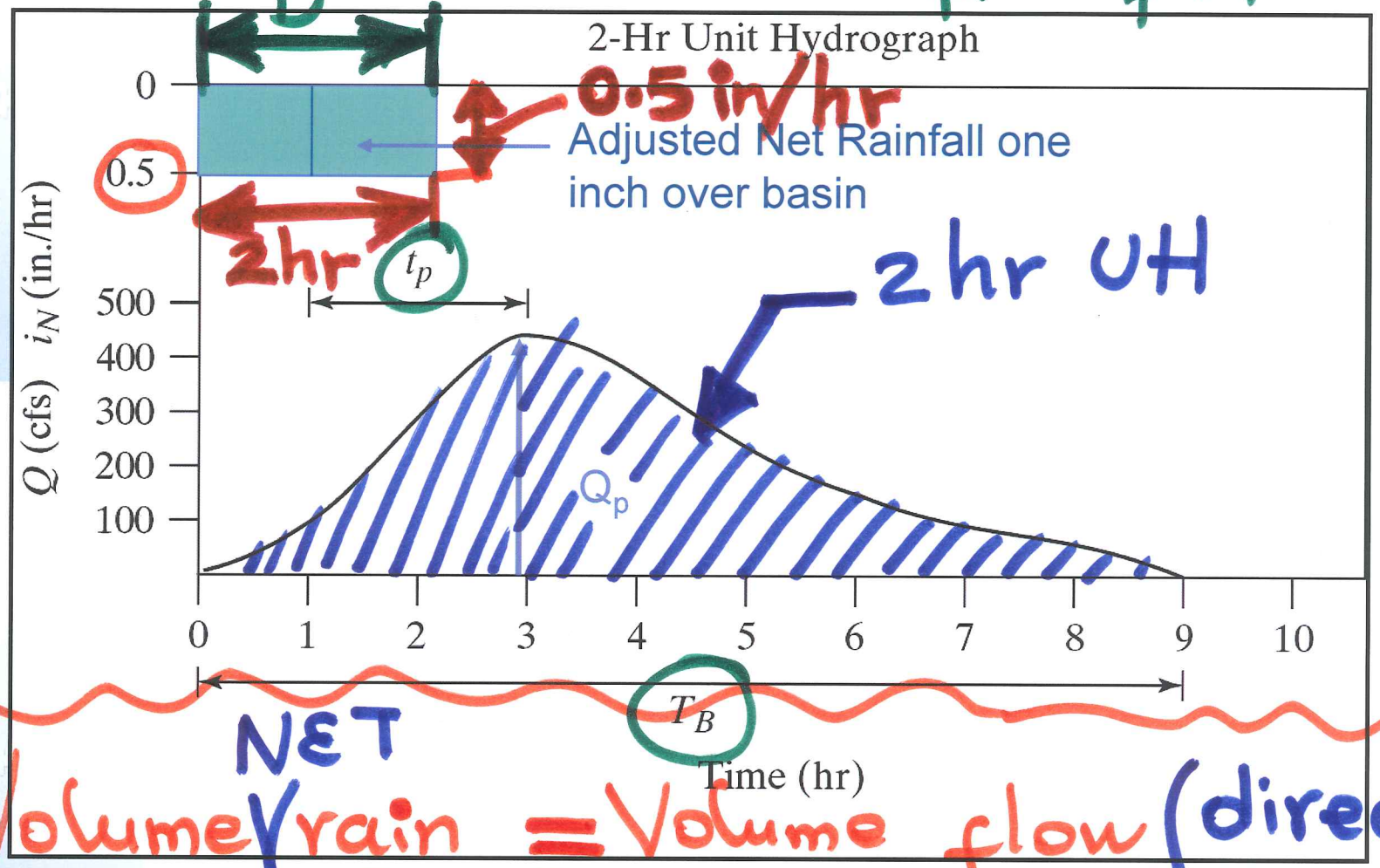
- Subtract BF
- Subtract Infiltration
- Determine Net Rain
- Integrate hydrograph
- Adjust hydrograph ordinates to match net rainfall Volume
- Determine UH

D = 2-Hr Unit Hydrograph

D = Duration of net rainfall



NET Volume rain = Volume flow (direct runoff)

t_p = Lag time

T_B = Time Base

D = 2-Hr Unit Hydrograph (Cont.)

