Chapter One

Hydrologic Principles

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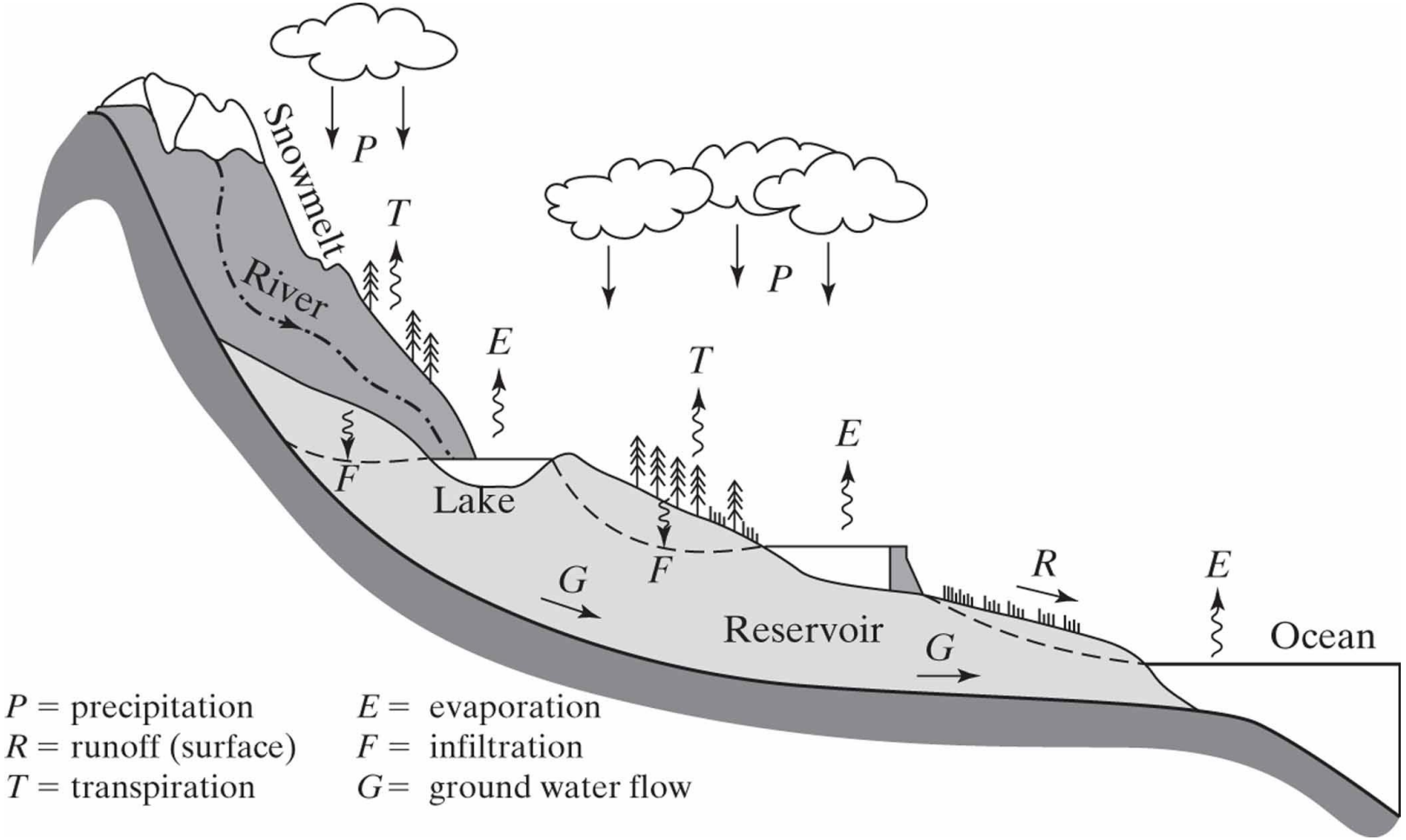

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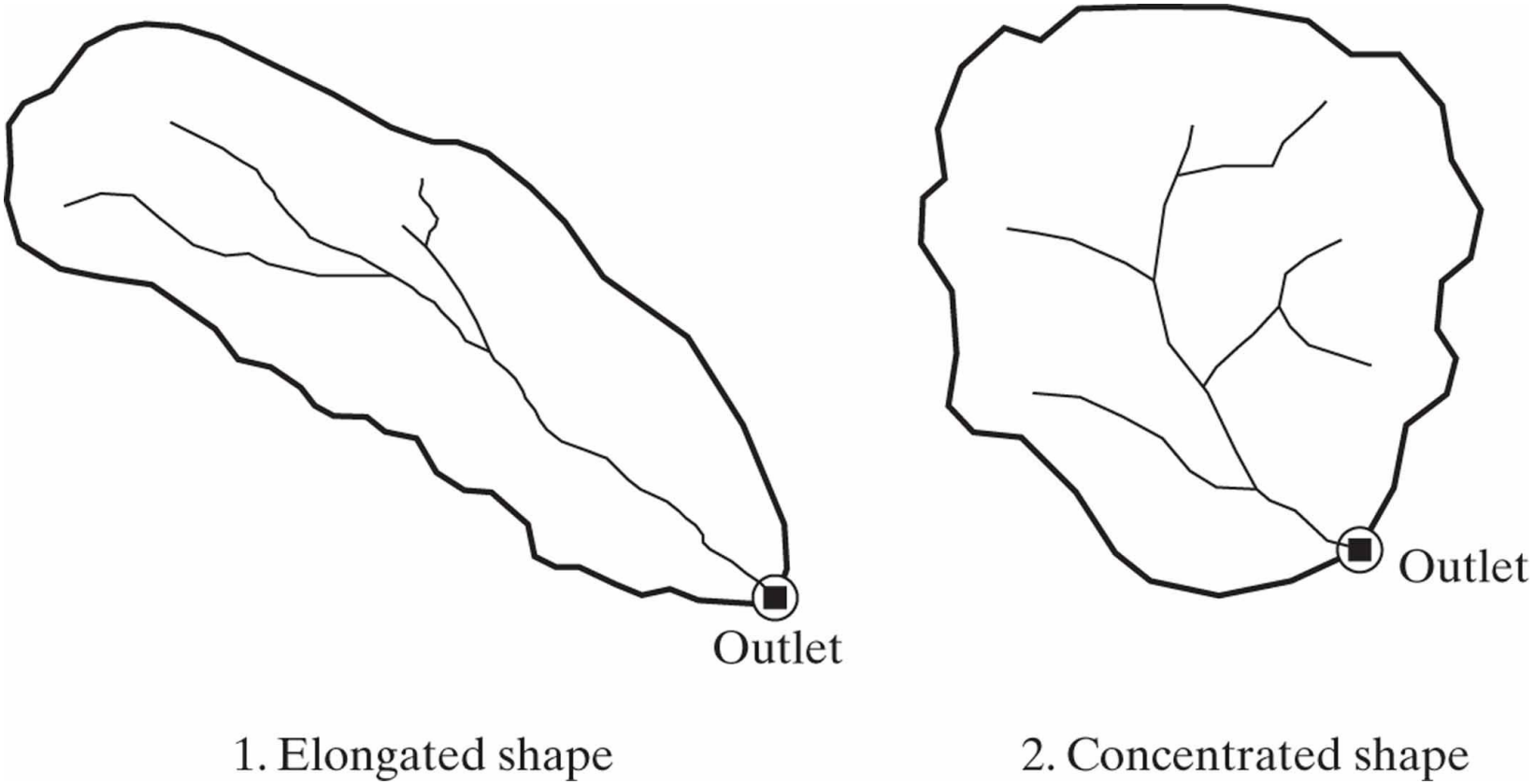

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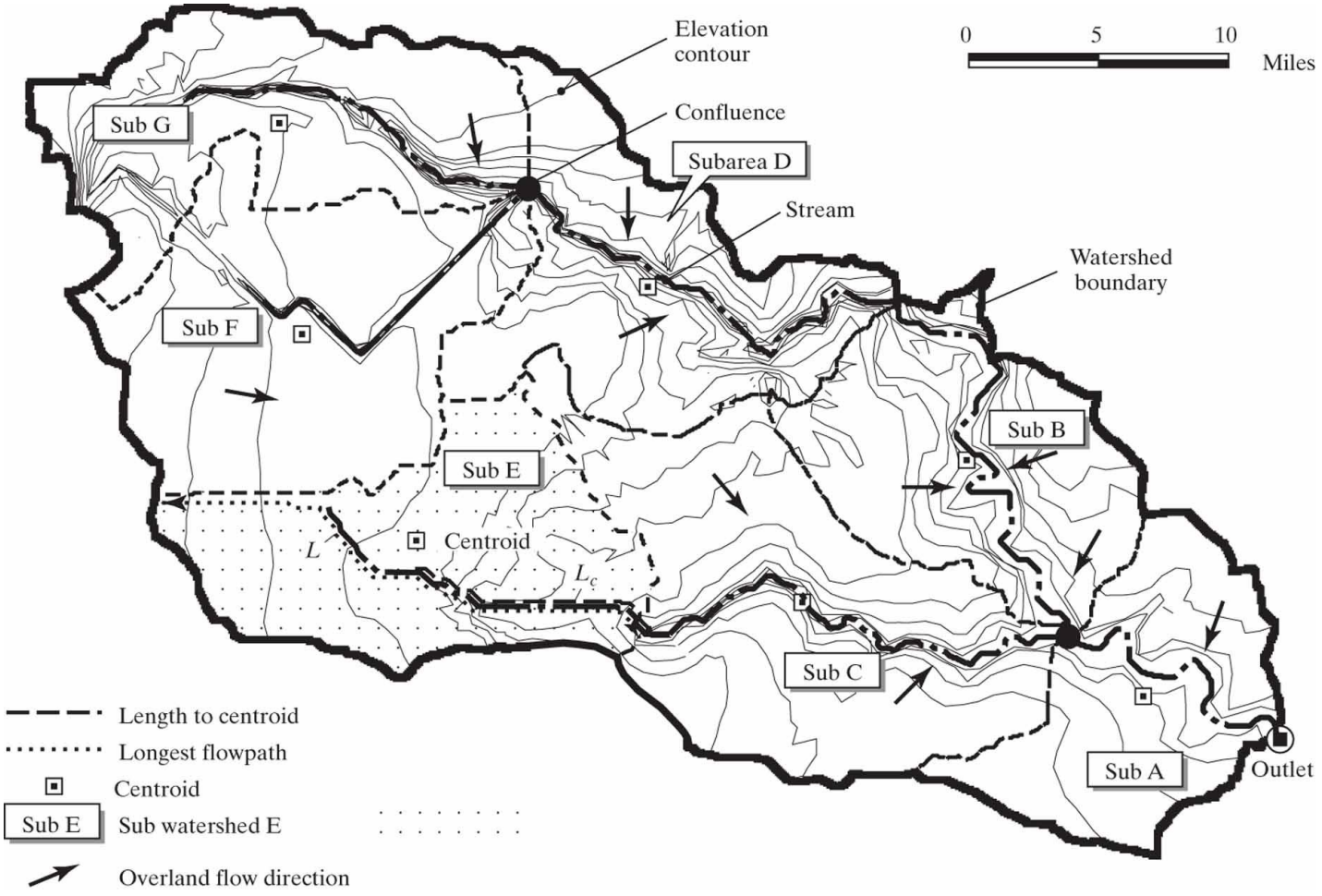

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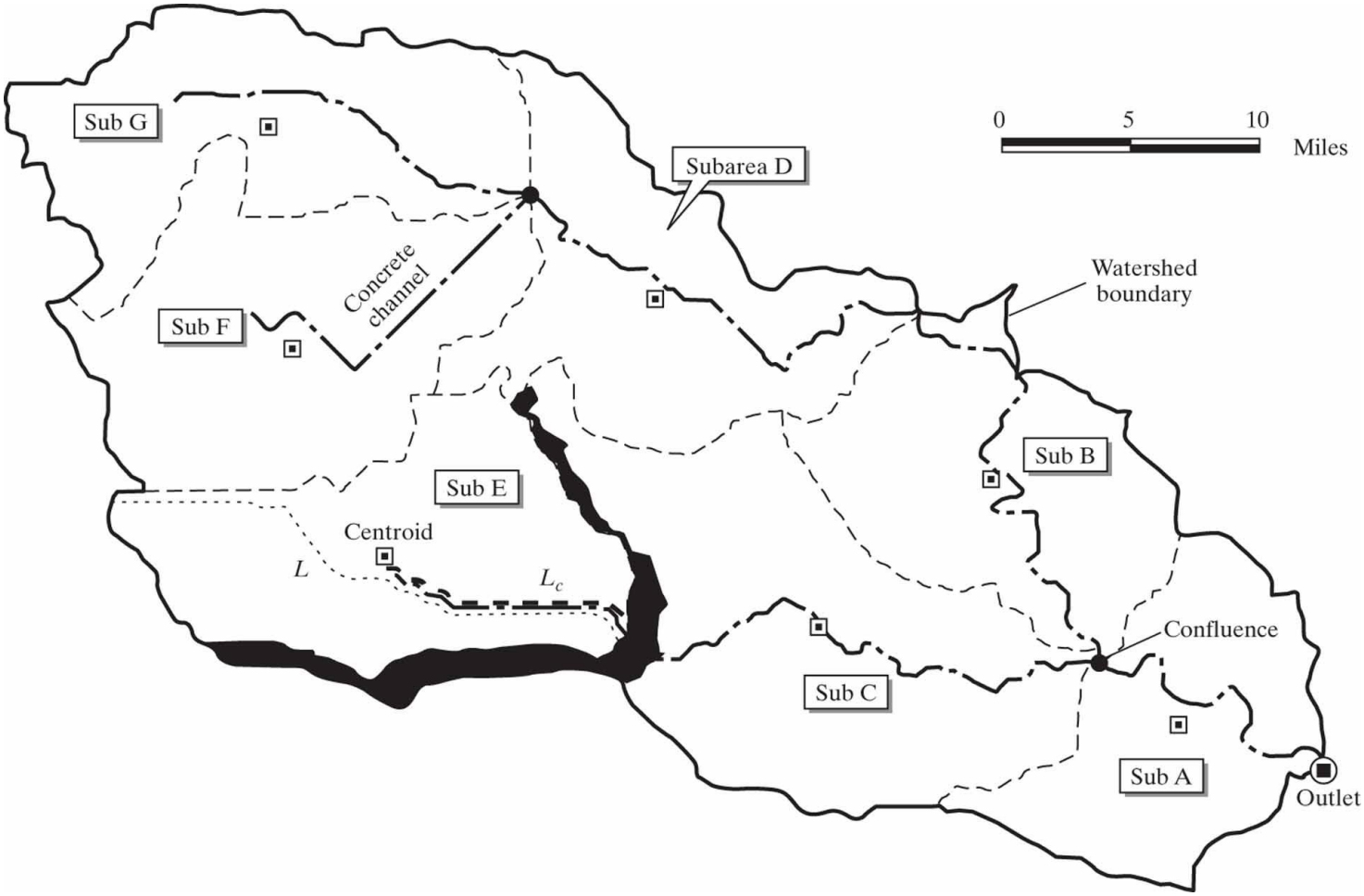

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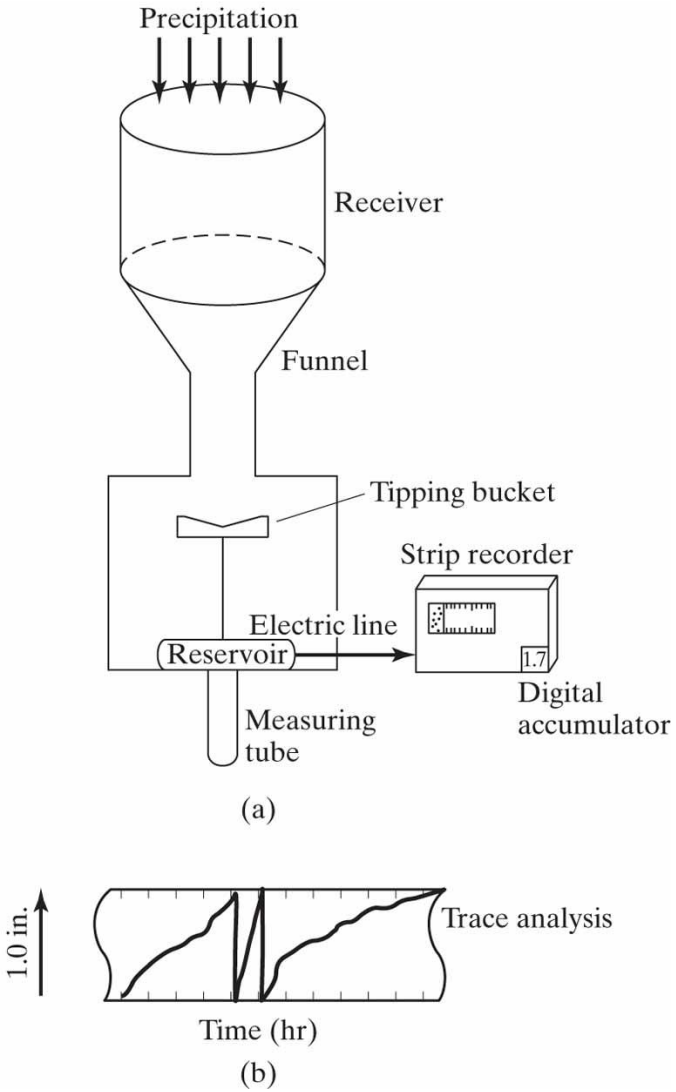

