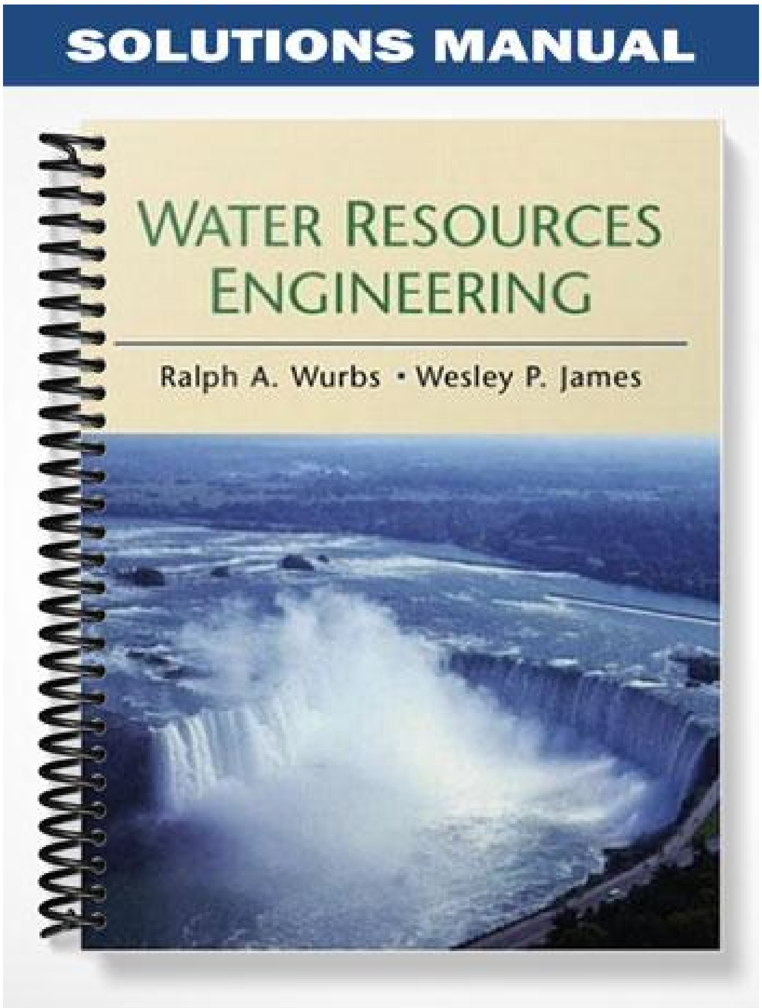
SOLUTIONS MANUAL
WATER RESOURCES
ENGINEERING
Ralph A. Wurbs • Wesley P. James

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Contents

Chapter 1

Chapter 1 has no end-of-chapter homework problems. Several questions for homework assignments are suggested below.

1. Search the internet and/or your university library to find information regarding water resources management in your state.

   a. What proportions of the total water use in your state are for agricultural use, municipal use, and industrial use? Indicate whether your data are for withdrawals or consumptive use. What are the projections for the future?

   b. What proportions of the total water use are supplied by groundwater and surface water?

   c. Describe major water problems and issues being addressed in your state.

2. Review recent issues of Civil Engineering Magazine published by the American Society of Civil Engineers to find articles related to water resources engineering. Select an article of particular interest to you and prepare a brief summary.

3. Summarize water issues addressed in recent issues of your local newspaper or in popular magazines.

4. Select three of the agencies listed in Table 1.4. Visit their web sites. Describe the mission and activities of each of these agencies. What types of information do they provide on their web sites.

5. Visit the web sites of the Hydrologic Engineering Center, International Groundwater Modeling Center, and Bureau of Reclamation Hydrologic Modeling Inventory (Table 1.7). Describe the types of computer models addressed at these sites. What means are adopted by the agencies maintaining these web sites to facilitate use of available generalized computer simulation models throughout the professional water resources engineering community?

6. Describe significant differences that you might expect to encounter in the planning, design, implementation, and maintenance of water resources projects in lesser developed countries versus developed countries such as the United States.

7. List various structural facilities that serve as components of a municipal water supply system. Describe several nonstructural demand management measures that may be adopted by a city in managing its water supply.

8. List various types of structural measures that are often constructed to control floods. Describe several types of nonstructural measures that are often adopted to reduce flood damages.

9. Compliance with government regulations is a key aspect of the professional practice of water resources engineering. Cite three examples of regulatory programs that significantly impact water resources development and management.

