Solutions Manual

INTRODUCTION TO HYDROLOGY

FIFTH EDITION

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CHAPTER 1

1.1 $100*10^6*0.02 = 2*10^6$ m^3
1 acre-ft = 43,560 cubic feet
cubic meters*35.31 = cubic feet
$(2*10^6*35.31)/43{,}560 = 1{,}612.2$ acre-ft

1.2 volume/volume per unit time = time
(500,000*0.3)/(0.5) = 300,000 sec.
300,000/3,600 = 83.3 hours

1.3 (450 + 500)/2 - (500 + 530)/2 = avg. inflow - avg. outflow
the change in storage is thus - 40 cfs
-40*3600/43560 = -3.31, the change in storage in acre-ft.
The initial storage is thus depleted by 3.31 ac-ft
3.31*43,560/35.31 = 4,083 cubic meters

1.4 125/365 = 0.34 cm/day = 0.035 cm/day
0.34/2.54 = 0.13 in./day

1.5 volume = 5280*5280*0.5 = 13,939,220 cubic feet
V/Q = time
13,939,220*3600/12 = 1,161,600 sec, or 322.7 hr, or 13.4 days

1.6 ET = P - R
$R = (140*3600*24*365)/(10,.000*1000^2) =$
0.44 m/yr or 44 cm/yr
ET = 105 - 44 = 61 cm/yr
This is a crude estimate.

1.7 equivalent depth = vol/area
inflow = 25*3600*24*365 = 788,400 cubic feet/yr
inflow/(3650*43560) = 4.96 ft/yr
E = 100*365/3650 = 10.0 ft/yr
Hence there is a drop in level of 5.04 ft

1.8 Iavg. - Oavg. = change in storage per unit time
(20 - 18)*3600 = 7,200 cubic meters
The storage is thus increased by 7,200 cubic meters
resulting in a final storage of 27,200 cubic meters

CHAPTER 2

Problems in this chapter are to be developed by the instructor.

CHAPTER 3

3.1 – 3.4 To be assigned by instructor.

3.5 For the James River rainfall:

Interval in.	f	Σf	P(x)	F(x)
(36-37)	2	2	0.057	0.057
(38-39)	4	6	0.114	0.171
(40-41)	7	13	0.200	0.371
(42-43)	9	22	0.257	0.628
(44-45)	5	27	0.143	0.771
(46-47)	4	31	0.114	0.885
(48-49)	2	33	0.057	0.942
(50-51)	2	35	0.057	0.999 1.000

a) $P(MAR \geq 40) = 1.000 - 0.171 = 0.829 = 82.9\%$

b) $P(MAR \geq 50) = 0.057 = 5.7\%$

c) $P(40 \leq MAR \leq 50) = 0.942 - 0.171 = 0.771 = 77.1\%$

3.6 Using the curve data for a standard normal curve (Table B.1) requires standardization of the limits of the integral,

$$z = \frac{x - \bar{x}}{S} = \frac{8 - 4}{2} = 2$$

From Table B.1, the integral is the area to the right of F(z = 2), or 0.5 - 0.4772 = 0.0228.

3.7 For the data given:

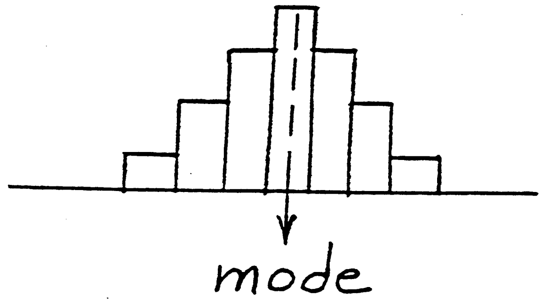
a) The area under the curve must be 1.0 to qualify as a probability density function,

$$A = \int_0^b f(x)dx = \frac{b^3}{8} \doteq 1.0$$

This gives b = 2.0

b) This is the area between 0.0 and 0.5, or $0.5^3/8 = 0.016$

3.8 The histogram is symmetric, has zero skew, and mean = median = mode.



Sketch for Prob. 3.8

Since area to right of mode is 50%, F(mode) = 50% and T = 2 yr.