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Table E1–3. Rainfall Data from a Recording Gage

Time (hr)	Gage Rainfall (in.)	Gage Intensity (in./hr)	Time (hr)	Gage Rainfall (in.)	Gage Intensity (in./hr)
0	0	0	5.75	3.78	0.24
0.25	0.02	0.08	6	3.84	0.24
0.5	0.07	0.2	6.25	3.9	0.24
0.75	0.4	1.32	6.5	3.95	0.2
1	0.55	0.6	6.75	4.1	0.6
1.25	0.6	0.2	7	4.3	0.8
1.5	0.62	0.08	7.25	4.93	2.52
1.75	0.62	0	7.5	5.4	1.88
2	0.82	0.8	7.75	5.61	0.84
2.25	0.88	0.24	8	5.77	0.64
2.5	0.92	0.16	8.25	6.17	1.6
2.75	1.06	0.56	8.5	6.22	0.2
3	1.1	0.16	8.75	6.27	0.2
3.25	1.47	1.48	9	6.29	0.08
3.5	1.87	1.6	9.25	6.3	0.04
3.75	2.32	1.8	9.5	6.31	0.04
4	3.1	3.12	9.75	6.32	0.04
4.25	3.4	1.2	10	6.33	0.04
4.5	3.48	0.32	10.25	6.34	0.04
4.75	3.54	0.24	10.5	6.35	0.04
5	3.62	0.32	10.75	6.36	0.04
5.25	3.68	0.24	11	6.37	0.04
5.5	3.72	0.16	11.25	6.38	0.04

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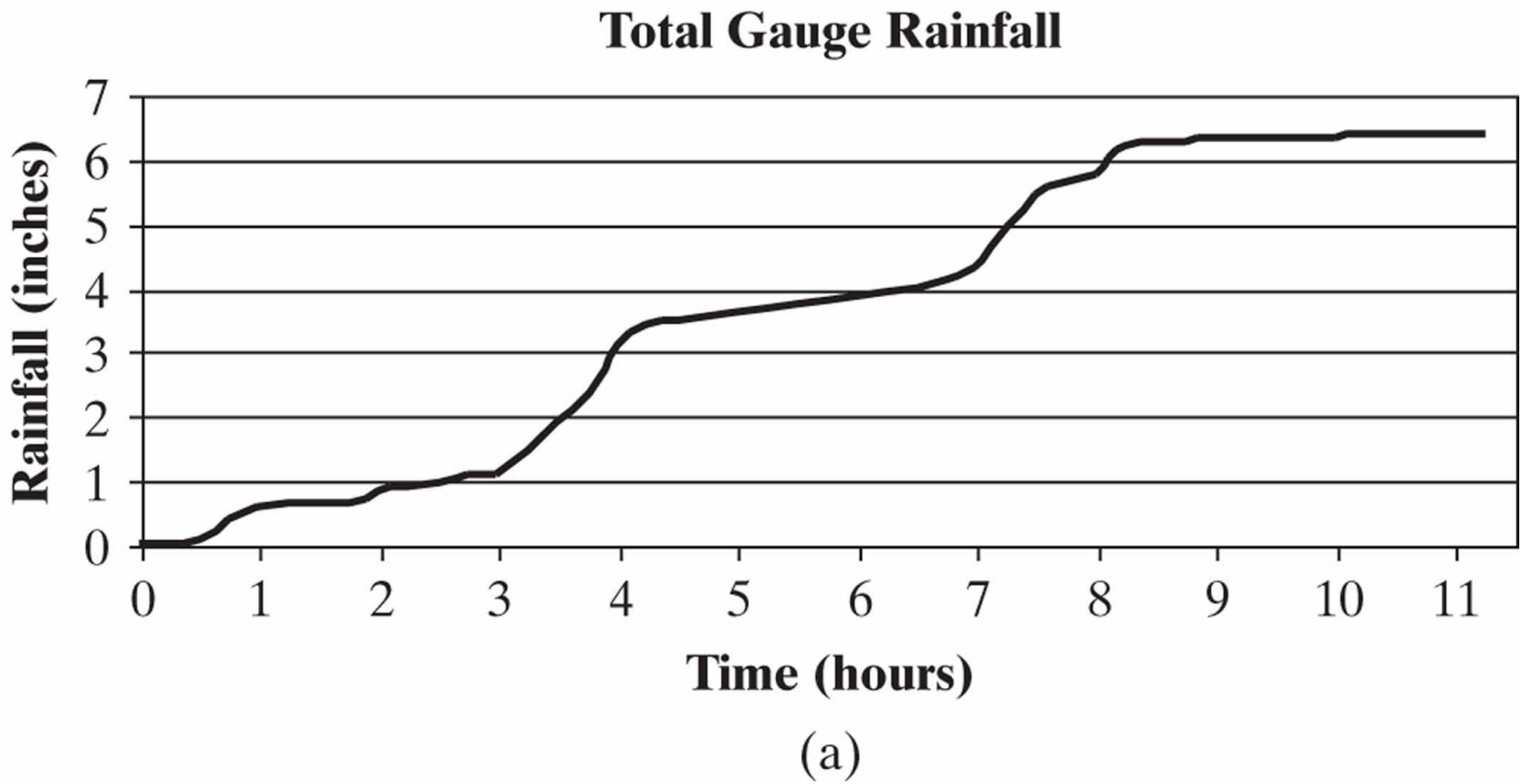

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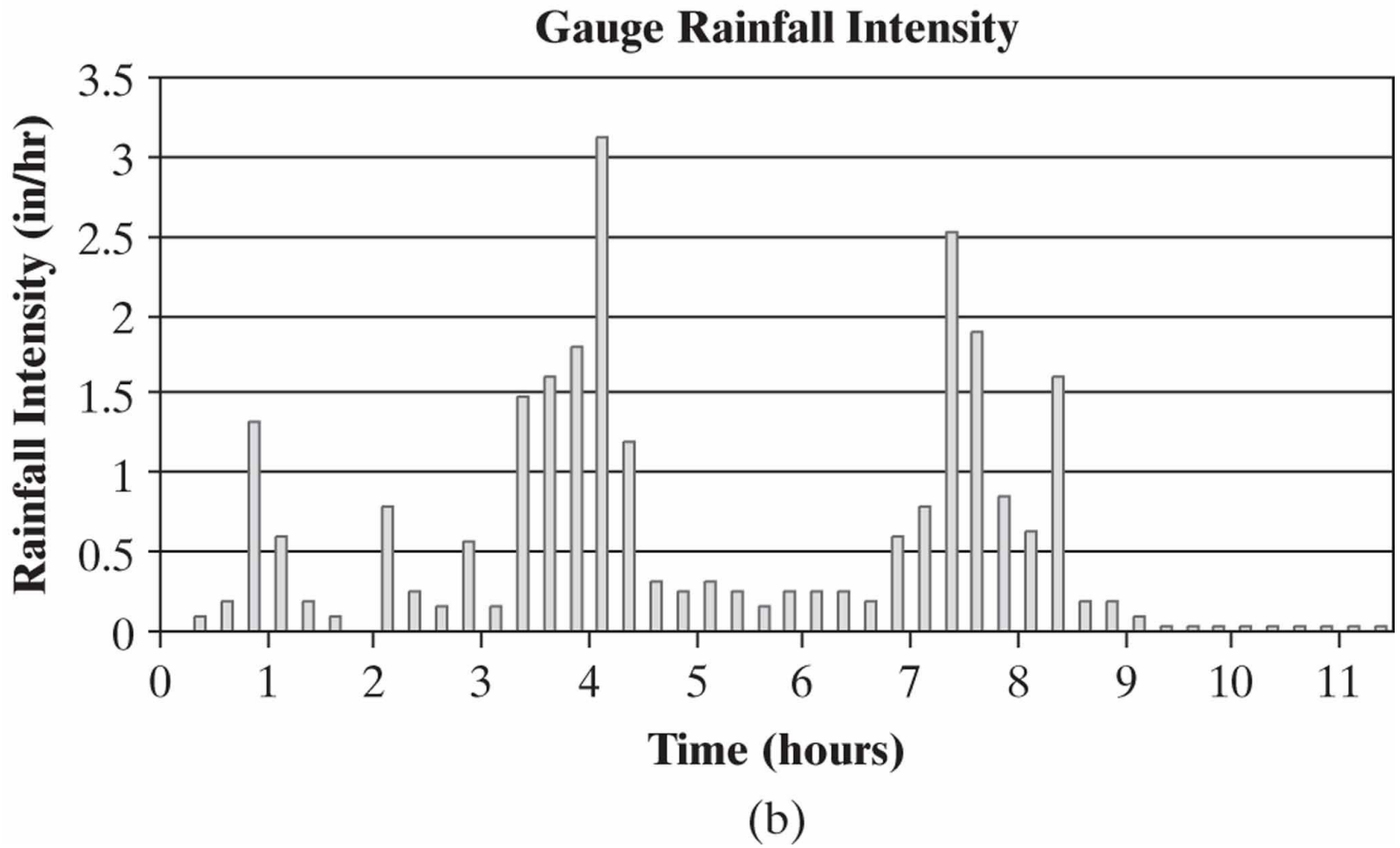

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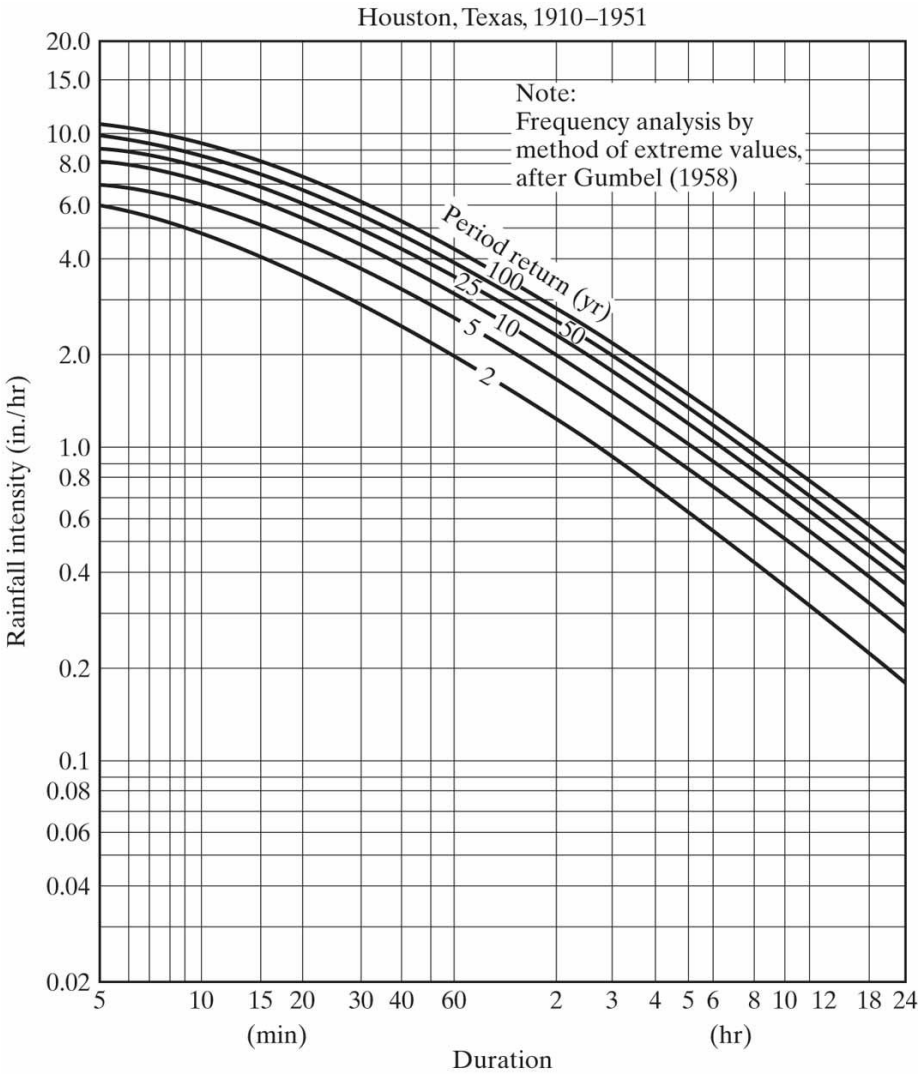

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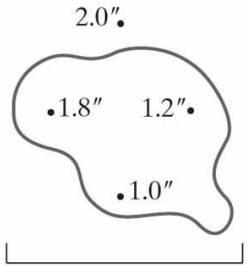
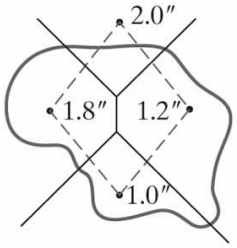


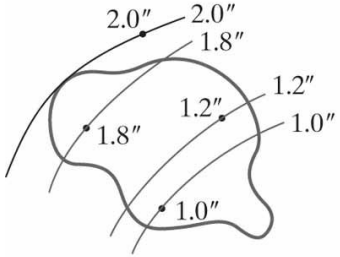
$$\frac{1.8 + 1.2 + 1.0}{3} = 1.33 \text{ in.}$$

(a) Arithmetic mean



P_i (in.)	A_i (mi^2)	A_i/A_r	$(P_i)(A_i/A_r)$ (in.)
2.0	1.5	0.064	0.13
1.8	7.2	0.305	0.55
1.2	5.1	0.216	0.26
1.0	9.8	0.415	0.42
Σ =	23.6	1.000	1.35 in.

(b) Thiessen polygon method



Isohyet (in.)	A (mi^2)	P_{av} (in.)	V (in.$-$mi^2)
2.0	5.1	1.9	9.69
1.8	9.8	1.5	14.7
1.2	3.1	1.1	3.41
1.0	5.6	0.5*	2.8
	23.6		30.6

Average rainfall = 30.6/23.6 = 1.30 in.

* Estimated

(c) Isohyetal method

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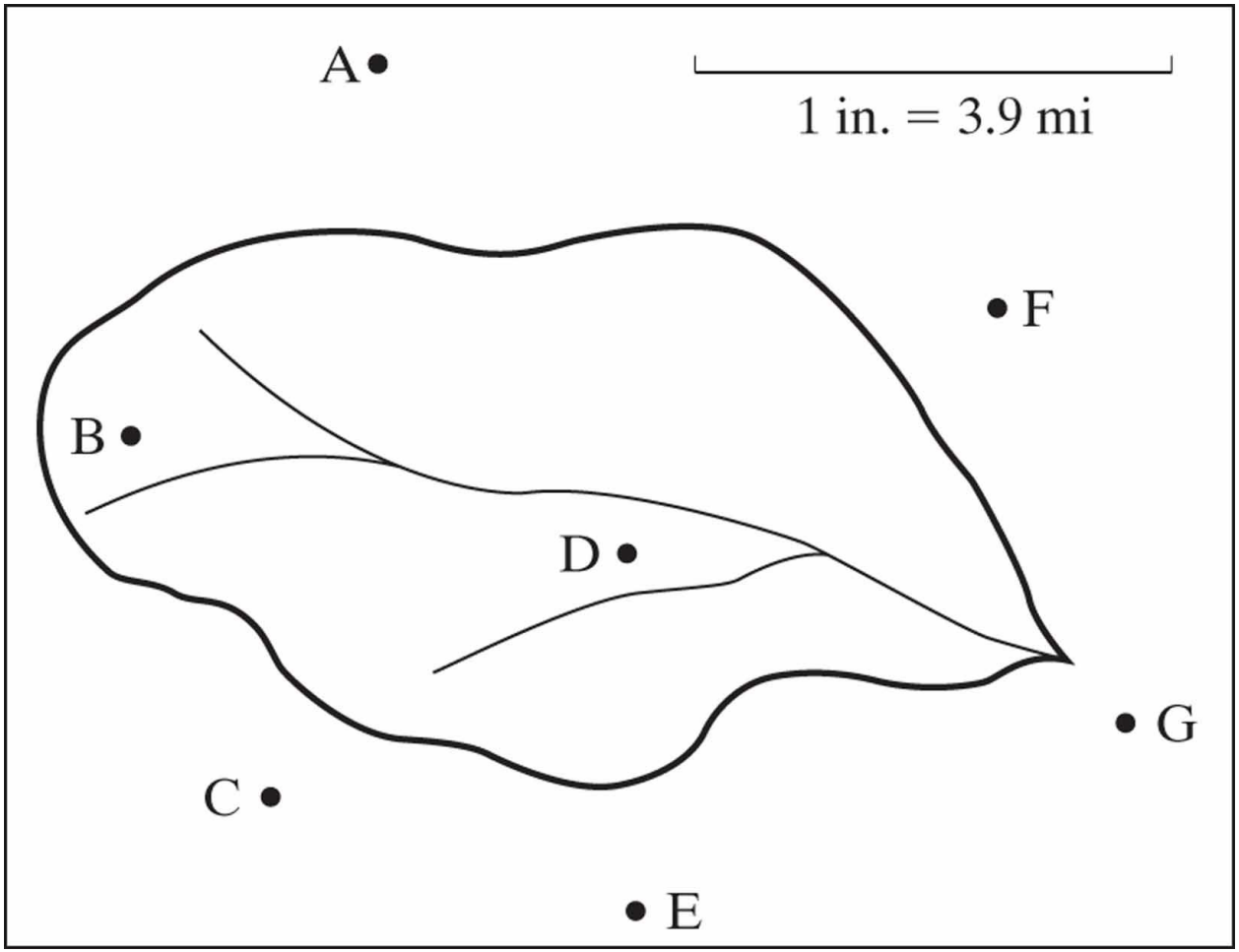