   Answer:

   1. flood plain management regulations under National Flood Insurance Program
   2. wastewater treatment plant effluent, urban stormwater, and other discharge permits under the National Pollutant Discharge Elimination System (NPDES)
   3. USACE Section 404 permit program for dredge and fill material
   4. Endangered Species Act requirements

10. Assume you are a civil engineer employed by a consulting engineering firm. Cite the governmental agencies or other organizations with which you would interact in regard to the following aspects of your work. Which agencies:

    a. hire your consulting engineering firm to do work? (Answer: cities, water districts, state agencies, USACE, USBR, FEMA, EPA, other federal agencies, industries)

    b. provide gaged streamflow data for use in your projects? (Answer; USGS)

    c. provide water quality data for aquifers and rivers of interest in your projects? (Answer: U.S. Geological Survey)

    d. provide precipitation and other climatic data for use in your projects? (NWS)

    e. provide topographic maps for use in your projects? (USGS)

    f. grant permits for construction activities allowing movement (excavation and/or fill) of earth in the vicinity of streams? (USACE under the Section 404 permit program and cities under the National Flood Insurance Program administered by FEMA)

    g. grant a permit to your client to discharge wastewater treatment plant effluent into a stream? (EPA or designated state agency for administering the National Pollutant Discharge Elimination (NPDES) Program)

    h. grant a license to develop a hydroelectric power project? (FERC)

    i. provide funding for a water development project in a lesser developed nation? (United Nations Development Program and World Bank)

    j. provide computer programs for your use in conducting hydrologic and hydraulic studies for delineating the flood plain along a stream of interest to your client? (USACE Hydrologic Engineering Center, HEC-HMS and HEC-RAS)

    k. provide computer programs for your use in groundwater studies? (USGS and IGWMC)

    l. organize conferences allowing you to network with other professionals with similar interests, perhaps presenting the results of innovative work you have accomplished as well as learning about what others are doing? (ASCE, other professional societies)

Chapter 2

2.1

$$\frac{21{,}400{,}000{,}000\,\text{m}^3}{(1{,}000{,}000\text{ people})\left(\dfrac{100\text{ gal/day}}{\text{person}}\right)\left(365\,\dfrac{\text{day}}{\text{yr}}\right)\left(0.003785\,\dfrac{\text{m}^3}{\text{gal}}\right)} = 155\text{ years}$$

2.2

$$\text{land area} = \frac{2.14\times10^{10}\,\text{m}^3}{1.0\text{ m}} = 2.14\times10^{10}\,\text{m}^2$$

$$\text{area} = 2.14\times10^{10}\,\text{m}^2\left(\frac{1\,\text{km}^2}{1{,}000{,}000\,\text{m}^2}\right) = 21{,}400\,\text{km}^2$$

$$\text{area} = 21{,}400\,\text{km}^2\left(100\,\frac{\text{ha}}{\text{km}^2}\right) = 2{,}140{,}000\text{ hectares}$$

$$\text{area} = 21{,}400\,\text{km}^2\left(\frac{1\text{ mile}^2}{2.59\,\text{km}^2}\right) = 8{,}263\text{ mile}^2$$

$$\text{area} = 8{,}263\text{ mi}^2\left(640\text{ ac/mi}^2\right) = 5{,}288{,}000\text{ acres}$$

2.3

$$\text{evaporation} = (65{,}800\text{ ha})\left(\frac{1\,\text{km}^2}{100\text{ ha}}\right)\left(1{,}000{,}000\,\frac{\text{m}^2}{\text{km}^2}\right)(0.25\text{m})(0.7) = 115{,}150{,}000\,\text{m}^3$$

$$\text{evaporation} = 4.066\times10^9\,\text{ft}^3 = 93{,}340\text{ ac-ft}$$

2.4

$$\text{volume} = \left(280\,\text{km}^2\right)\left(1{,}000{,}000\,\text{m}^2/\text{km}^2\right)(0.725\text{ m}) = 2.030\times10^8\,\text{m}^3$$

$$\text{volume} = 7.168\times10^9\,\text{ft}^3 = 5.362\times10^8\text{ gal} = 164{,}560\text{ acre-feet}$$