BF = Baseflow = 100 cfs

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Original flow

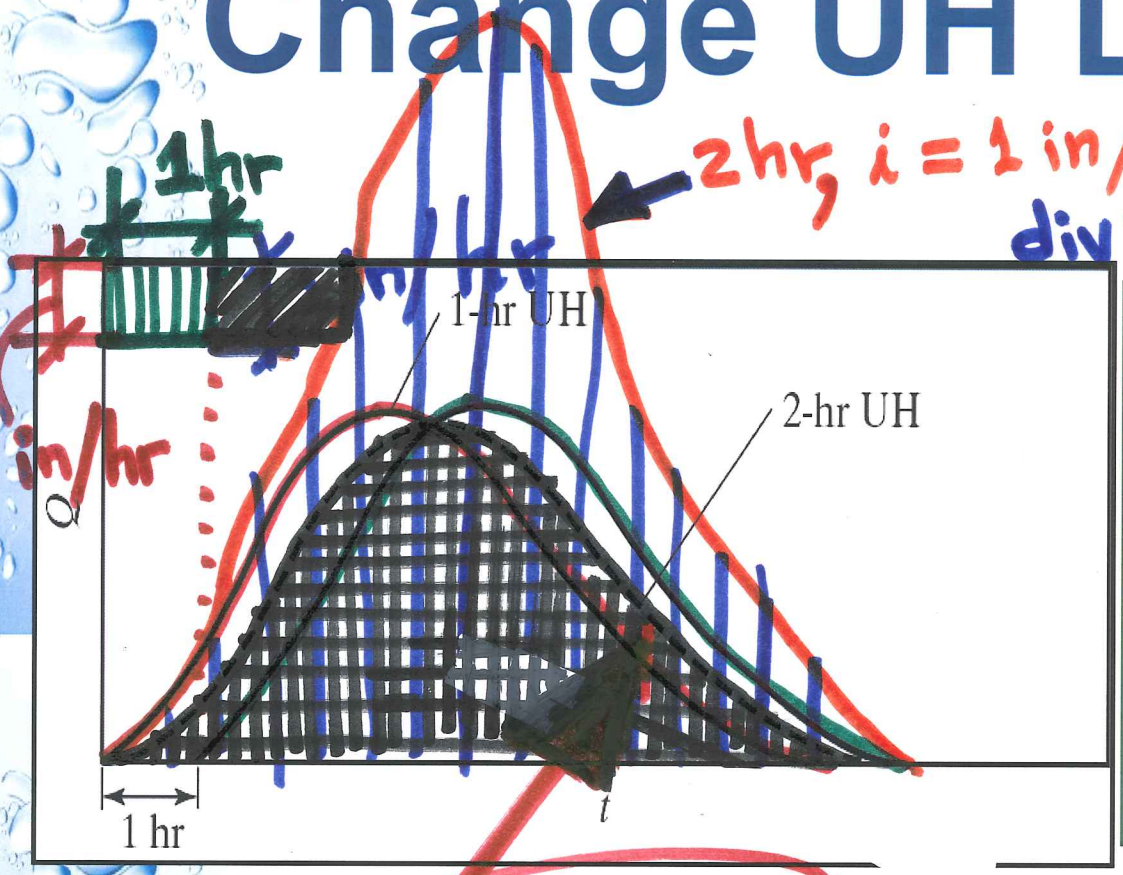
Time (hr)	Q (cfs)	Q-BF (cfs)	2-hr UH, Q
0	100	0	0
1	100	0	0
2	300	200	100
3	700	600	300
4	1000	900	450
5	800	700	350
6	600	500	250
7	400	300	150
8	300	200	100
9	200	100	50
10	100	0	0
11	100	0	0