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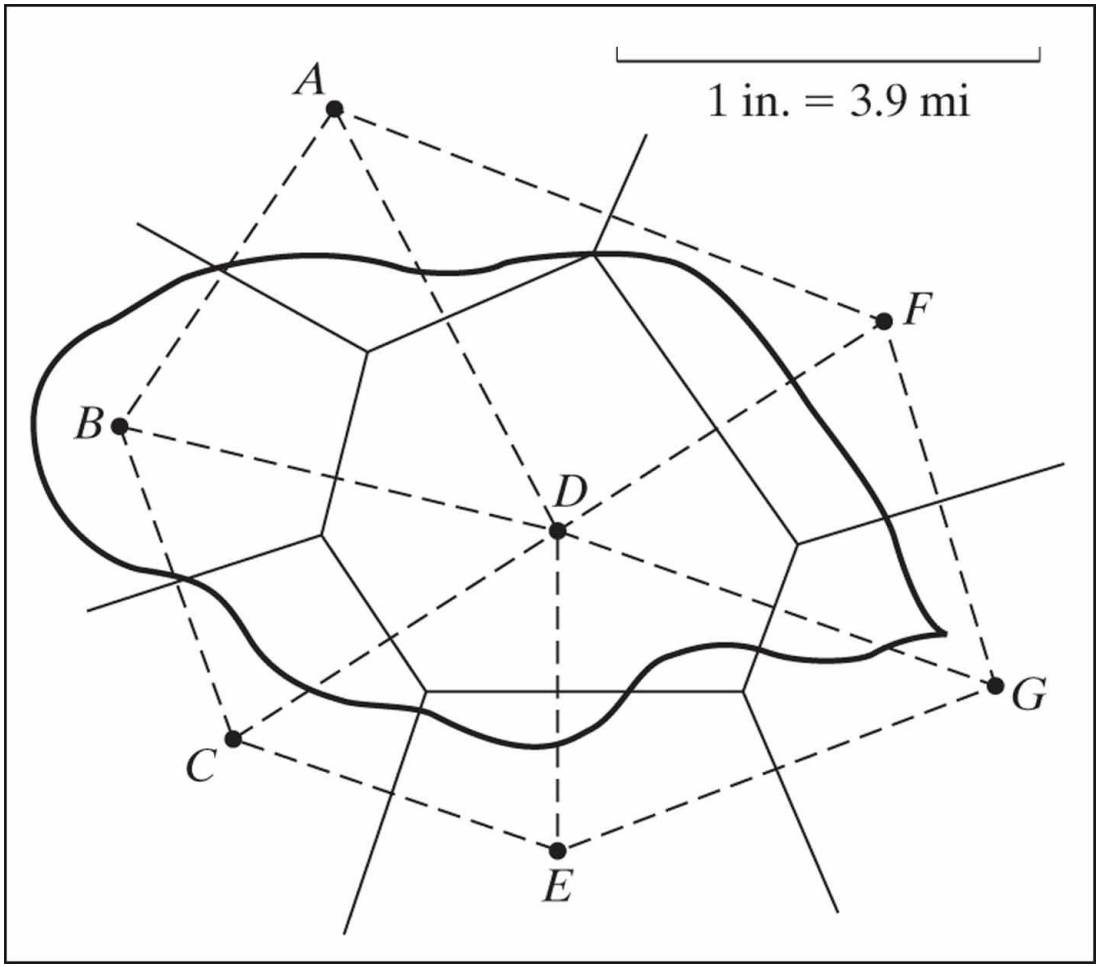

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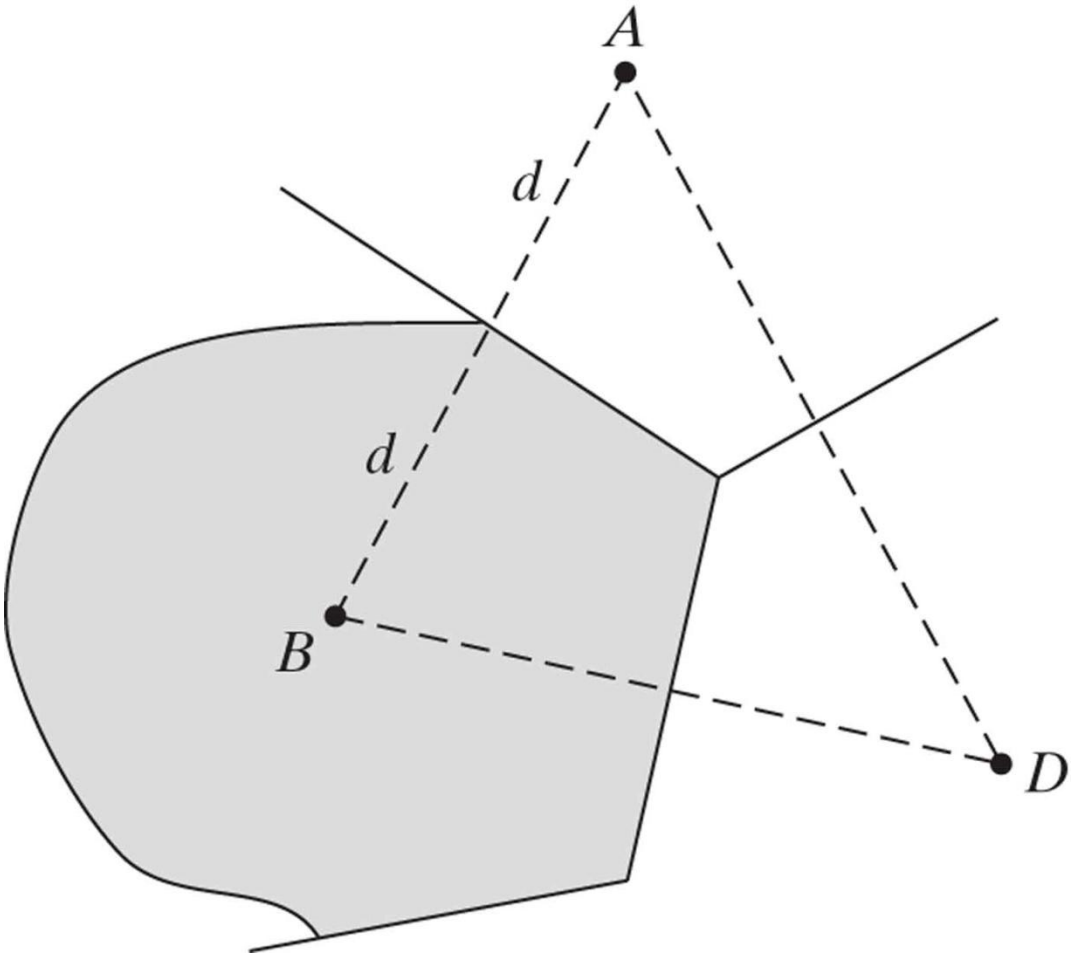

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Table E1–4.

Gage	P_i (in.)	A_i (mi^2)	A_i/A_τ	$(P_i)(A_i/A_\tau)$ (in.)
A	5.13	1.74	0.062	0.32
B	6.74	6.70	0.238	1.60
C	9.00	1.77	0.063	0.57
D	6.01	13.02	0.463	2.78
E	5.56	0.83	0.029	0.16
F	4.98	2.68	0.095	0.47
G	4.55	1.42	0.050	0.23
		28.16	1.000	6.13

Table E1-4

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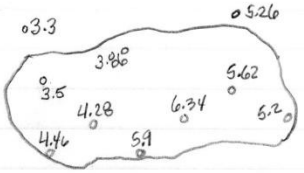
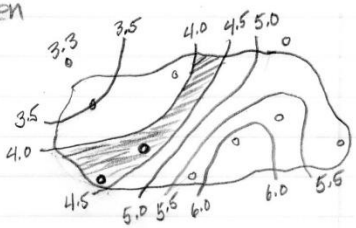
Isohyetal Method

1. Develop an isohyetal map that shows contours of equal precipitation. To do this interpolate between rainfall amounts





2. Calculate average precipitation $P_{avg\,i}$ between isohyets. $\frac{4+4.5}{2} = 4.25$

3. Determine the area between isohyets. Grids

4. Calculate weighted precipitation for each by multiplying the $P_{avg\,i}$ between isohyets by the area enclosed between isohyets.

5. The average precipitation is the sum of these products divided by the total area.

$$P_{avg} = \frac{\sum P_{avg(i)} \cdot A_i}{\sum A}$$

Isohyets	A_i (mi²)	$P_{avg(i)}$ (in)	$P_i \times A_i$
3.3			
3.5	19	3.45	66
4.0	106	3.75	398
4.5	102	4.25	434
5.0	60	4.75	285
5.5	150	5.25	788
6.0	84	5.75	483
6.5	47	6.20	291
Total	568		2745

esimated based on 3.3 at gage outside

estimate

$$P = \frac{2745}{568} = 4.83 \text{ in}$$

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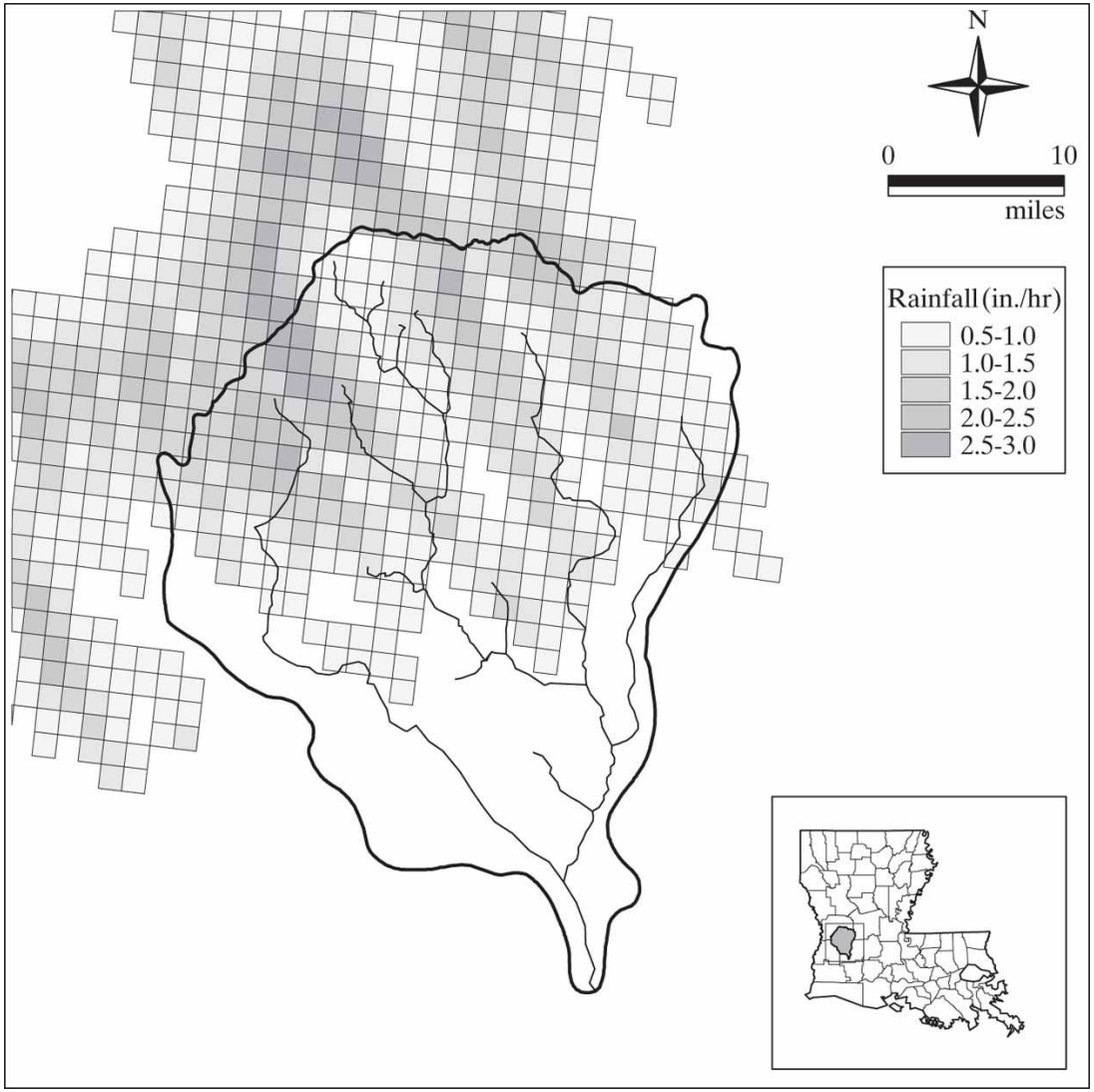

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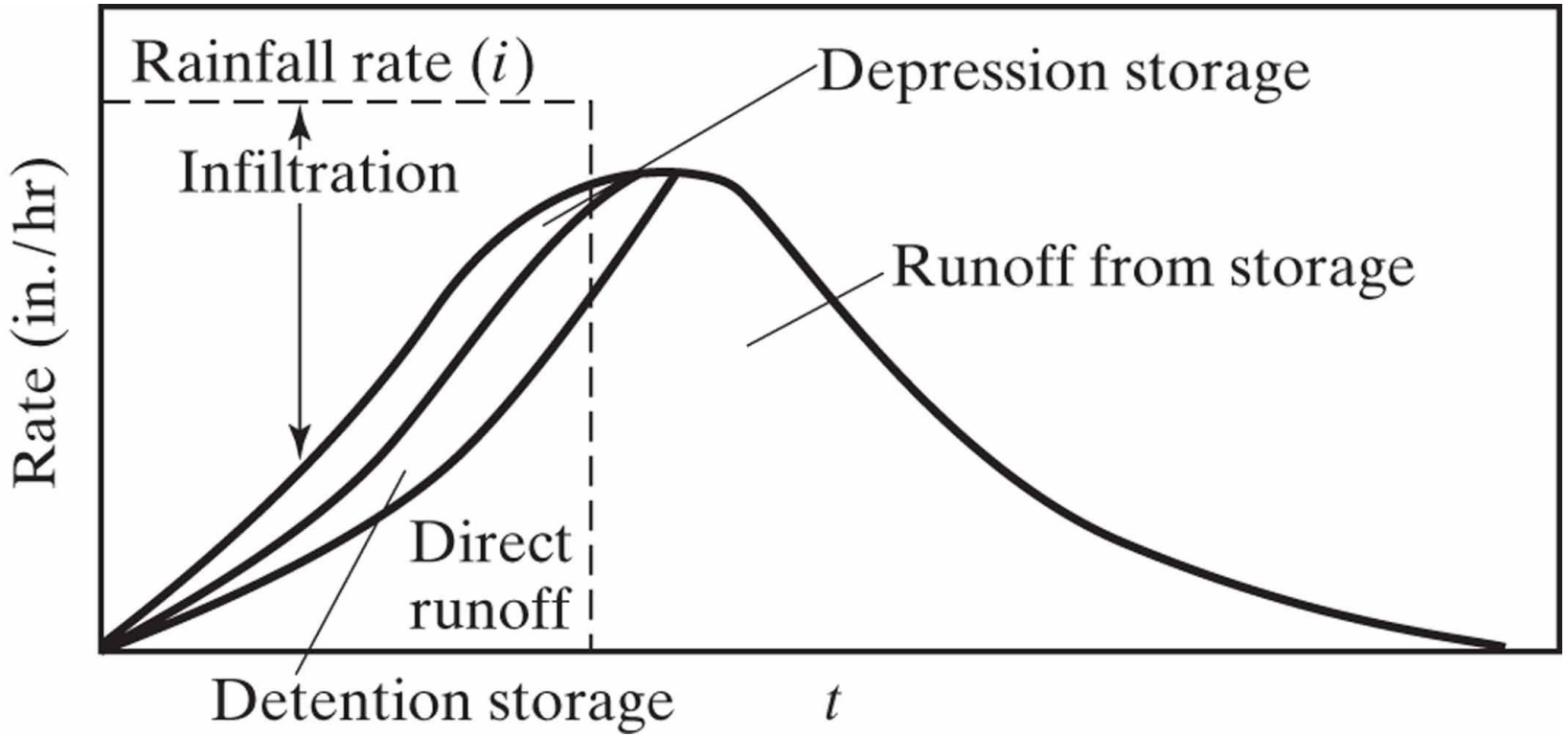