3.9 Given x = 10.3, s = 1.1, $C_v = 0.11$, n = 20

$$S.E.(\bar{x}) = s/\sqrt{n} = 1.1/\sqrt{20} = 0.245$$

$$S.E.(s) = s/\sqrt{2n} = 1.1/\sqrt{40} = 0.0174$$

$$S.E.(C_v) = C_v\sqrt{1+2C^2}/\sqrt{2n} = 0.11\sqrt{1+2(.11)^2}/\sqrt{40} = 0.017$$

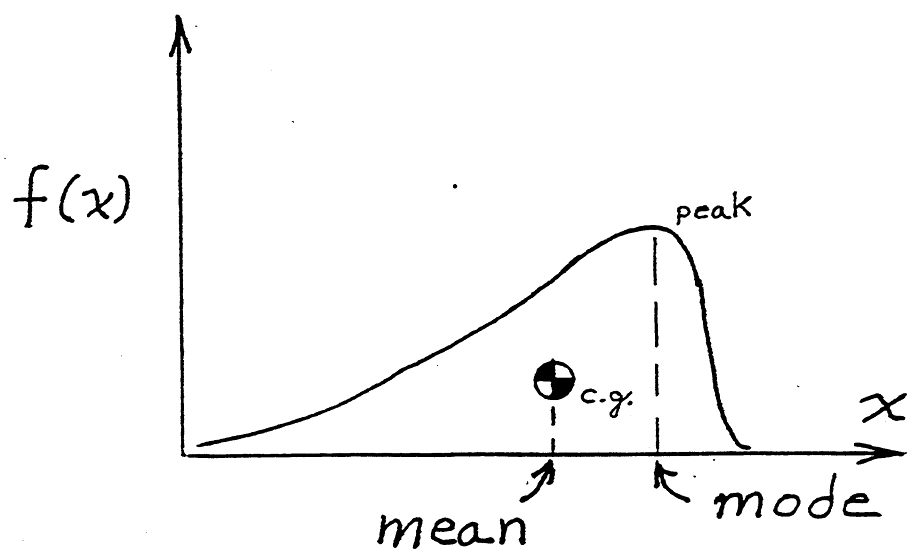
95 % C.L.: $z = \pm 1.96$

$$\bar{x} \pm 1.96\,(S.E._{\bar{x}}) = 10.3 \pm 0.48$$

= {10.78 to 9.82}

3.10 Because the median divides the area in half, most of the area would be to the right of the median. The distribution is probably skewed right.

3.11 Sketch:



Sketch of p.d.f. for Prob. 3.11

a) Left skewed

b) Negative because Pearson skew = (mean - mode)/s_x

3.12 For the 30,000 cfs value:

$$T_r = \frac{60 \text{ yrs}}{3 \text{ times}} = \underline{\underline{20 \text{ yrs}}}$$

3.13 Frequency analysis:

a)

m rank	Peak value	$F = \frac{m}{10}$	$T_r = 1/F$
1	1000	.1	10
2	900	.2	5
3	800	.3	3.33
4	700	.4	2.5
5	600	.	.
6	500	.	.
7	400	.	
8	300		
9	200		
10	100		

By interpolation, 4-yr value is

$$800 + \frac{4 - 3.33}{5 - 3.33}(100)$$

$$= 840 \text{ cfs}$$

b) Using Table B.1,

$$Q_{4\text{-yr}} = \bar{Q} + K\, s_Q = 550 + .67(300) = 750 \text{ cfs}$$

3.14 For an annual precipitation of 30 in.

a) $P(x \geq 30) = G(30)$

$z = (30 - 27.6)/6.06 = 0.396$

$F(z) = 0.15392$

$G(30) = 0.5 - 0.15392 = 0.346$

b) Risk in 3 years $= 1 - (1 - G(30))^3$

$= 0.720$

c) $P(\text{all three years}) = G(30)^3 = 0.041$

3.15 $P(E_1 \cup E_2) = P(E_1) + P(E_2) - P(E_1 \cap E_2)$

a) If E_1 and E_2 are independent, $P(E_1|E_2) = P(E_1)$
and $P(E_1 \cap E_2) = P(E_1) \times P(E_2)$
$P(E_1 \cup E_2) = 0.3 + 0.3 - 0.3 \times 0.3 = 0.51$

b) If dependent, with $P(E_1|E_2) = 0.1$,

$P(E_1 \cap E_2) = 0.1 \times 0.3 = 0.03$
and $P(E_1 \cup E_2) = 0.3 + 0.3 - 0.03 = 0.57$