−100 baseflow

/2 divide by 2

2 hr UH

Change UH Duration

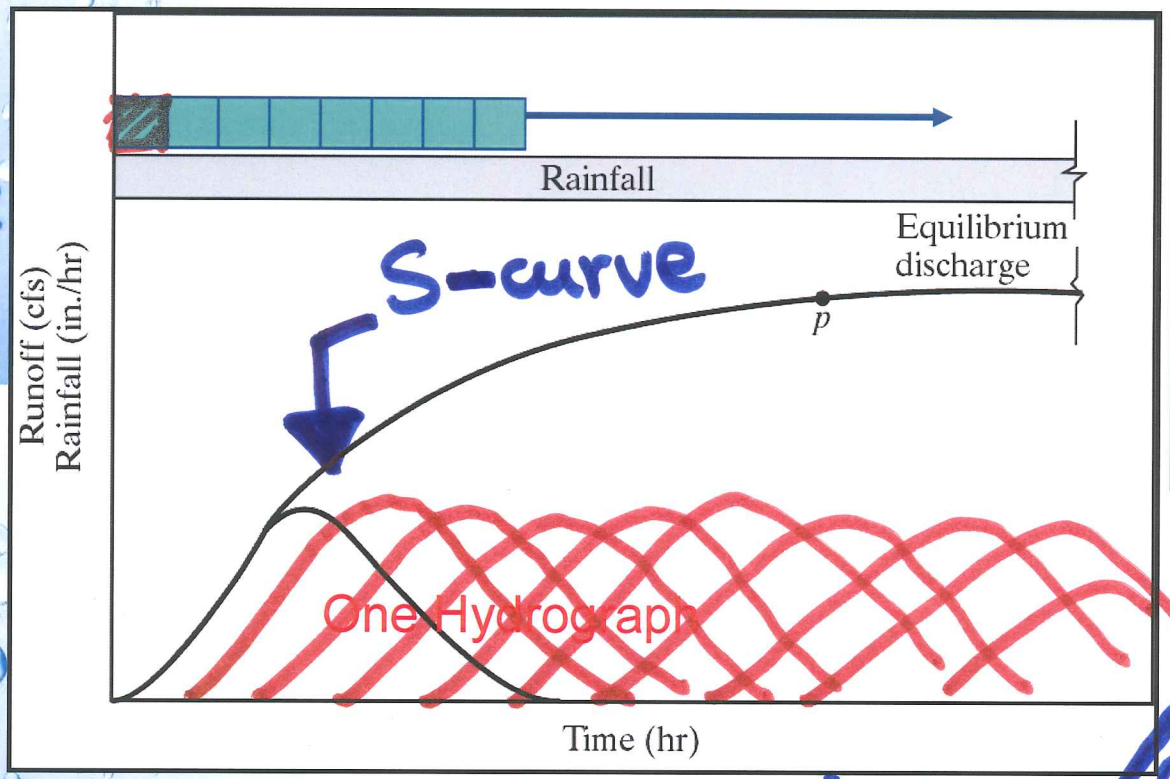


2hr, $i = 1$ in/hr (Not unit hydrograph)
divide by 2 (for UH)

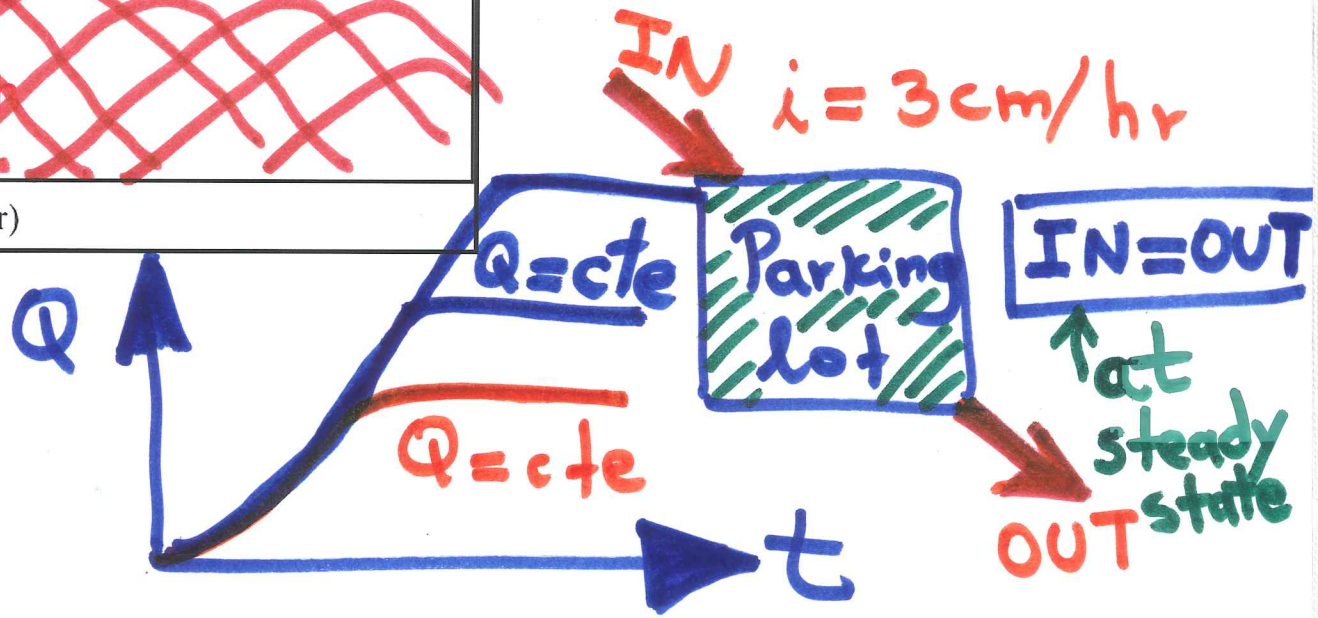
- Consider 1 hr UH
- Add and Lag two UH by one hour
- Sum and divide by 2
- Results in 2 hr UH

2hr UH

Equilibrium Hydrograph



- Uniform Rain
- Inflow = Outflow
- Equiv. to summing "n" hydrographs in time
- Produces "S" curve