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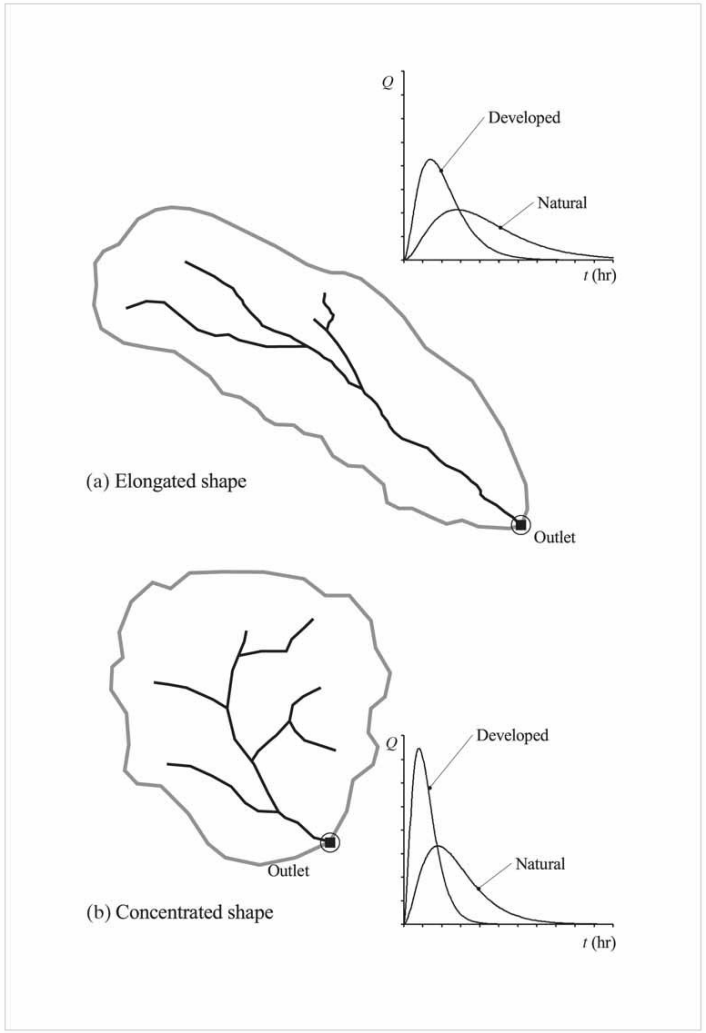

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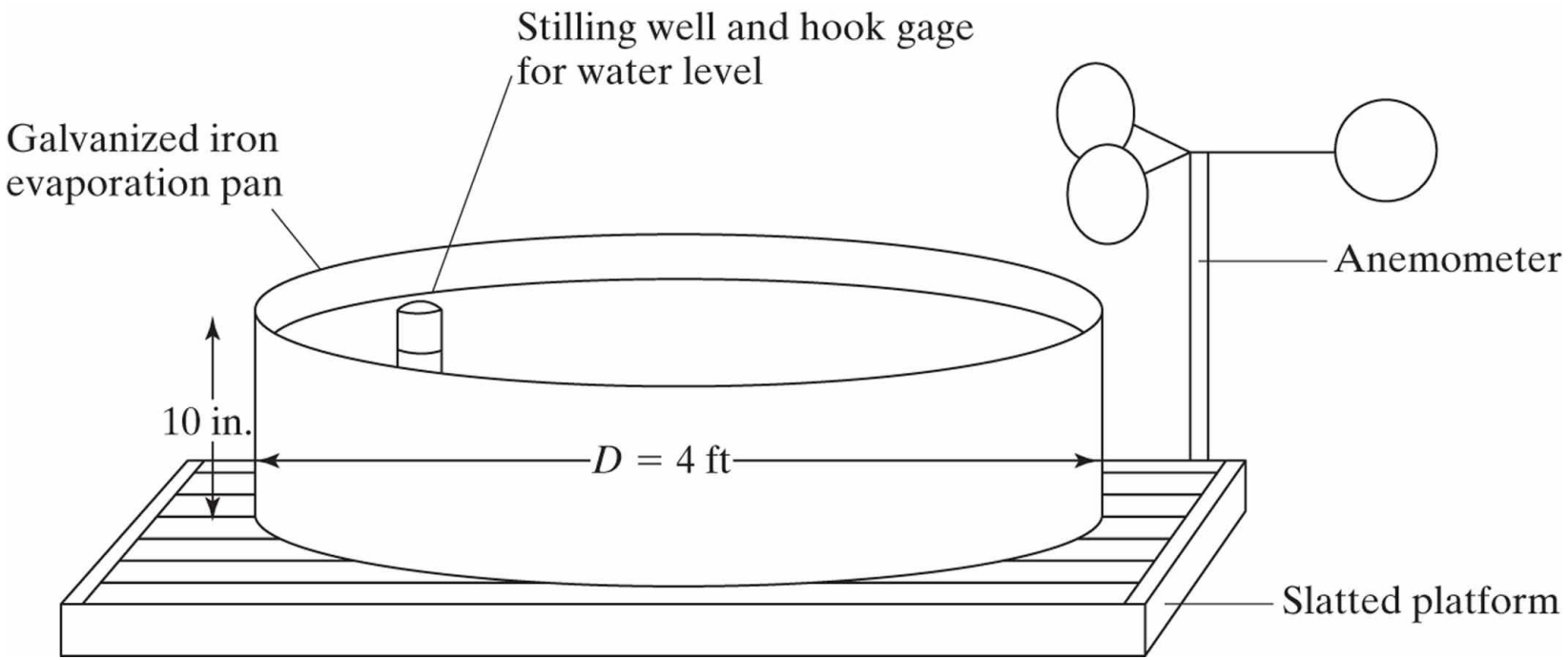

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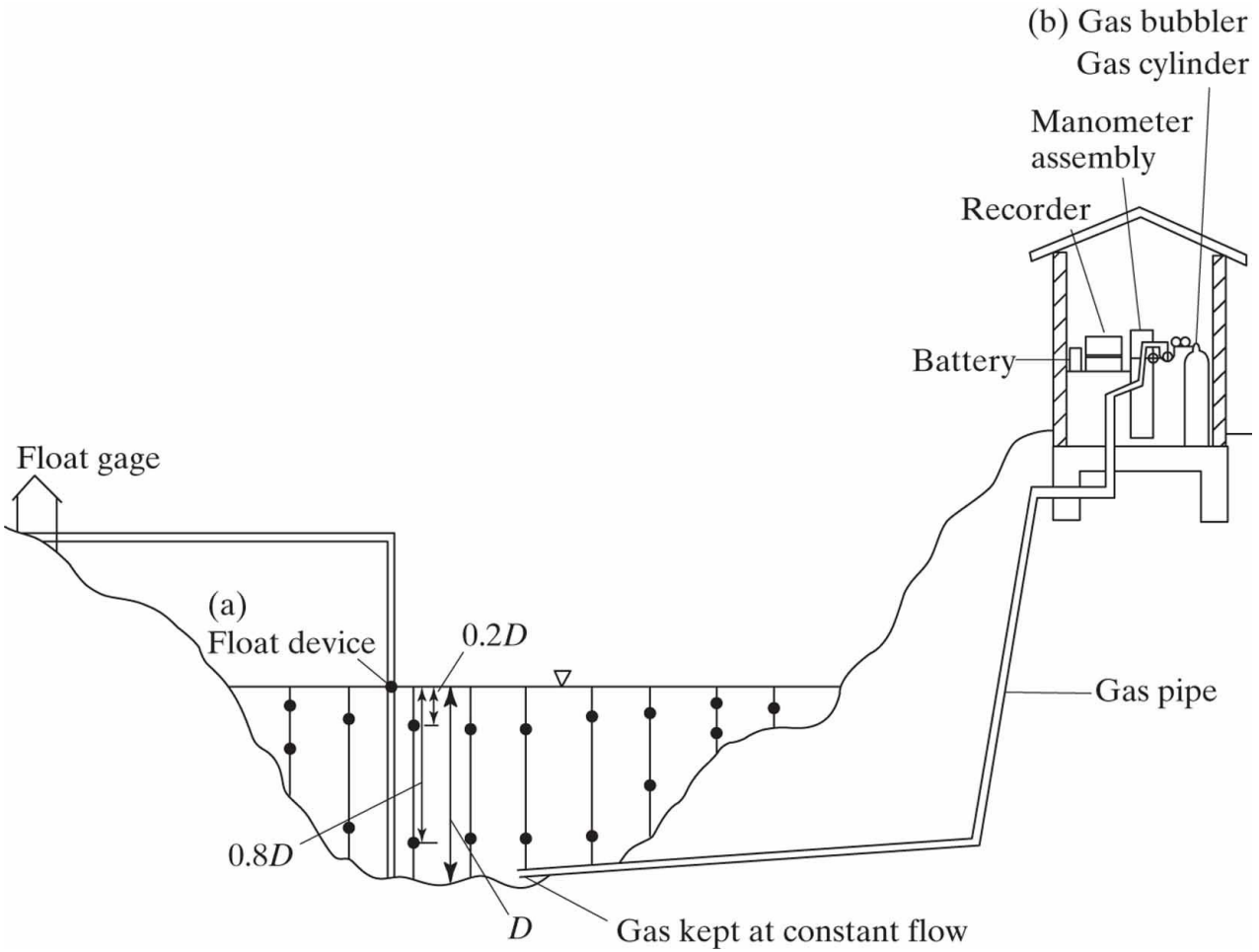

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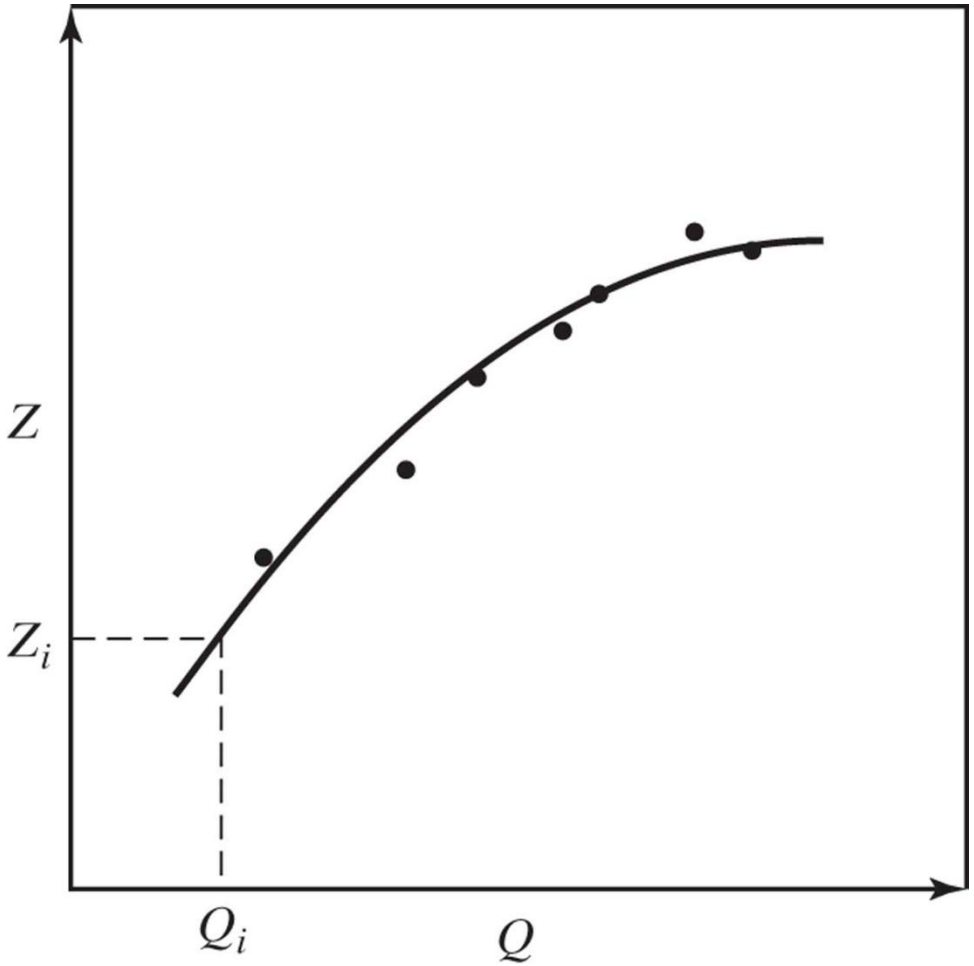

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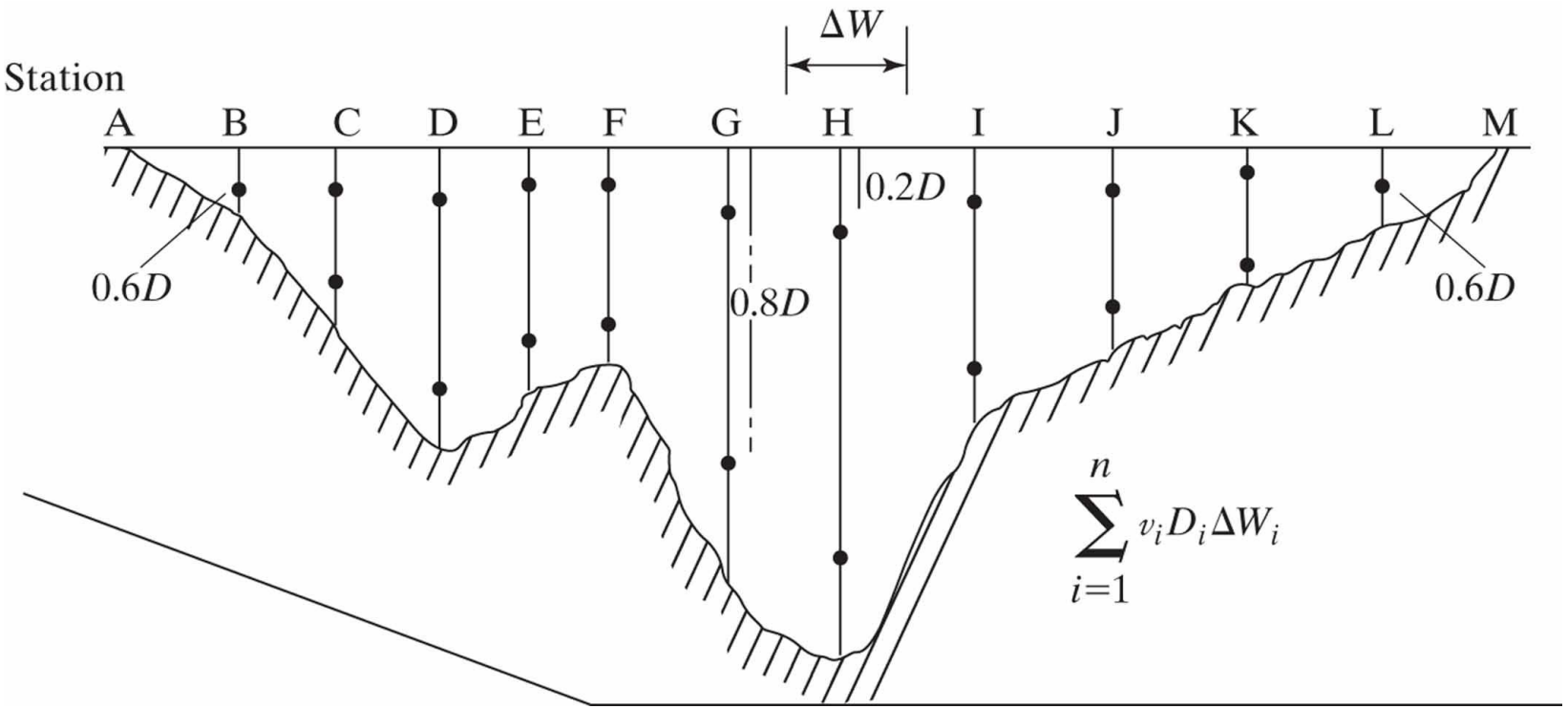

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Table E1–5.