3.16 $P(A) = 0.4$, $P(\text{no } A) = P(\bar{A}) = 1 - 0.4 = 0.6$

$P(B) = 0.5$, $P(\text{no } B) = P(\bar{B}) = 1 - 0.5 = 0.5$;

A and B independent

a) $P(A \cap B) = P(A) \times P(B) = 0.4 \times 0.5 = 0.20$

b) $P(A \cap B) = P(\bar{A}) \times P(\bar{B}) = 0.6 \times 0.5 = 0.30$

3.17 $P(E_1|E_2) = 0.9$, $P(E_2|E_1) = 0.2$, $P(E_1 \cap E_2) = 0.1$
$P(E_1) = P(E_1 \cap E_2)/P(E_2|E_1) = 0.1/0.2 = 0.5$
$P(E_2) = P(E_1 \cap E_2)/P(E_1|E_2) = 0.1/0.9 = 0.111$

3.18 Two random events that are:

a) Mutually exclusive:
A: Precipitation today exceeds 4 in.
B: Precipitation today does not exceed 3"

b) Dependent:
A: Precipitation today exceeds 4 in.
B: Runoff today exceeds 1 in.

c) Mutually exclusive and dependent:
A: Precipitation today does not exceed 4 in.
B: Runoff today exceeds 6 in.

d) Neither mutually exclusive nor dependent:
A: Today's precipitation exceeds 4 in.

B: Groundwater pumpage this year will exceed 3 acre-feet per acre

3.19 $P(A) = 0.4$, $P(B) = 0.5$

a) $P(A \cap B) = P(A)\,P(B|A) = 0.4(0.5) = 0.20$

b) $P(\bar{A} \cap \bar{B}) = 0.6(0.5) = 0.30$

c) $P(\bar{A} \cap \bar{B}) = P(A)\,P(B) = 0.6(0.5) = 0.30$

3.20 For the given data:

a) Only if $P(B|A) = P(B)$

Now, $P(B) = 0.6$

$$P(B|A) = \frac{P(A \text{ and } B)}{P(A)}$$

Since $P(A \text{ and } B) = 0.2$ and $P(A) = 0.4$

$$P(B|A) = \frac{0.2}{0.4} = 0.5, \text{ Dependent}$$

b) No, mutually exclusive if $P(A \text{ and } B) = 0$, but $P(A \text{ and } B) = 0.2$

c) $P(B) = 0.6$

d) $P(\bar{A}) = 1 - 0.4 = 0.6$

e) $P(\bar{A} \text{ and } \bar{B}) = P(\bar{B}|\bar{A})\,P(\bar{A})$

From data, P(both) = 0.2

Check: $P(\bar{A} \text{ and } \bar{B}) = 1 - P(E_1) - P(E_2) - P(E_3)$

Possibles:	Warm Mar Apr Flood	Cold Mar Apr Flood	Warm Mar Apr Dry	Cold Mar Apr Dry
	P = 0.2	P = 0.4	P = 0.2	P = 0.2

f) $P(B/A) = 0.5$

g) to make them independent,

$$P(B|A) = P(B)$$
Since $P(B) = 0.6$

$$P(B|A) = \frac{P(A \text{ and } B)}{P(A)} = \frac{0.2}{0.4} = 0.5$$

Change P(B) to 0.5, without changing P(A and B)

3.21 A: Flood
B: Ice-jam

$P(A \text{ and } B) = P(A|B)P(B)$, thus $P(A \text{ and } B) < P(A|B)$
and $P(A \text{ and } B) < P(A)$