S-Curves for UH

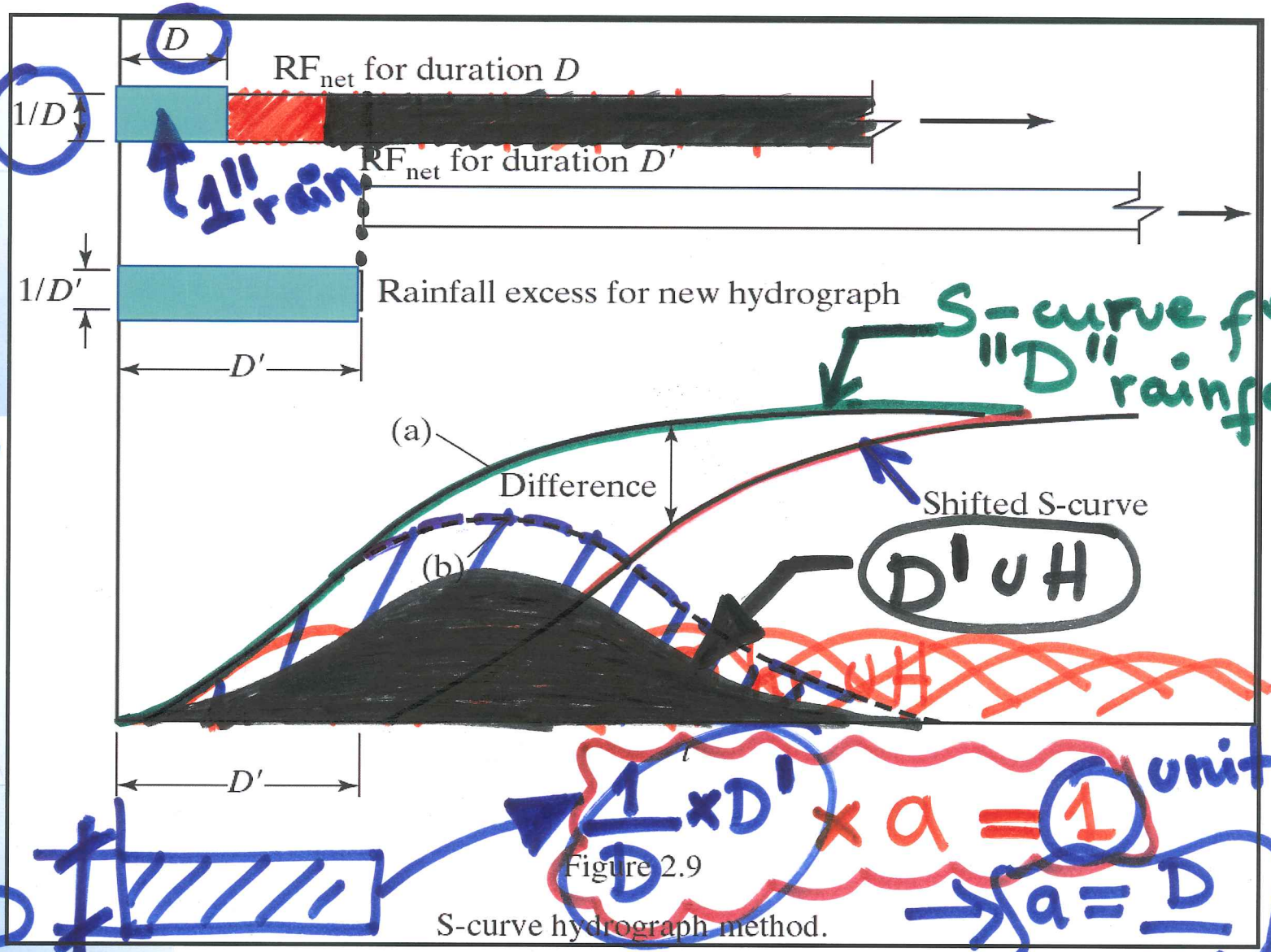
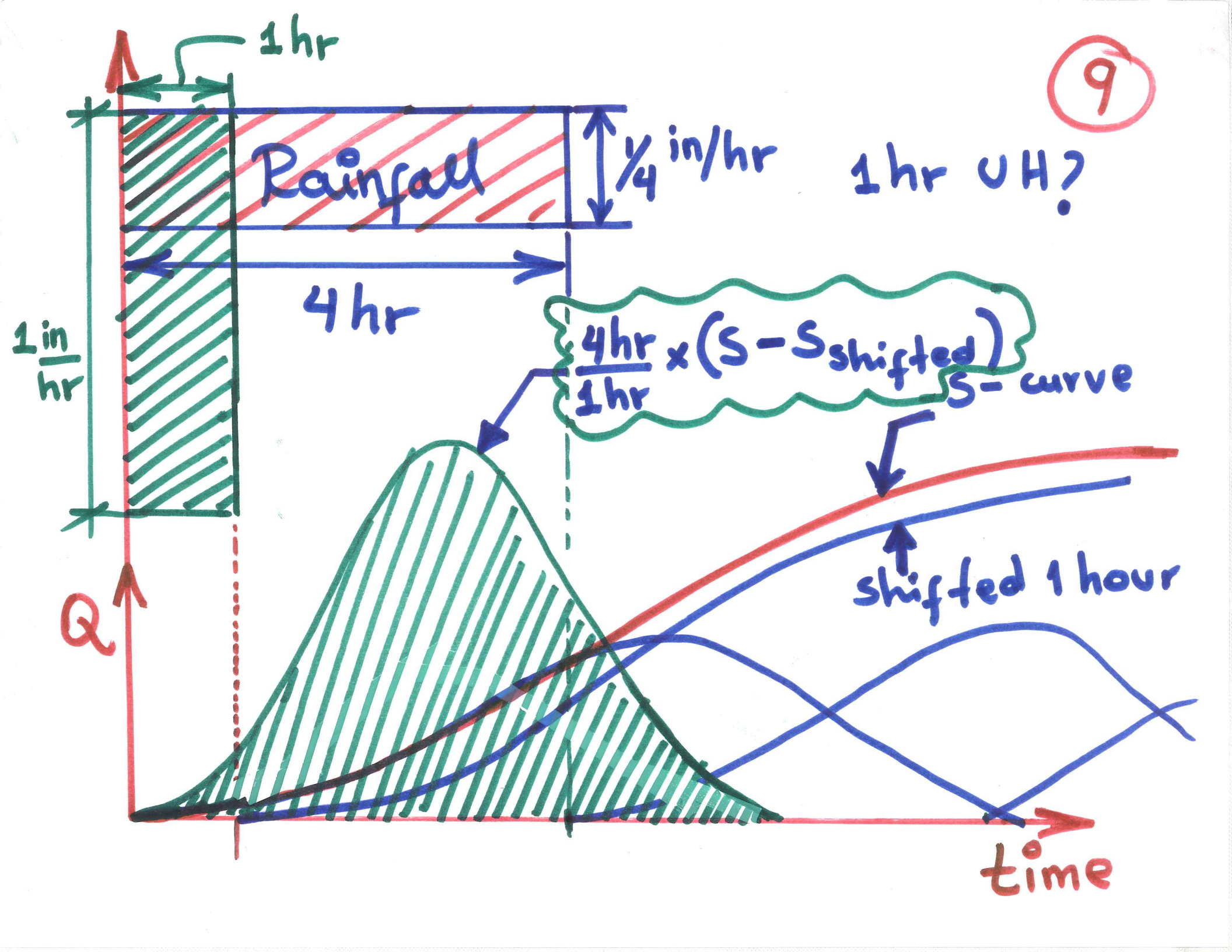