Measurement Station	Distance Across Stream (ft)	Width ΔW (ft)	Depth D (ft)	Mean Velocity v (ft/sec)	Area $\Delta W \cdot D$ (ft^2)	Discharge (cfs)
A	0	7	0	0	0	0
B	14	13	1.1	0.43	14.3	6.15
C	26	12	2.6	0.61	31.2	19.03
D	38	11.5	3.5	1.54	40.25	61.99
E	49	11.5	3.2	1.21	36.8	44.53
F	61	14.5	3.1	1.13	44.95	50.79
G	78	17	3.9	1.52	66.3	100.78
H	95	18	4.2	2.34	75.6	176.90
I	114	19	3.3	1.42	62.7	89.03
J	133	19	2.9	1.34	55.1	73.83
K	152	19	2.1	1.23	39.9	49.08
L	171	19	1.4	0.53	26.6	14.10
M	190	9.5	0	0	0	0
	Sum = 190 ft				493.7 ft^2	686 cfs
	Average velocity = 1.4 ft/s					
	Total discharge = 686 cfs					

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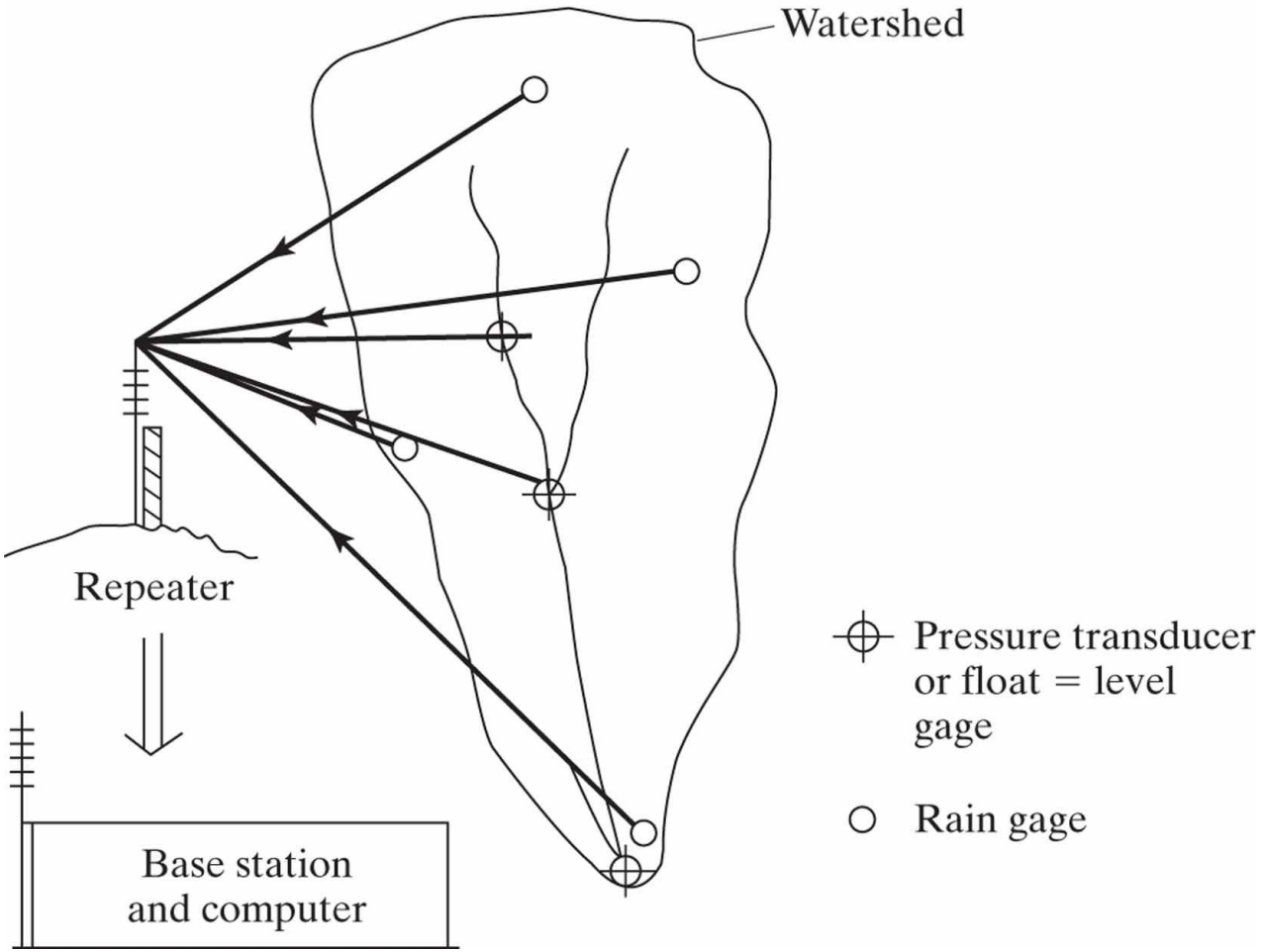

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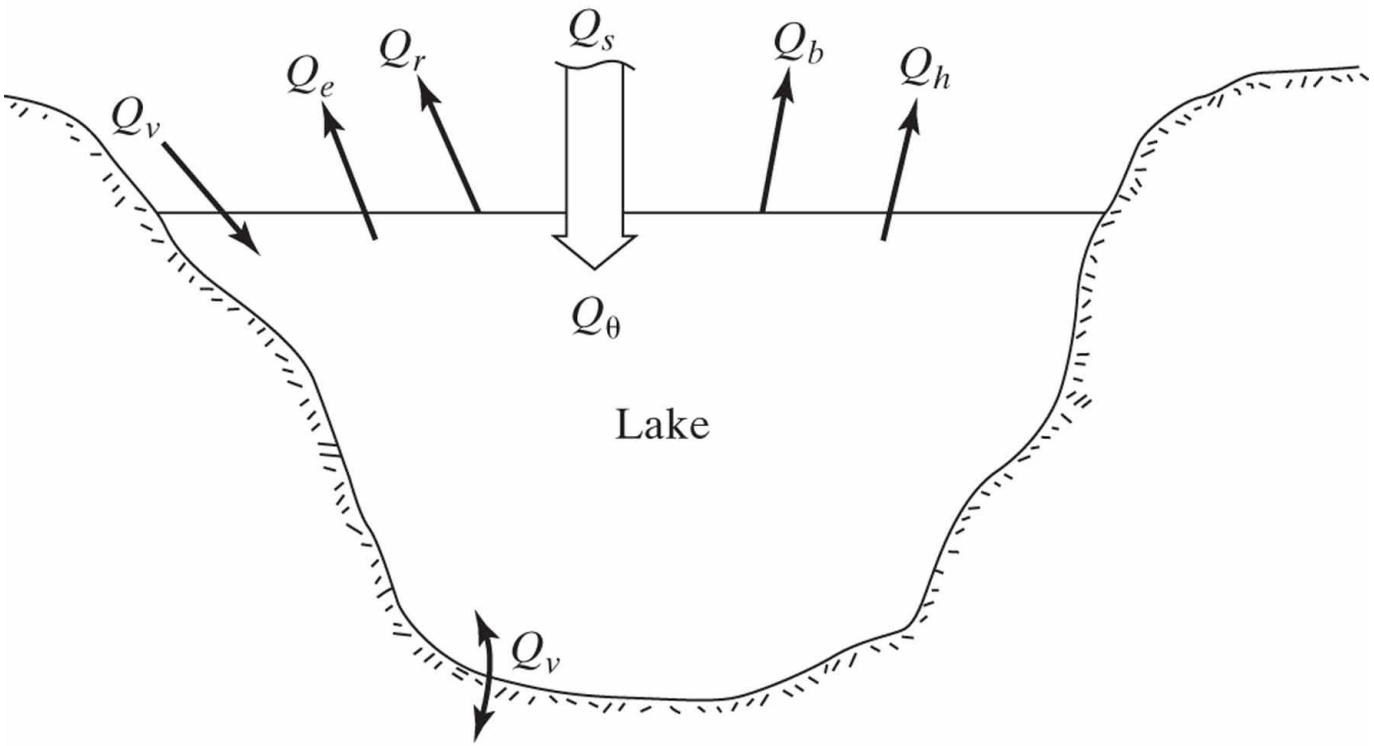

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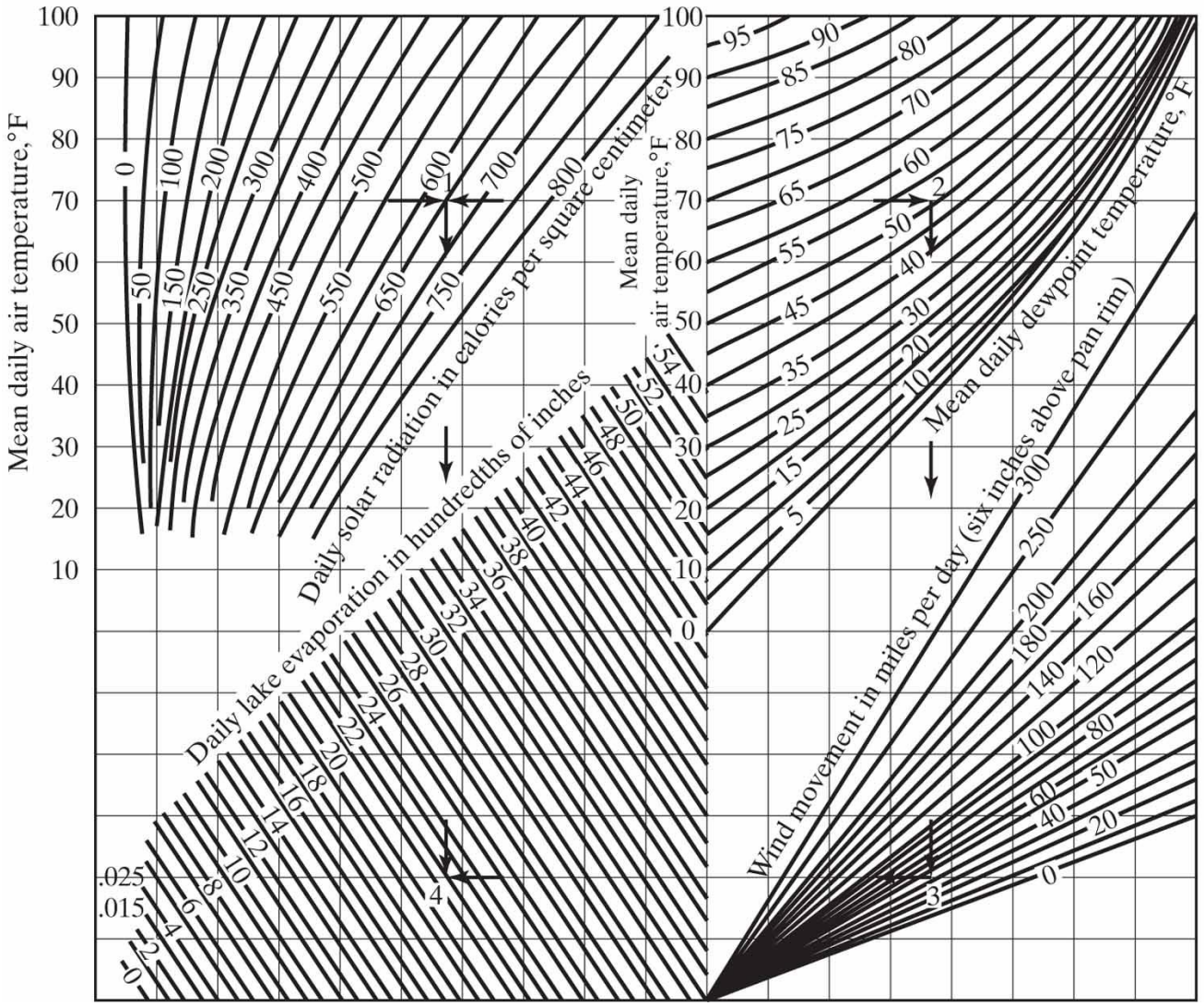

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Table 1–5. Pan Coefficients for Evapotranspiration Estimates

Type of Cover	Pan Coefficient	Reference
St. Augustine grass	0.77	Weaver and Stephens (1963)
Bell peppers	0.85–1.04	
Grass and clover	0.80	Brutsaert (1982, p. 253)
Oak–pine flatwoods (east Texas)	1.20	Englund (1977)
Well-watered grass turf		Shih et al. (1983)
Light wind, high relative humidity	0.85	
Strong wind, low relative humidity	0.35	
Everglades agricultural areas	0.65	
Irrigated grass pasture (central California)	0.76	Hargreaves and Samani (1982)

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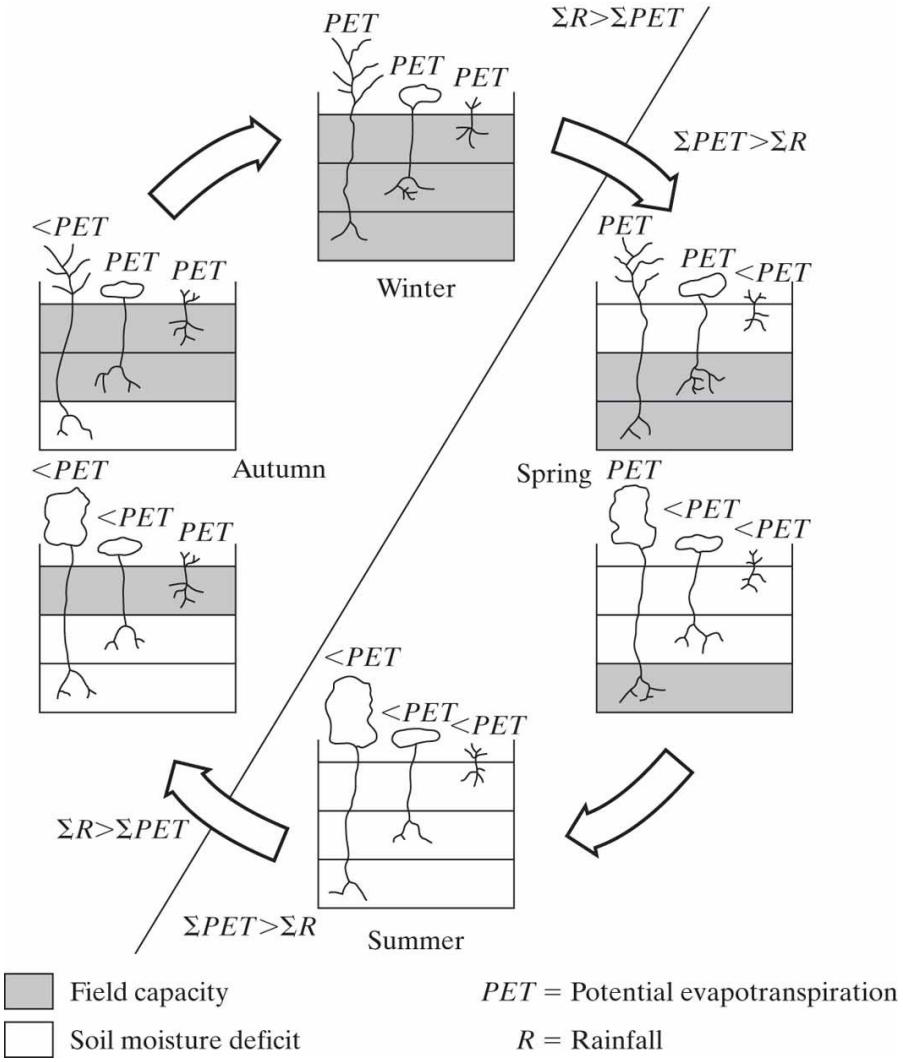

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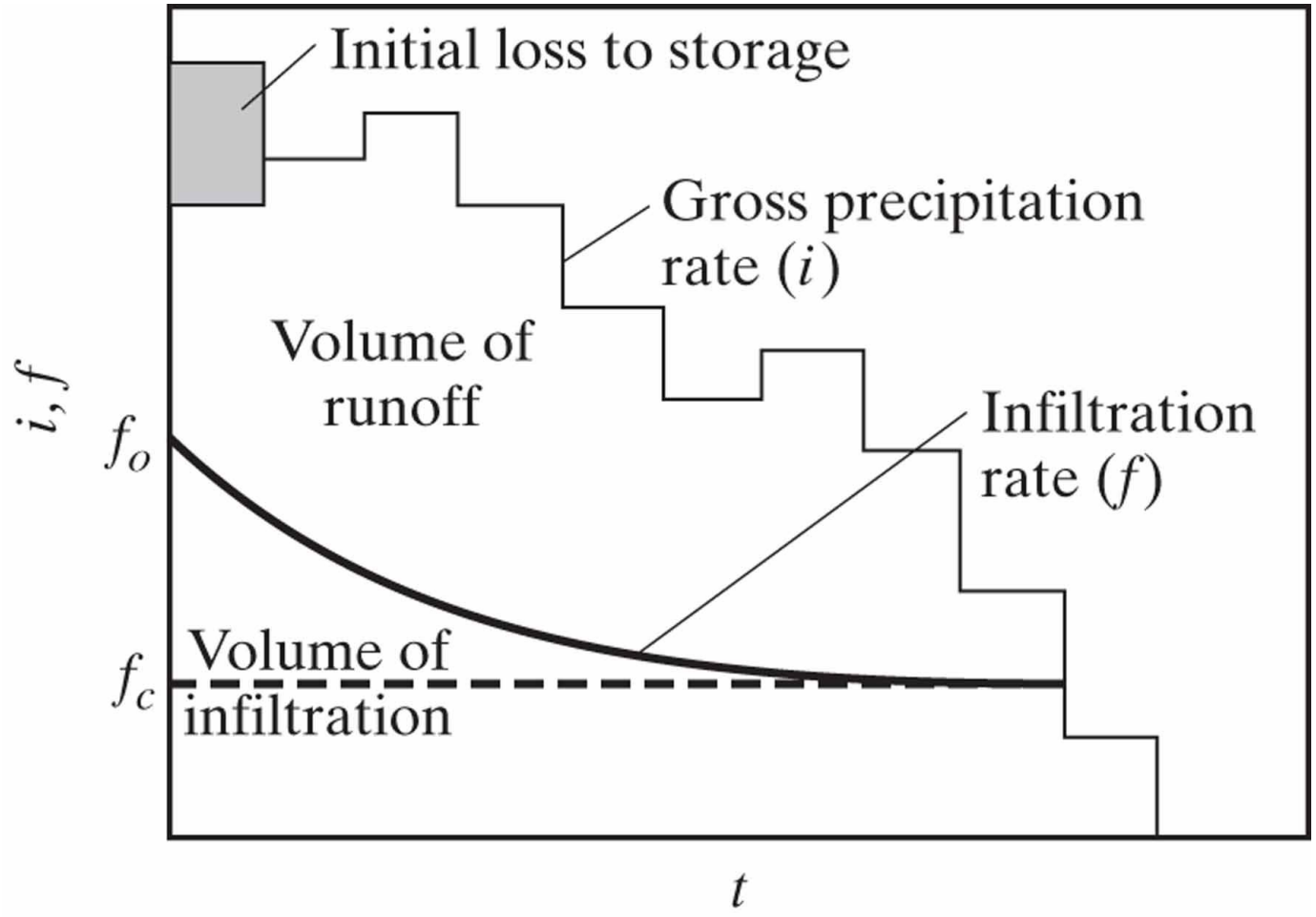