Also $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$
Also $P(A) < P(A|B)$ because $B < S$
Ranking: Largest = P(A or B)
Second = P(A|B)
Third = P(A)
Fourth = P(A and B)

3.22 For the information given:

a) Both statements say the same thing when $\underline{\underline{n}} = \underline{t} = T_r$ years,
or $T_r = 1$ yr

b) First:

$$\left(1 - \frac{1}{T}\right)^{t-1} = \left(1 - \frac{1}{3}\right)^{t-1} = \left(\frac{2}{3}\right)^2 = \frac{4}{9} = 0.444$$

Second: P = Probability annual precipitation value will not be equaled or exceeded in any single year,

$$P = 1 - F_X = 1 - \frac{1}{3} = \frac{2}{3}$$

$$\frac{n!}{r!\,(n-r!)} P^{n-r} (1-P)^r = \frac{3!}{1!\,(2)!} \left(\frac{2}{3}\right)^{3-1} \left(1-\frac{2}{3}\right)^1 = \underline{\underline{4/9}}$$

3.23 For risk = 50%, $R = 0.5 = 1-(1 - 1/T)^2$

for 2 consecutive yr
Solution gives $T = 3.41$ yr
For risk = 100%, $R = 1 = 1-(1-1/T)^2$, $T = 1$ yr

3.24 For the temporary cofferdam:

a) P(overtopping in any yr) = P(F) = 1/T = /20 = 0.05

b) P(non-exceed in yr 1 and non-exceed in yr 2 and exceed in yr 3) = P(F) x P(F) x P(F) = 0.95 x 0.95 x 0.5 = 0.451

c) Risk $= 1-(1 - 1/T)^n$

$$1-(1 - 1/20)^5 = 0.226$$

d) P(non-exceed in 5 consecutive yr)

$$= (1 - 1/20)^5 = 0.774$$

3.25 For N = 33, median = 17th largest flow.

Defining Q as the annual peak:

a) P(Q exceeds median) = 17/33 = 0.515

b) $T_r = 1/G(Q) = 1/0.515 = 1.94$ yrs.

c) G(Q) = 0.515 in any year.

d) 1 - G(Q) = 0.485

e) P(Q < median in all 10 yrs)

$$= P(Q \cap Q \cap Q \cap Q...) = (0.485)^{10} = 0.00072$$

f) P(Q ≥ median at least once in 10 years)

$$= 1 - (1 - G(Q))^{10} = 0.99928$$

g) P(Q_1 and Q_2 exceed median)

$$= P(Q_1)\ P(Q_2)$$

$$= G(Q)\ G(Q) = 0.265$$

h) P(Q_1 exceeds median and Q_2 does not)

$$G(Q)(1-G(Q)) = 0.250$$

3.26 For the temporary floodwall:

a) P(overtopping in any yr) = P(F) = 1/T = 1/20 = 0.05

b) P(non-exceed in 3 consecutive yr) $= (1 - P(F))^3$

$$= P(\bar{F})^3 = 0.95^3 = 0.857$$

c) Risk $= 1-(1-1/T)^N = 1-(1 - 1/20)^3 = 0.143$

d) P(exceed in 1st yr only or exceed in 2nd yr only or 3rd yr only)

= P(in 1st yr only) + P(in 2nd yr only) + P(in 3rd yr only)

$$= P(F) \times P(\bar{F}) \times P(\bar{F}) + P(\bar{F}) \times P(F) \times P(\bar{F}) + P(\bar{F}) \times P(\bar{F}) \times P(F)$$

$$= (0.05)(0.95)(0.95) + (0.95)(0.05)(0.95) + (0.95)(0.95)(0.05) = 0.135$$

e) P(exceed in 3rd yr exactly) $= P(\bar{F}) \times P(\bar{F}) \times P(F) = (0.95)(0.95)(0.05) = 0.045$

3.27 The owner's acceptance level is:

Risk $= 1 - (1 - 1/T_r)^n = 0.25$
Substitution of n = 20 gives $T_r = 70$ yrs, thus the wall should be between 8.5 and 10.0 ft, or interpolating, 9.1 ft.