Figure 2.9
S-curve hydrograph method.


1 hr
Rainfall
¼ in/hr
1 hr UH?
4 hr
1 in/hr
4hr/1hr x (S - S shifted)
S - curve
shifted 1 hour
Q
time

S-Curves

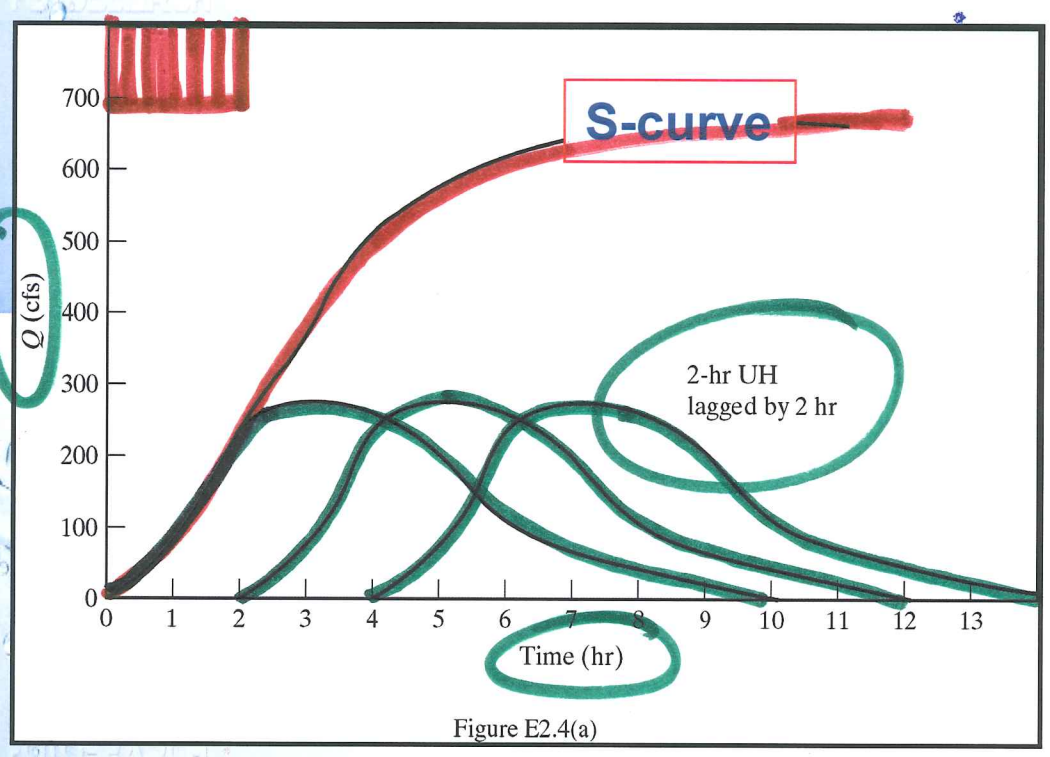
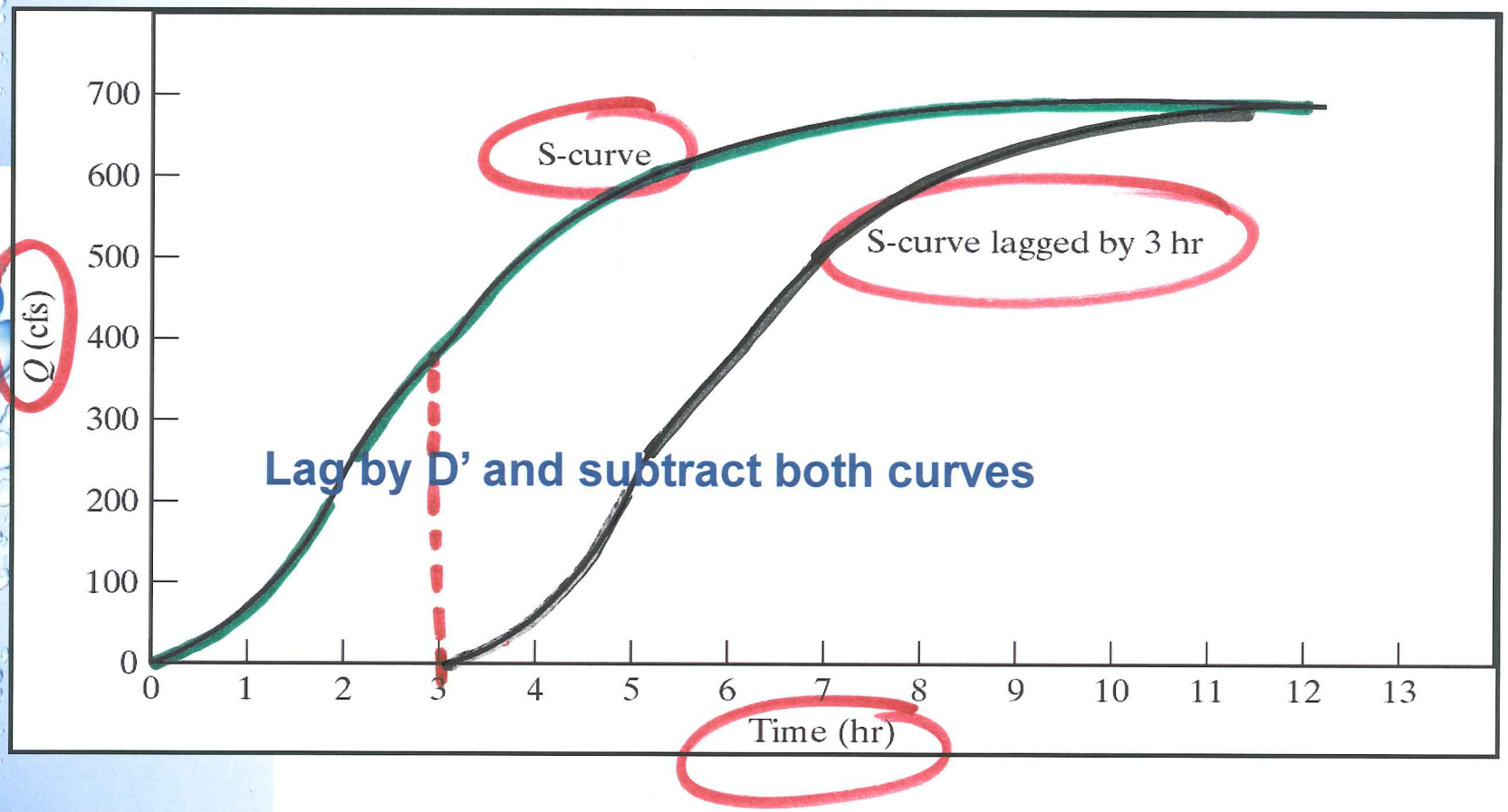