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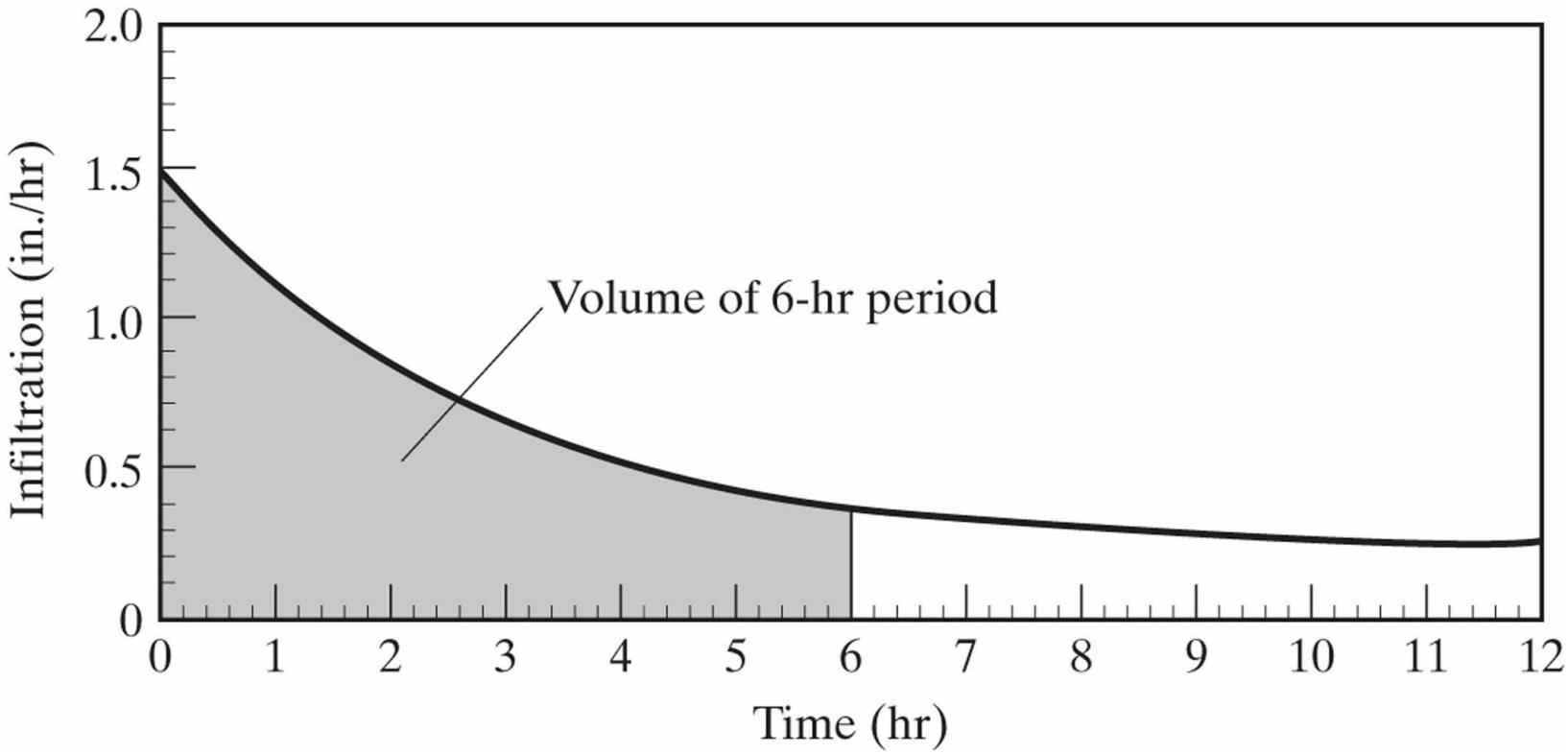

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Table 1–6. Typical Values of the Parameters of f_0, f_c, and k of the Horton Model

Soil Type	f_c (in./hr)	f_0 (in./hr)	k (hr^{-1})
Alphalpha loamy sand	1.40	19.00	38.29
Carnegie sandy loam	1.77	14.77	19.64
Dothan loamy sand	2.63	3.47	1.40
Fuquay pebbly loamy sand	2.42	6.24	4.70
Leefield loamy sand	1.73	11.34	7.70
Tooup sand	1.80	23.01	32.71

After Rawls et al., 1976.

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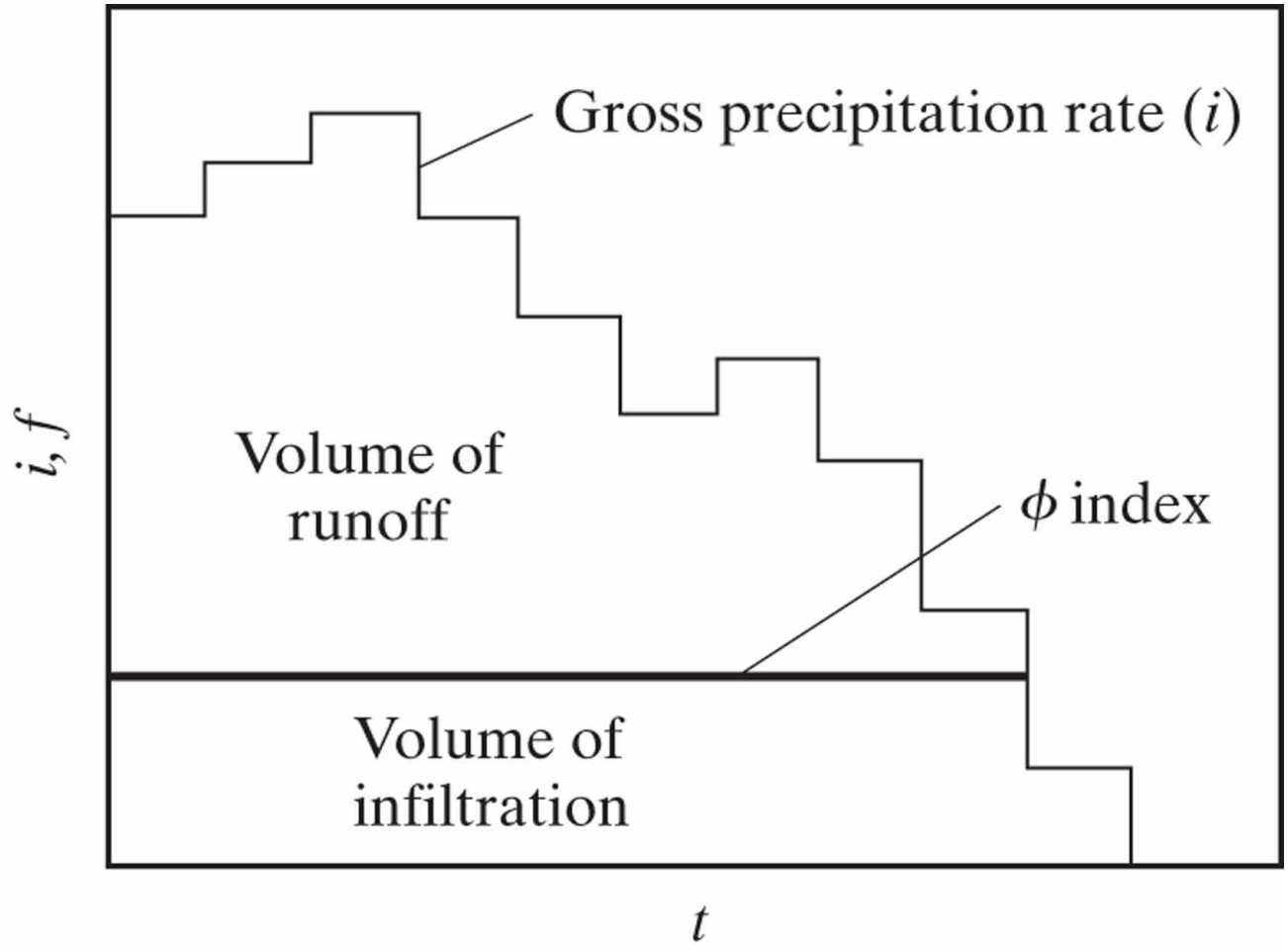

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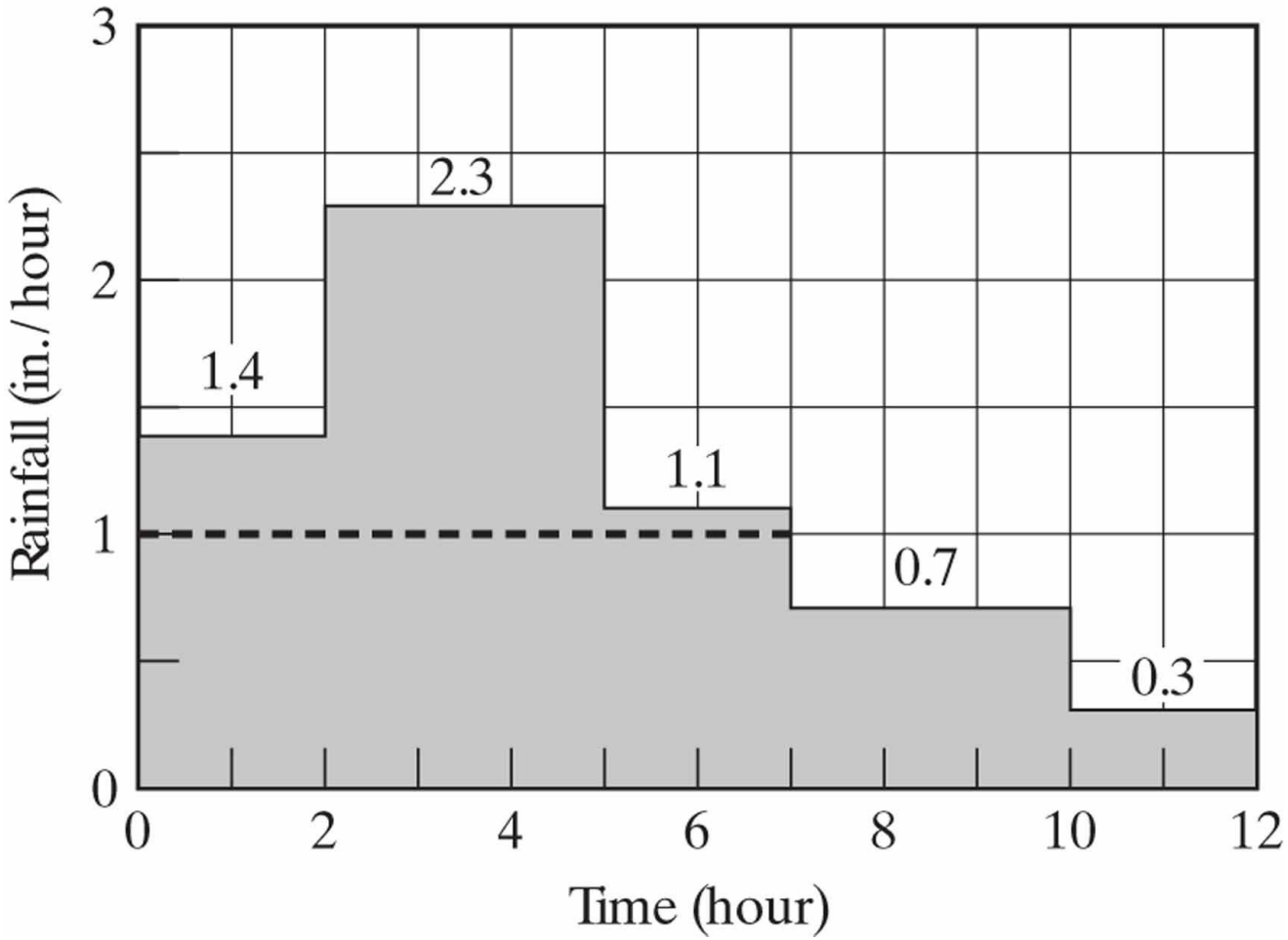

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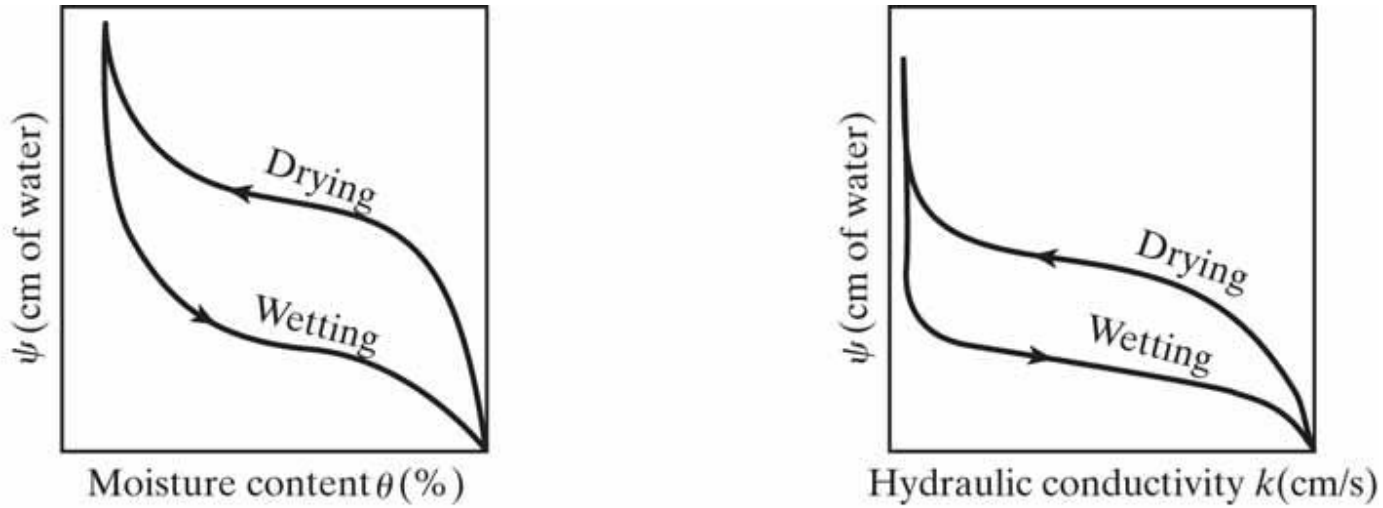