2.5

$$\text{volume} = \left(8{,}250\,\frac{\text{ft}^3}{\text{s}}\,\text{day}\right)(86{,}400\text{ s/day}) = 7.128\times10^8\,\text{ft}^3$$

$$\text{volume} = 16{,}364\text{ acre-feet}$$

$$\text{flow rate} = \frac{7.128\times10^8\,\text{ft}^3}{(30\text{ days})(86{,}400\text{ s/day})} = 275\,\text{ft}^3/\text{s}$$

$$\text{flow rate} = \left(275\,\text{ft}^3/\text{s}\right)\left(0.02832\,\text{m}^3/\text{ft}^3\right) = 7.79\,\text{m}^3/\text{s}$$

2.6 annual water use = 950,000(175 gal/day)(365 days/yr) = 60,680 million gallons/year

$$\begin{aligned}\text{annual water use} &= 8.11\times10^{9}\ \text{ft}^3/\text{yr}\\ &= 186{,}200\ \text{ac-ft/yr}\\ &= 93{,}880\ \text{sfd/yr}\\ &= 2.297\times10^{8}\ \text{m}^3/\text{yr}\\ &= 2.297\times10^{11}\ \text{liters/yr}\end{aligned}$$

2.7

$$\text{irrigation requirement} = 1.2\,\text{ft} - \frac{3.2}{12}\,\text{ft} = 0.933\,\text{ft}$$

$$\begin{aligned}\text{volume} &= (780\,\text{ac})(0.933\,\text{ft}) = 728\ \text{ac-ft}\\ &= 3.17\times10^{7}\ \text{ft}^3\\ &= 898{,}000\ \text{m}^3\end{aligned}$$

2.8

$$\begin{aligned}\text{flow} &= (132\,\text{mi}^2)(640\,\text{ac/mi}^2)(25\,\text{inches/yr})(\text{ft}/12\,\text{inches})(0.20)\\ &= 35{,}200\ \text{ac-ft/yr}\end{aligned}$$

$$\text{flow} = 17{,}450\ \text{sfd/yr}$$

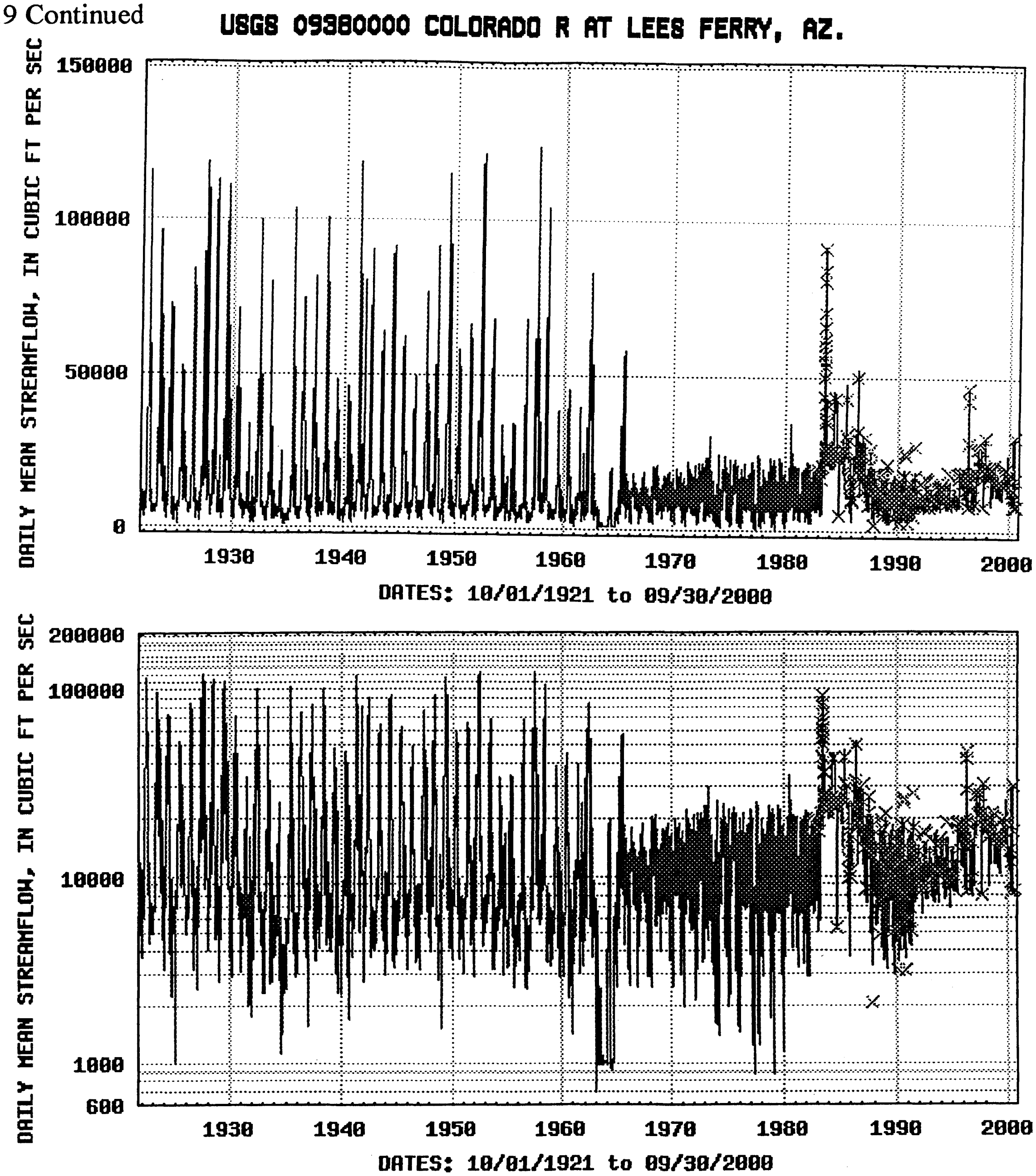
$$\text{flow} = \frac{\left(17{,}750\,\dfrac{\text{ft}^3}{\text{s}}\cdot\text{day}\right)/\text{year}}{365\,\text{days/year}} = 48.6\ \text{ft}^3/\text{s}$$