Figure E2.4(a)

- **Convert 2 hr Unit hydrograph to 3-hr**
- Lag each 2-hr UH by Duration D
- Add to produce *S* curve

Lag S Curves in time, subtract them, and multiply by D/D'



3 hr. Unit Hydrograph from a 2 hr. UH (D/D')

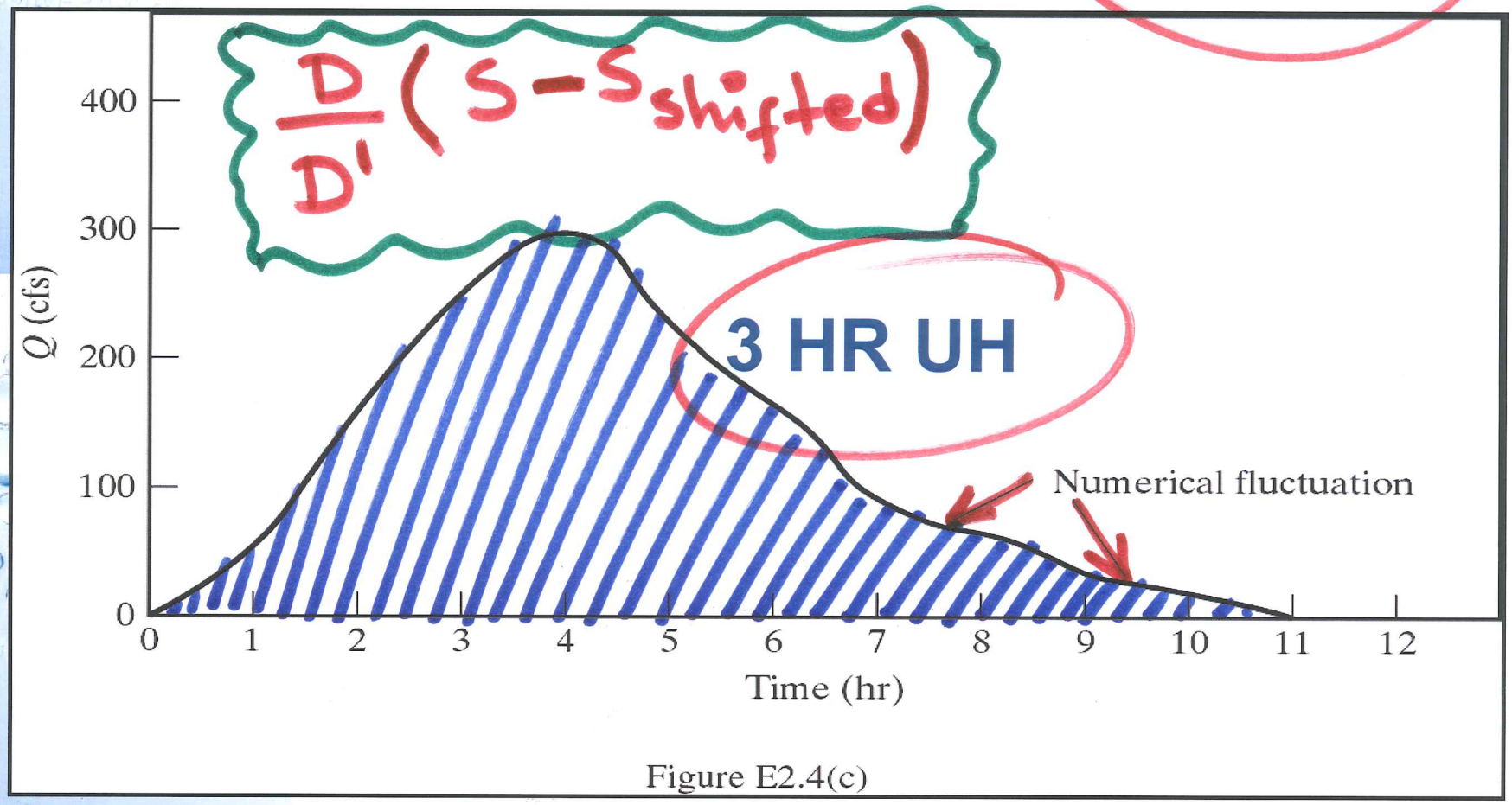
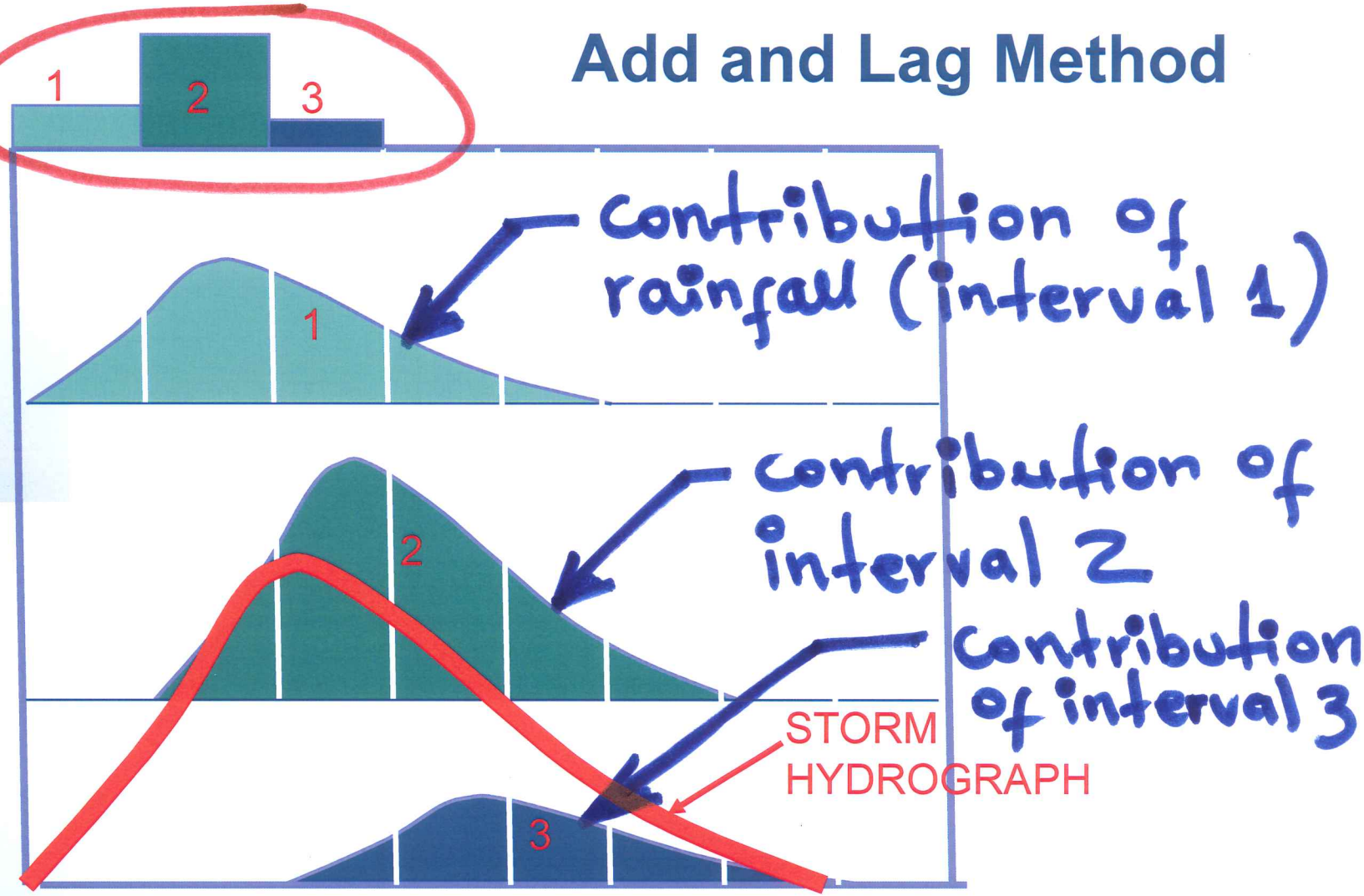