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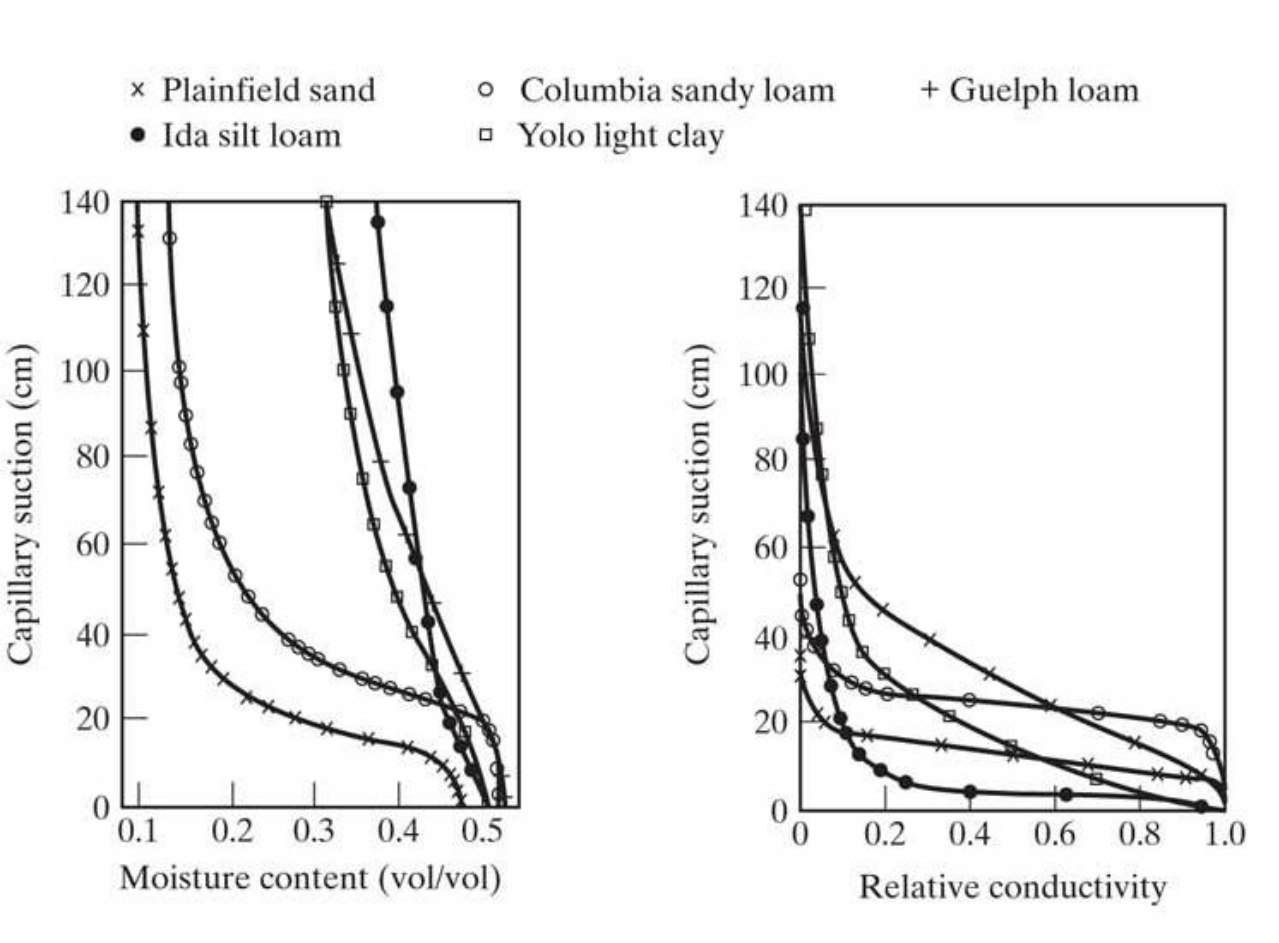

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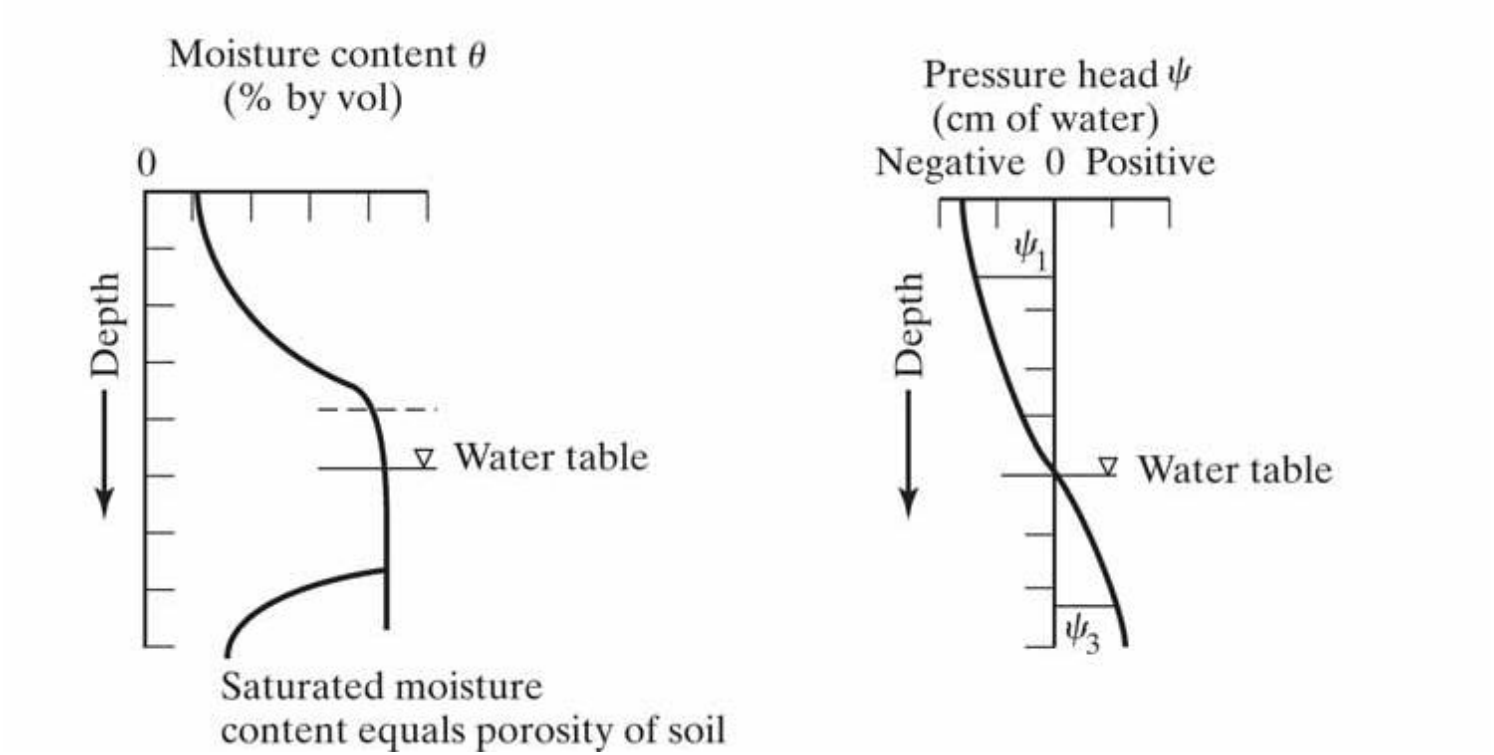

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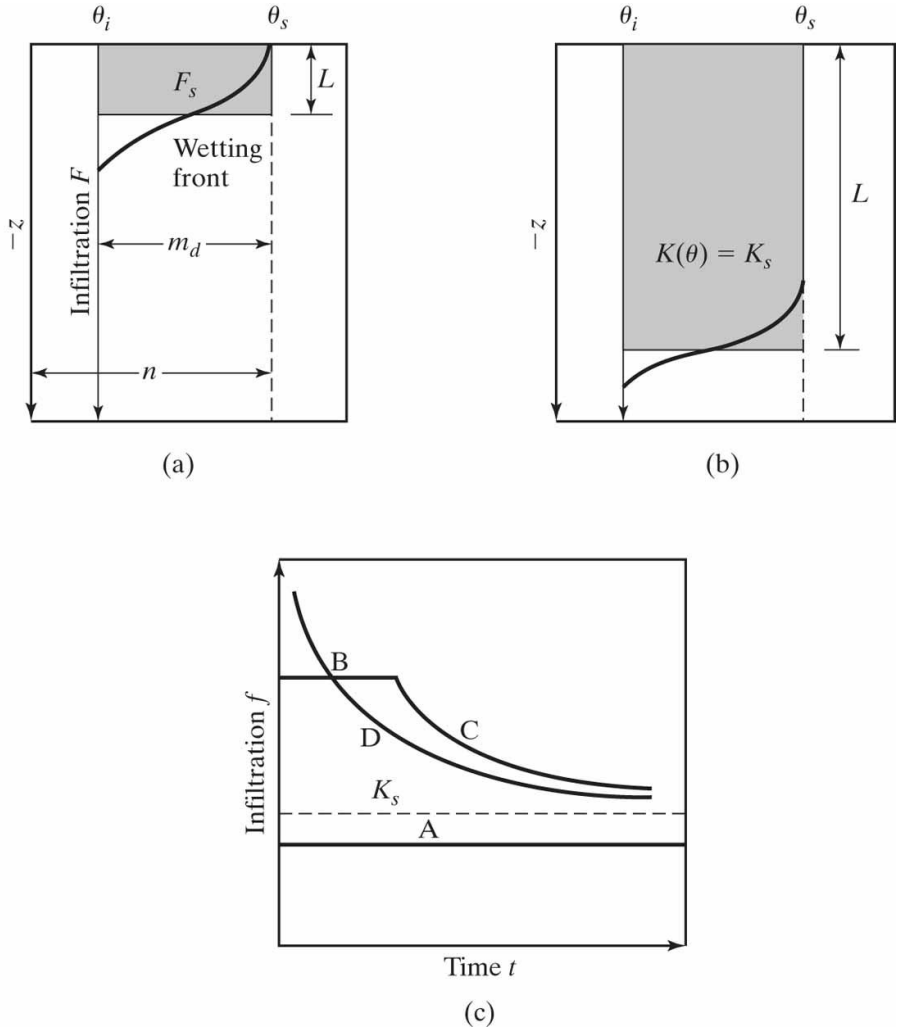

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Table 1–7. Green–Ampt Infiltration Parameters for Various Soil Texture Classes

Soil Class	Porosity η	Effective Porosity θ_e	Wetting Front Suction Head ψ (-cm)	Hydraulic Conductivity K (cm/hr)
Sand	0.437	0.417	4.95	11.78
	0.374–0.500	0.354–0.480	0.97–25.36	
Loamy sand	0.437	0.401	6.13	2.99
	0.363–0.506	0.329–0.473	1.35–27.94	
Sandy loam	0.453	0.412	11.01	1.09
	0.351–0.555	0.283–0.541	2.67–45.47	
Loam	0.463	0.434	8.89	0.34
	0.375–0.551	0.334–0.534	1.33–59.38	
Silt loam	0.501	0.486	16.68	0.65
	0.420–0.582	0.394–0.578	2.92–95.39	
Sandy clay loam	0.398	0.330	21.85	0.15
	0.332–0.464	0.235–0.425	4.42–108.0	
Clay loam	0.464	0.309	20.88	0.10
	0.409–0.519	0.279–0.501	4.79–91.10	
Silty clay loam	0.471	0.432	27.30	0.10
	0.418–0.524	0.347–0.517	5.67–131.50	
Sandy clay	0.430	0.321	23.90	0.06
	0.370–0.490	0.207–0.435	4.08–140.2	
Silty clay	0.479	0.423	29.22	0.05
	0.425–0.533	0.334–0.512	6.13–139.4	
Clay	0.475	0.385	31.63	0.03
	0.427–0.523	0.269–0.501	6.39–156.5	

Source: Rawls, Brakensiek, and Miller, 1983.

Table 1-7

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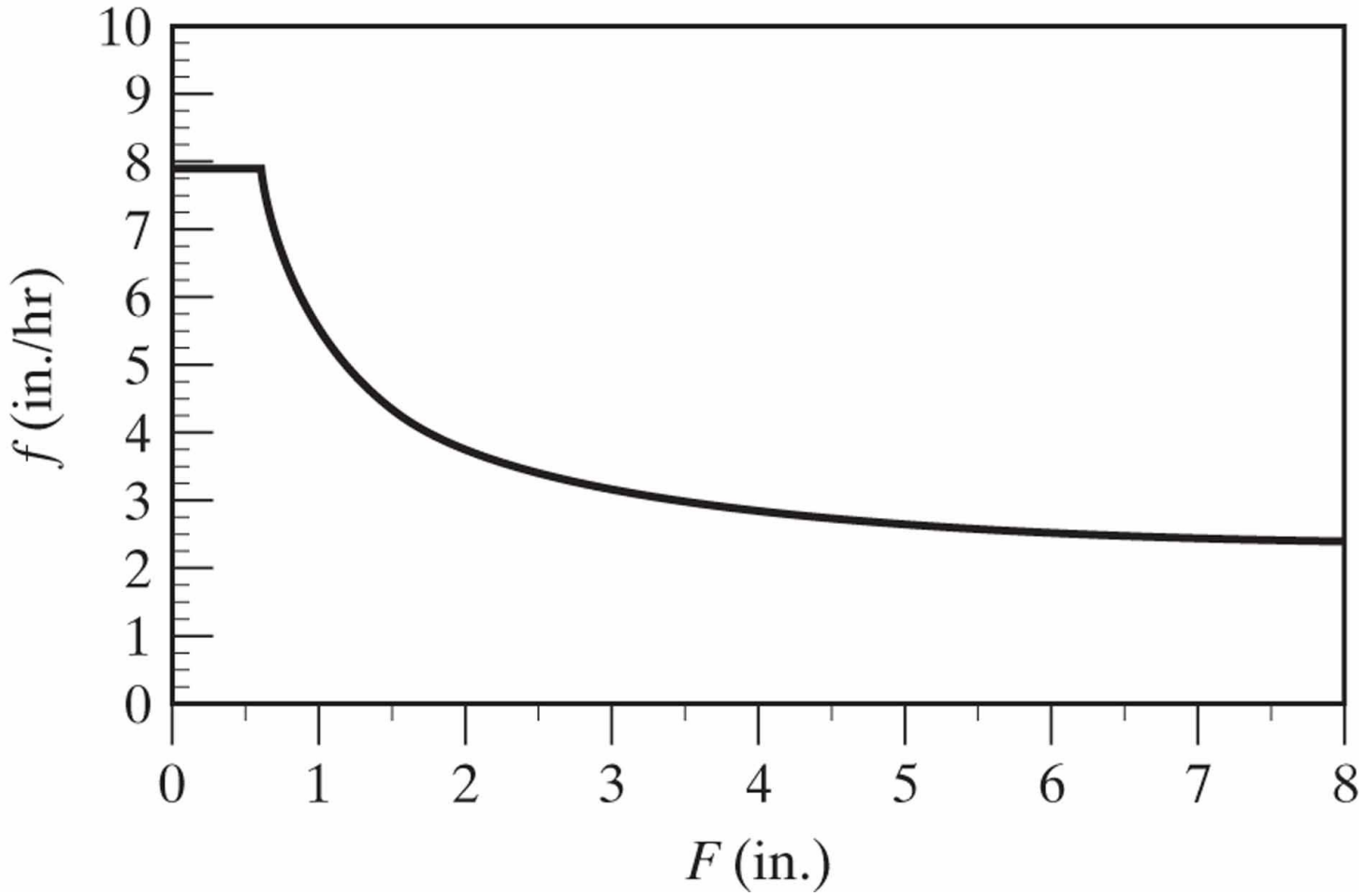

Figure E1-10

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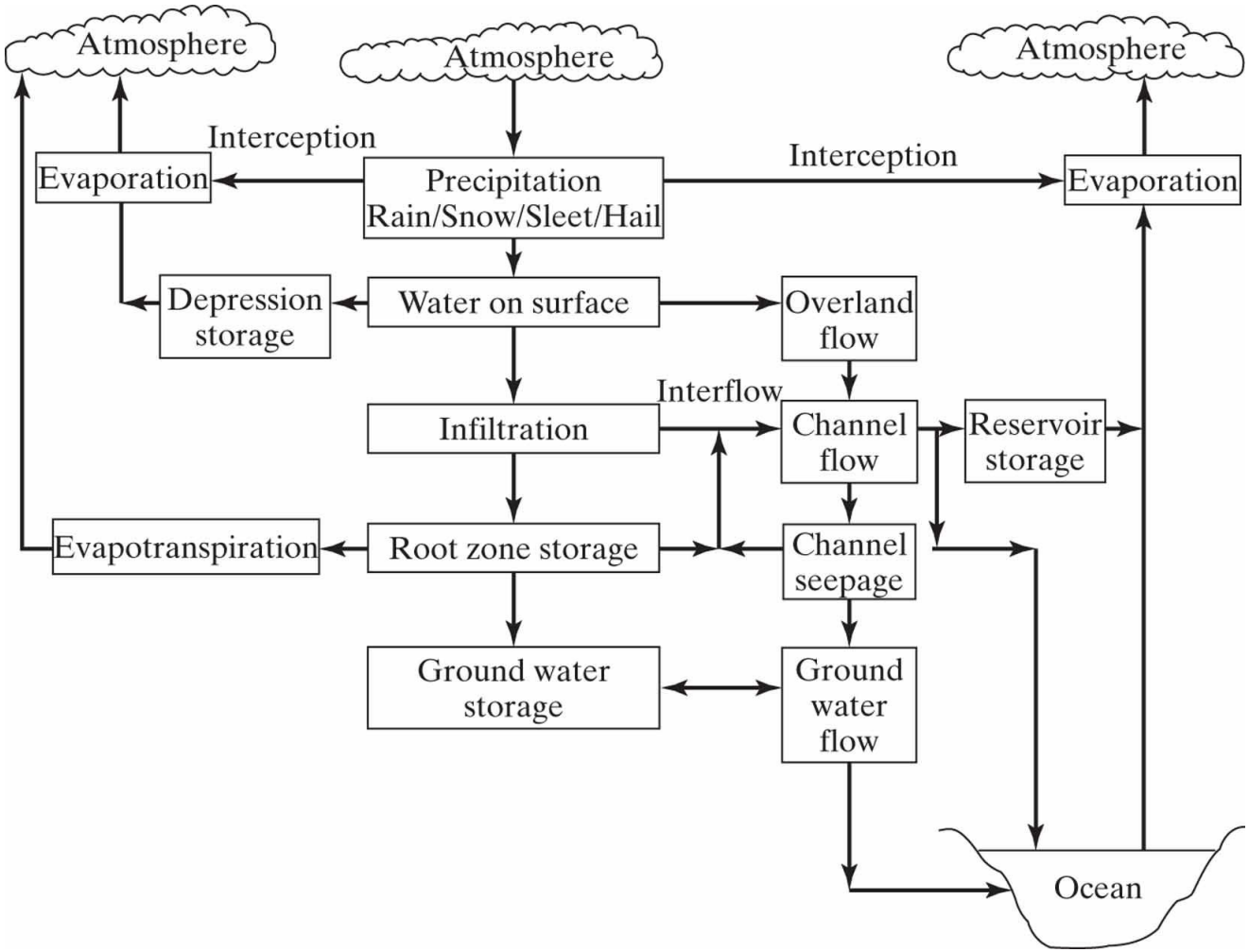

Figure 1-25

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Table P1–3.