$$\text{flow} = 1.38\ \text{m}^3/\text{s}$$

2.9 The National Water Information System (NWIS) can be accessed through the U.S. Geological Survey web site: http://water.usgs.gov

The drainage area above station 09380000 on the Colorado River is 111,800 mile^2. The daily flow hydrograph printed through the NWIS is reproduced on the next page alternatively with an arithmetic scale and a log scale.

2.9 Continued



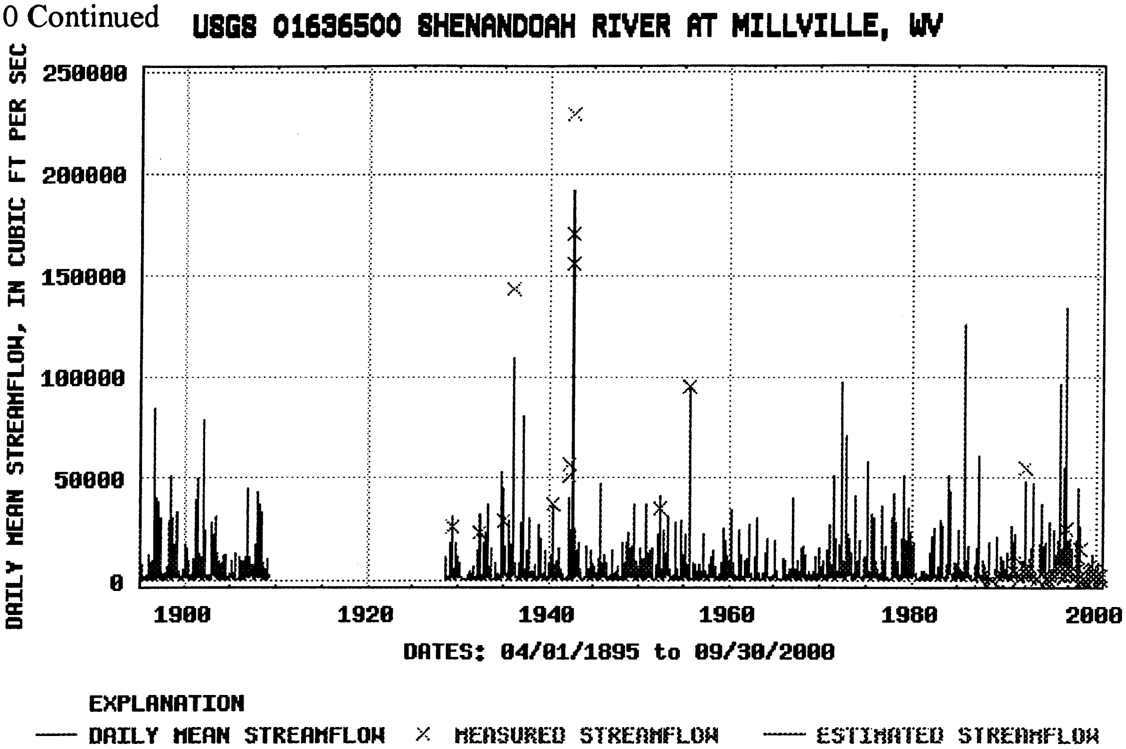
2.10 The National Water Information System (NWIS) can be accessed through the U.S. Geological Survey web site: http://water.usgs.gov