Figure E2.4(c)

Hydrograph Convolution

Add and Lag Method



Add up the ordinates of all three to produce storm hydrograph

Unit Hydrograph derivation from flow/precipitation data

Precipitation → P (Vector)

$$Q_1 = P_1 U_1$$

$$Q_2 = P_2 U_1 + P_1 U_2$$

$$Q_3 = P_3 U_1 + P_2 U_2 + P_1 U_3$$

$$Q_n = P_1 U_n + P_2 U_{n-1} + P_3 U_{n-2} + \cdots$$

$$[Q] = [P][U]$$

$$[P^T P]\,[U] = [P^T]\,[Q]$$

$$[U] = [P^T P]^{-1}\,[P^T]\,[Q]$$

P^T (Transpose of P)

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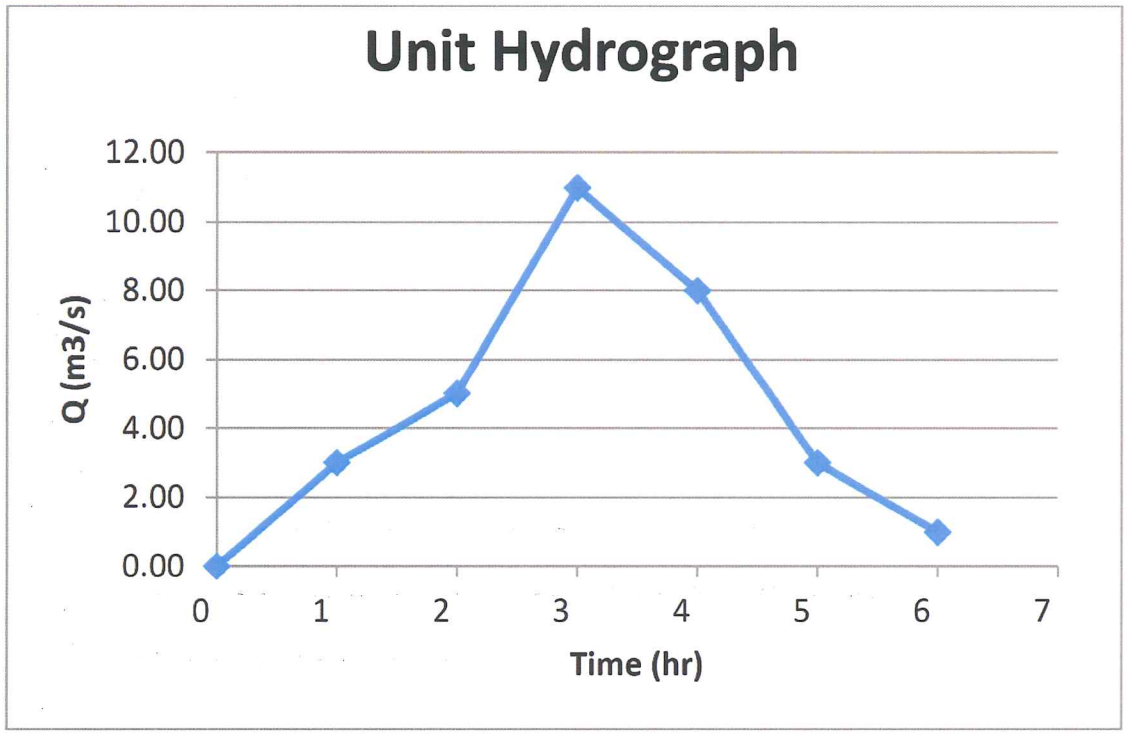
In-class Assignment 3 (Cont.):

Student Name:

The table below indicates the ordinates of a unit (1-cm) hydrograph for a storm of 3-hr duration over a watershed of 10km^2. Compute the ordinates for a 6-hr duration storm for a net rainfall intensity of 2.5 cm/hr. (Hint- Use superposition)



t (hr)	Q (m^3/s)	
0	0.00	
1	3.00	
2	5.00	
3	11.00	
4	8.00	
5	3.00	
6	1.00	

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In-class Assignment 3

Student Name:

Given the S-curve (developed from a 1-hr unit hydrograph) find the 3 hour unit hydrograph

t (hr)	S-curve
0.00	0.00
1.00	184.00
2.00	460.00
3.00	552.00
4.00	644.00
5.00	644.00
6.00	644.00
7.00	644.00