3.28 For Oak Creek:

a) Freq. = m/N = 3/60 = 0.05
b) P(F) = freq. = 0.05
c) T = 1/P(F) = 1/0.05 = 20 yr

d) $P(\bar{F}) = 1 - P(F) = 1 - 0.05 = 0.95$

e) P(non-exceed in two consecutive yr) = $P(\bar{F}) \times P(\bar{F}) = 0.95 \times 0.95 = 0.9025$

f) P(one or more exceed in 20 yr)=Risk
$= 1 - (1 - 1/T)^N$
$= 1 - (1 - 0.05)^{20} = 0.642$

g) P(non-exceed in one yr and exceed in next yr)

$= P(\bar{F}) \times P(F)$

$= 0.95 \times 0.05 = 0.0475$

h) Using Binomial Theorem, P(3 occurrences in 60 yr)
= P(x in n)
$= [n!/x!(n-x)!]p^x(1-p)^{n-x}$
$= [60!/3!\ 57!](0.05)^3(0.95)^{57} = 0.230$

i) Same as part f).

3.29 For Anniston, Alabama,

Mean rain = 57.2 in.
Standard deviation = 15.5 in.
100-yr X = 57.2 + K (15.5)
From Appendix B, K for 0.01 = 2.326,
$X_{100} = 93.2$ in.
The 1988 depth of 99 inches was the greatest depth of record. It has an apparent recurrence interval of 23 years. If the rain is normally distributed,
$99 = 57.2 + K_{99}\ (15.5)$

$K_{99} = 2.697$

The area to the right of 2.697 is .49647, giving a recurrence interval of 1/.00353 = 283 years.

3.30 $P(\mu < x < \mu + \sigma)$ = area from z = 0 to z = 1 = 0.3413 = 34.13%

3.31 $P(\mu - 3\sigma \leq X \leq \mu + 3\sigma)$ = area under standard normal from -3 to +3

From Appendix C.1:

$P(\mu - 3\sigma \leq x \leq \mu + 3\sigma) = 2(.4987) = 0.997$ or $= 99.74$ %

3.32 For Normal distribution of runoff:

$x = \bar{x} + zs, \quad s = \sqrt{9} = 3$

$11 = 14 + 3z, \quad z = -1.0, \quad F(z) = 0.3413$

$P(x \leq 11) = 0.5000 - 0.3413 = 0.1583$ in any yr

$P(x \leq 11$ in 3 consecutive yrs$) = 0.1588^3 = 0.004 = 0.4\%$

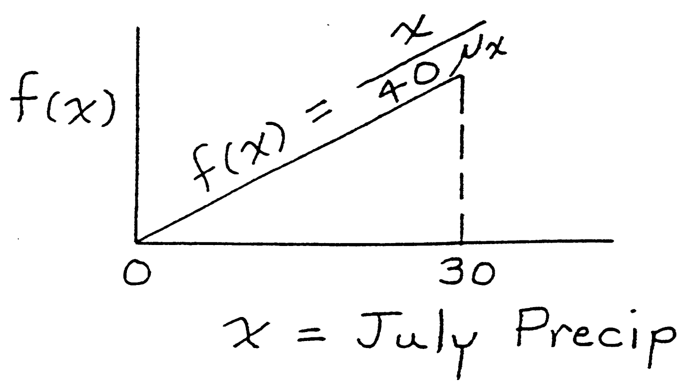
3.33 From Table B.1, the standard variate, z, with area to the right of 0.330 is 0.44 (area left = F(z) = 0.5 - 0.33 = 0.17). Thus,

$x = \bar{x} + zs$

$= 5 + 0.44\,(1.0) = 5.44$

3.34 Since $\mu = 0$, $\sigma = 1$, then $\int_{-2}^{2} f(z)dz = 2(0.4772) = 0.9544$

3.35 Given:



Prob. 3.35 Definition Sketch

$\mu_x \approx 30$ in.