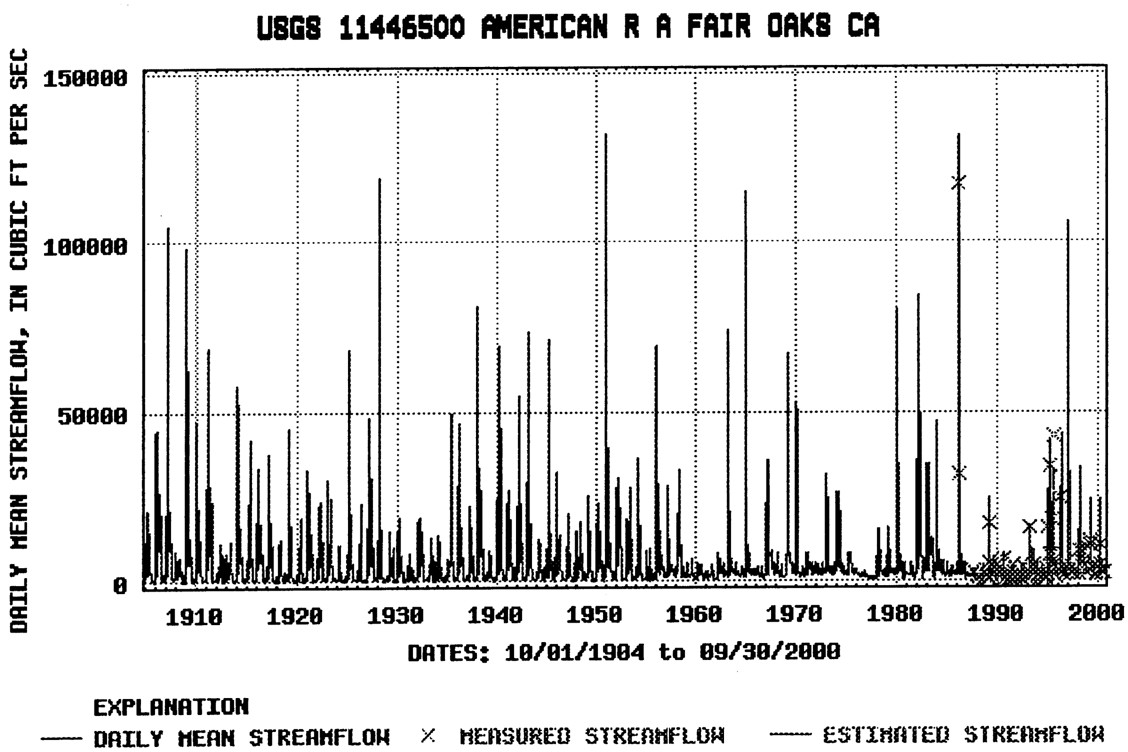
The drainage areas are:

station 01636500 on the Shenandoah River: drainage area = 3,022 mile^2
station 11446500 on the American River: drainage area = 1,888 mile^2

Hydrographs printed through the NWIS are reproduced on the next page.

2.10 Continued





2.11 Problem 2.11 consists of repeating Problems 2.9 and 2.10 for a gaging station of your choice.

2.12

A, ft^2	3.6	11.1	19.5	25.8	22.8	19.2	14.4	6.9
V, ft/s	0.72	1.01	1.295	1.435	1.23	1.14	1.025	0.84
Q, ft^3/s	2.6	11.2	25.3	37.0	28.0	21.9	14.8	5.8

flow rate = 147 ft^3/s

2.13

A, m^2	1.90	3.96	5.28	6.28	7.10	5.36	3.06	0.98
V, m/s	0.345	0.425	0.47	0.505	0.59	0.535	0.42	0.30
Q, m^3/s	0.656	1.683	2.482	3.171	4.189	2.868	1.285	0.294

flow rate = 16.63 m^3/s

2.14

Subbasin Area Km^2	Subbasin Area %	Annual Precipitation (mm)	Weighted Precipitation (mm)
5,200	4.16	981	40.8
18,600	14.88	752	111.9
32,400	25.92	678	175.7
20,800	16.64	495	82.4
37,200	29.76	520	154.8
10,800	8.64	504	43.5
125,000	100.00		609.1