Date and Time (5-min intervals)	Accumulated Rainfall (in.)	Discharge (cfs)
Sept. 1, 1999		
1605	0.0	0.0
1610	0.0	0.0
1615	0.10	0.0
1620	0.40	0.5
1625	0.60	5.0
1630	1.10	22.0
1635	1.40	60.0
1640	1.60	90.0
1645	1.80	102.0
1650	1.90	111.0
1655	2.00	119.0
1700	2.20	124.0
1705	2.30	130.0
1710	2.40	134.0
1715	2.50	137.0
1720	2.50	138.0
1725	2.60	137.0
1730	2.60	135.0

Table P1-3

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Table P1–3. (*Continued*)

Date and Time (5-min intervals)	Accumulated Rainfall (in.)	Discharge (cfs)
1740	RAIN ENDS	128.0
1800		111.0
1830		79.0
1900		46.0
1930		24.0
2000		11.0
2030		5.9
2100		3.5
2130		2.0
2200		1.2
2230		0.7
2300		0.4
2400		0.2

Table P1-3 (continued)

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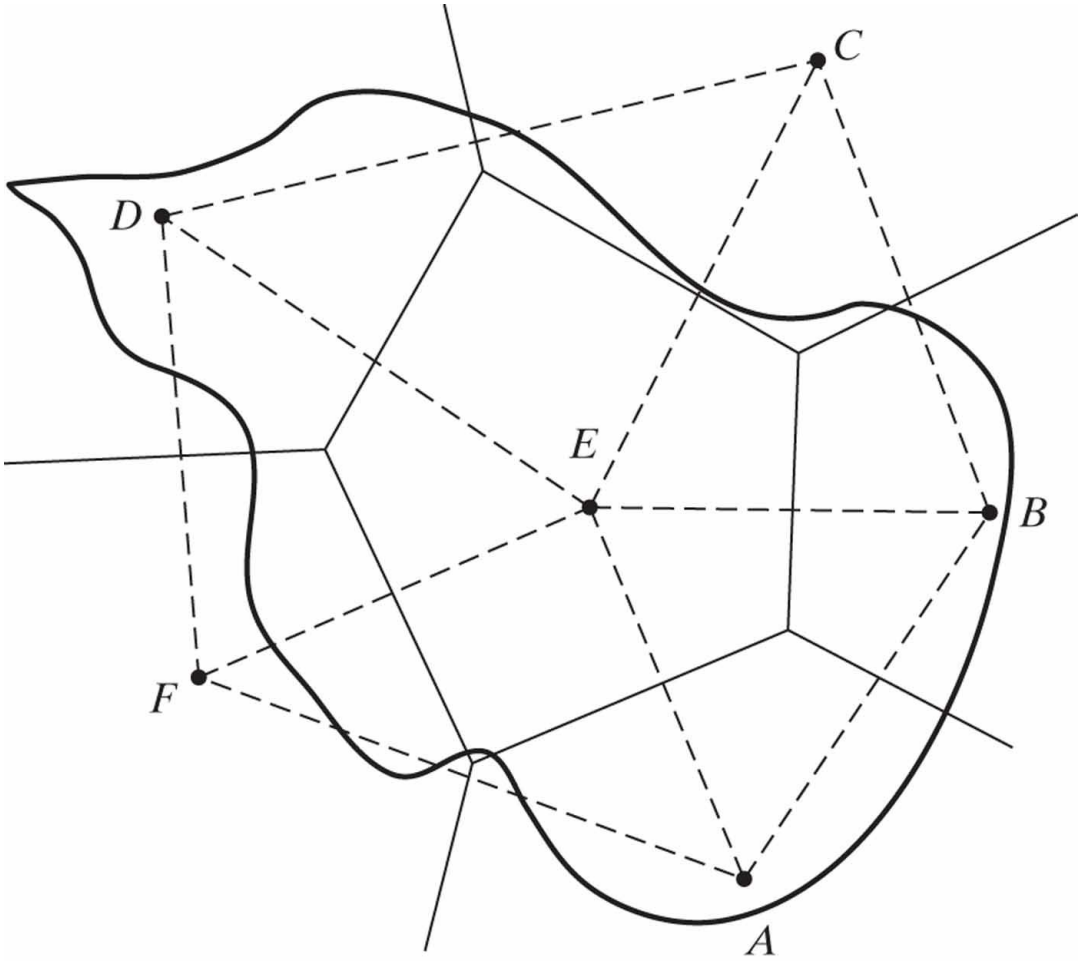

Figure P1-4

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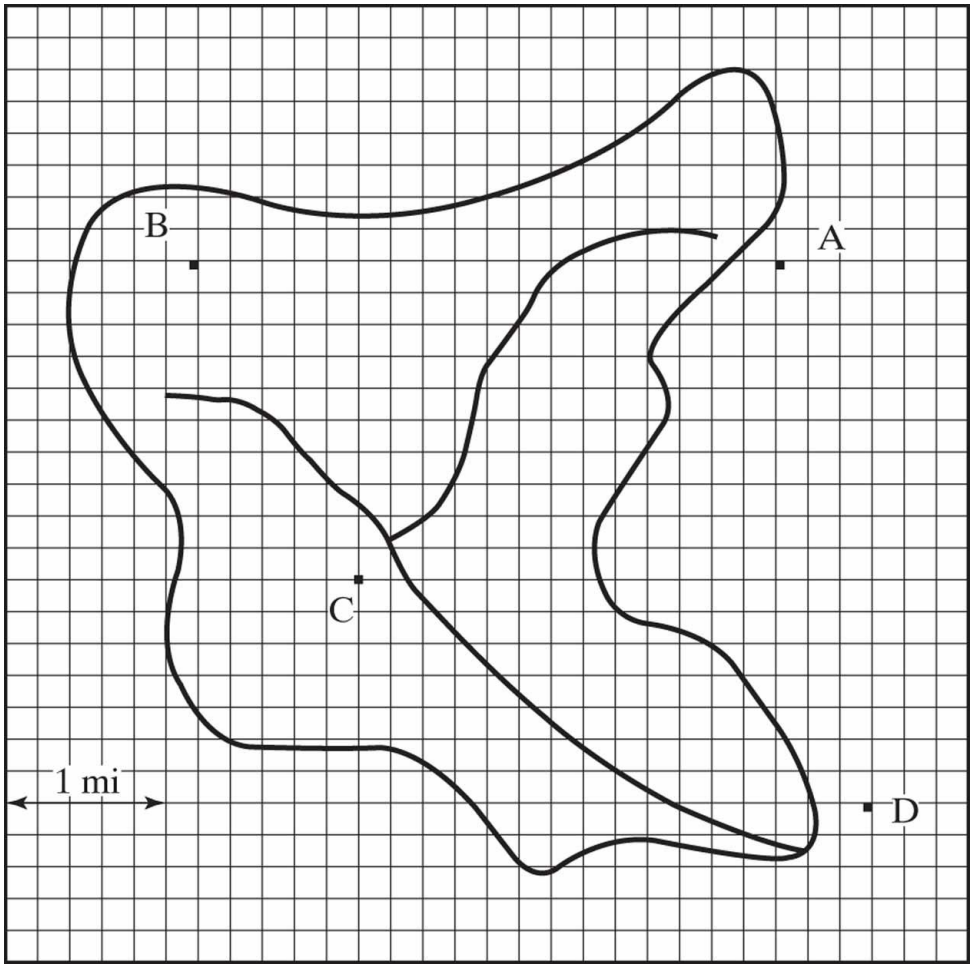

Figure P1-5

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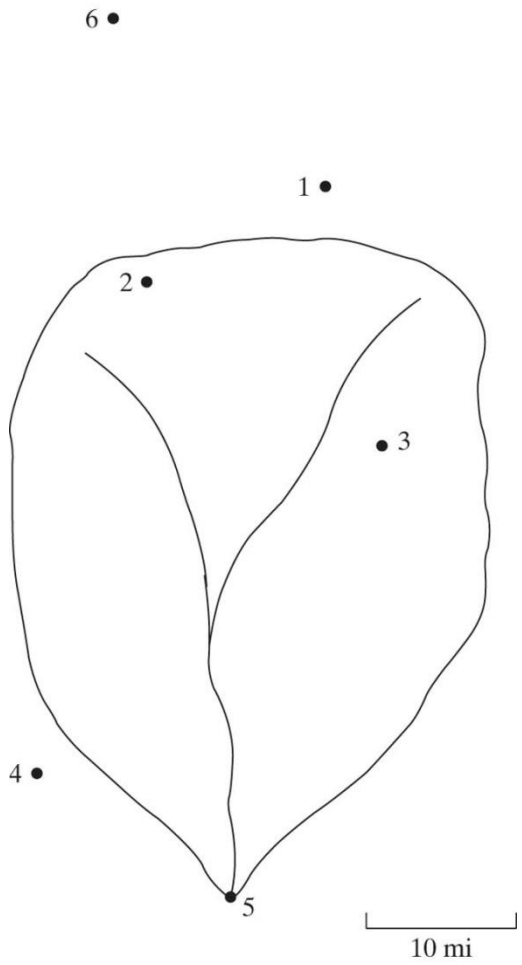

Figure P1-6

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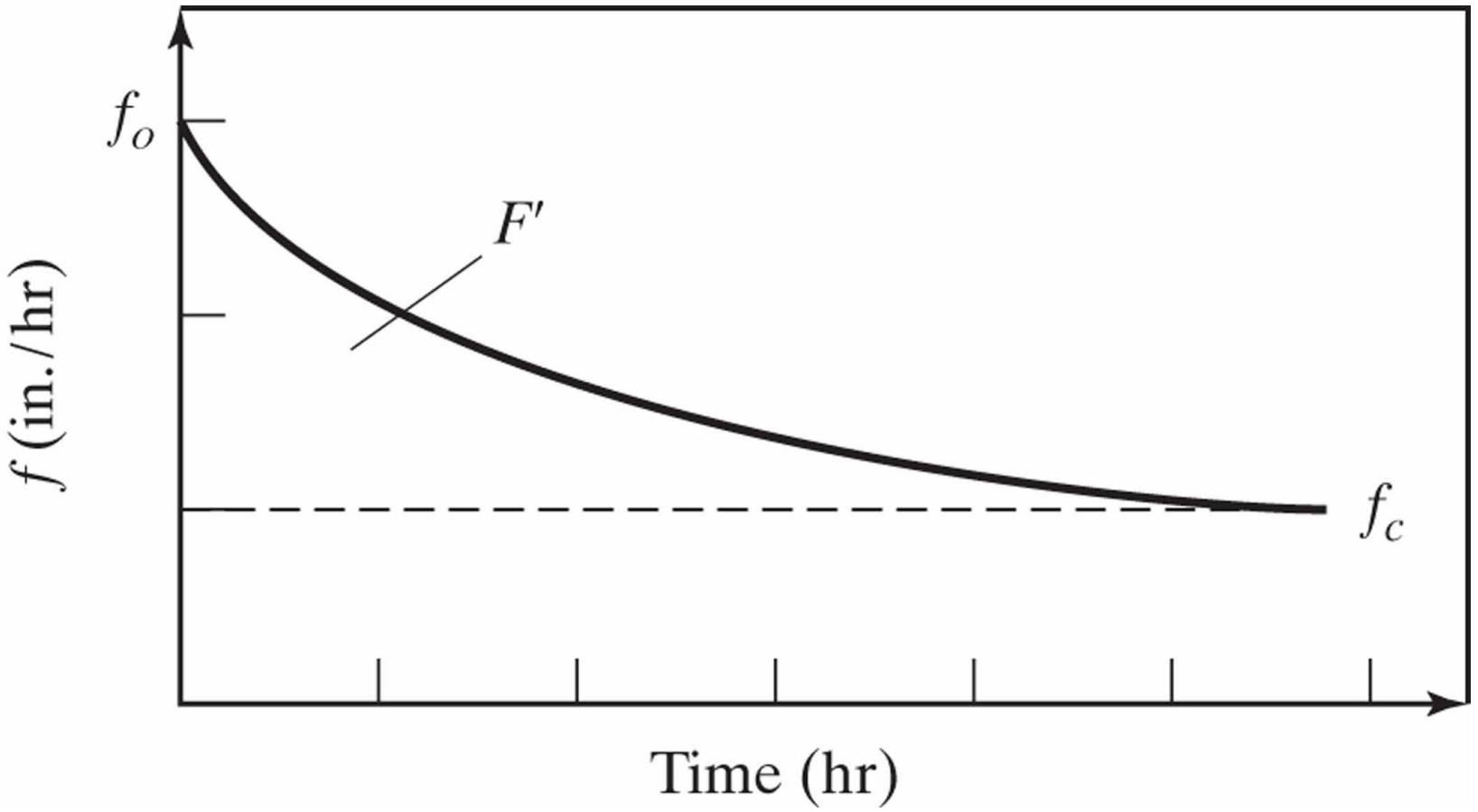

Figure P1-27

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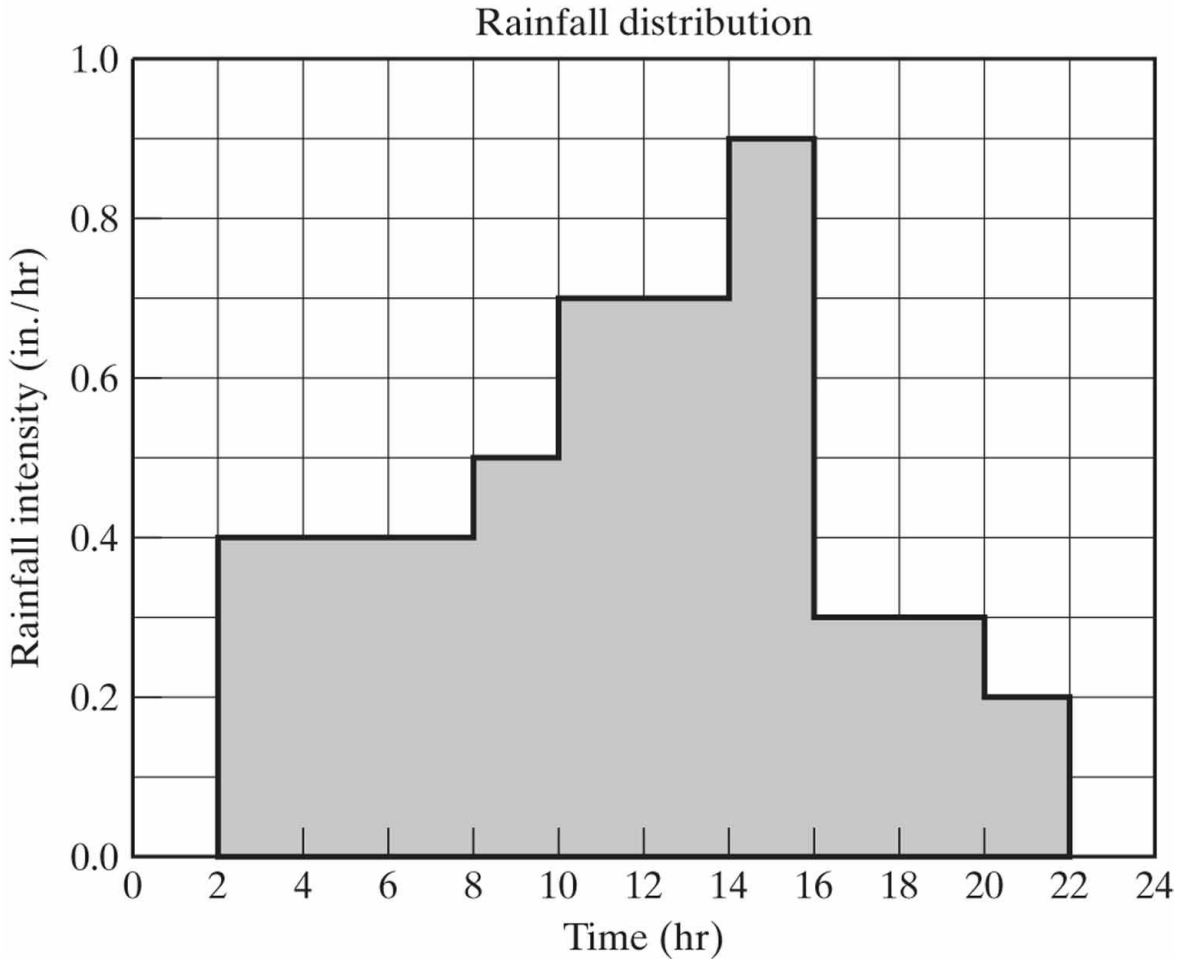

Figure P1-28

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