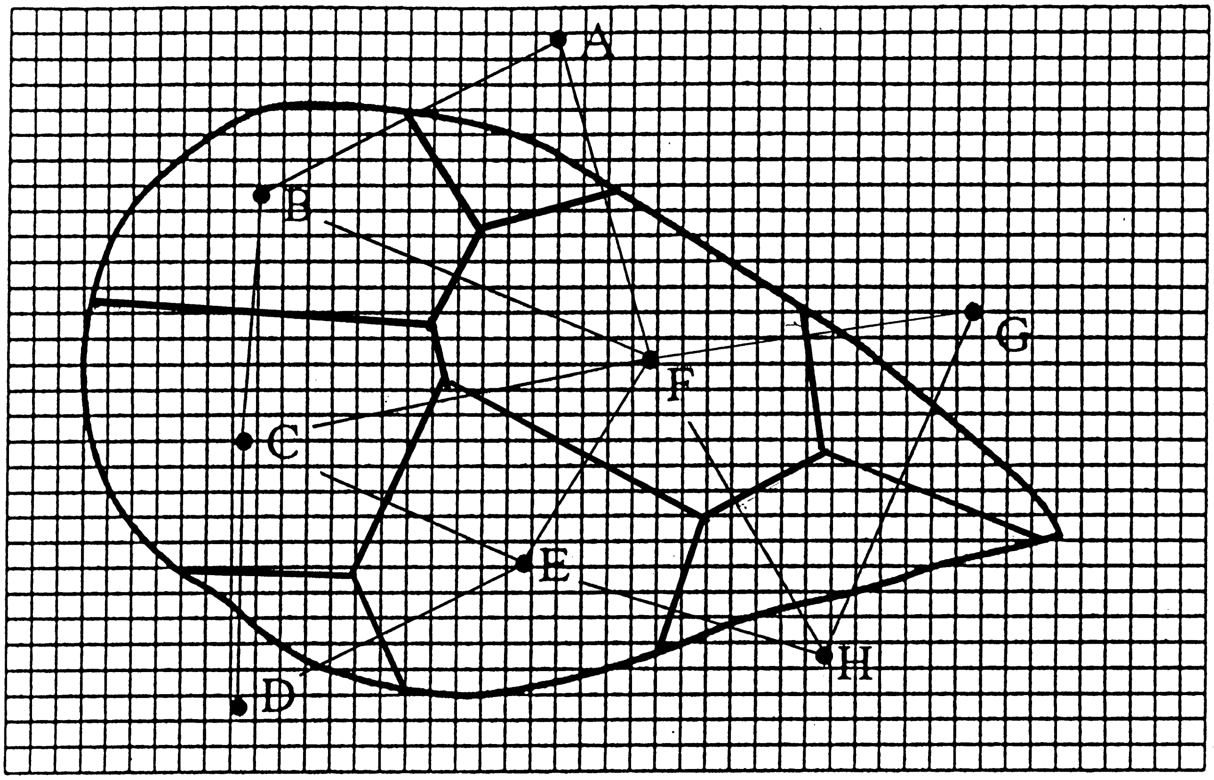
Basin mean annual precipitation = 609 mm

2.15

Gage	Area (%)	Rainfall (mm)	Weighted Depth (mm)
A	24	11	2.64
B	21	14	2.94
C	37	26	9.62
D	8	42	3.36
E	10	36	3.60
	------		---------
Total	100		22.16

Average rainfall depth = 22 mm

2.16 and 2.17 The Thiessen polygon network for Problems 2.16 and 2.17 is provided below.



2.16

Gage	Area (%)	Rainfall (inches)	Weighted Depth (inches)
A	3	5.6	0.168
B	16	4.2	0.672
C	21	3.9	0.819
D	4	2.5	0.100
E	20	1.8	0.360
F	22	0.9	0.198
G	5	2.4	0.120
H	9	0.3	0.027
Total	100		2.464

Average rainfall depth = 2.5 inches

2.17

Gage	Area (%)	Rainfall (mm)	Weighted Depth (mm)
A	3	25	0.8
B	16	18	2.9
C	21	92	19.3
D	4	95	3.8
E	20	192	38.4
F	22	175	38.5
G	5	152	7.6
H	9	168	15.1
Total	100		126.4

Average rainfall depth = 126 mm