by converting the average flowrate (q^i) during each hourly period to cubic meters, using the following expression, and then cumulatively by summing the hourly values to obtain the cumulative flow volume.

$$\text{Volume, m}^3 = (q_i, \text{m}^3/\text{s})(3600 \text{ s/h})(1.0 \text{ h})$$

For example, for the first three time periods shown in the data table, the corresponding hourly volumes are as follows:

For the time period M–1:

$$V_{M-1} = (0.275 \text{ m}^3/\text{s})(3600 \text{ s/h})(1.0 \text{ h}) = 990 \text{ m}^3$$

For the time period 1–2:

$$V_{1-2} = (0.220 \text{ m}^3/\text{s})(3600 \text{ s/h})(1.0 \text{ h}) = 792 \text{ m}^3$$

The cumulative flow, expressed in m^3, at the end of each time period is determined as follows:

At the end of the first time period M–1:

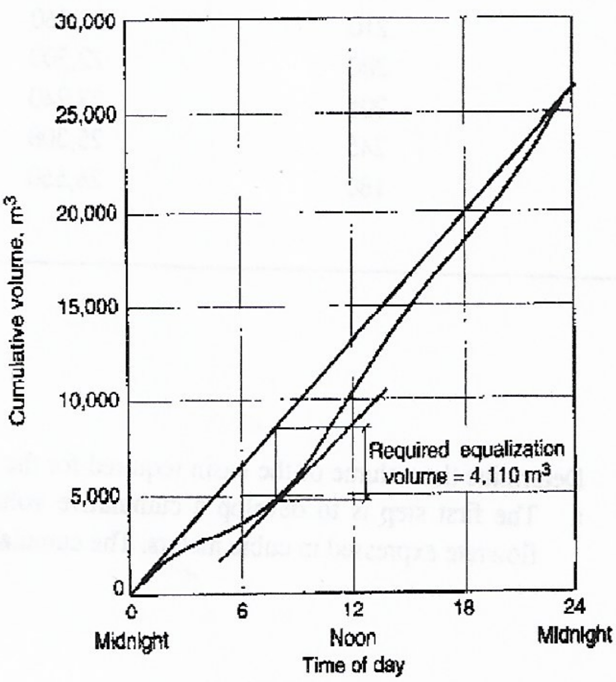
$$V_1 = 990 \text{ m}^3$$

At the end of the second time period 1–2:

$$V_2 = 990 + 792 = 1782 \text{ m}^3$$

The cumulative flows for all the hourly time periods are computed in a similar manner (see derived data in data table).

b. The second step is to prepare a plot of the cumulative flow volume, as shown in the following diagram. As will be noted, the slope of the line drawn from the origin to the endpoint of the inflow mass diagram represents the average flowrate for the day, which in this case is equal to 0.307 m^3/s.



c. The third step is to determine the required storage volume. The required storage volume is determined by drawing a line parallel to the average flowrate tangent to the low point of the inflow mass diagram. The required volume is represented by the vertical distance from the point of tangency to the straight line representing the average flowrate. Thus, the required volume is equal to

Volume of equalization basin, $V = 4110\ \text{m}^3$ ($145{,}100\ \text{ft}^3$)

2. Determine the effect of the equalization basin on the BOD mass loading rate. Although there are alternative computation methods, perhaps the simplest way is to perform the necessary computations starting with the time period when the equalization basin is empty. Because the equalization basin is empty at about 8:30 A.M., the necessary computations will be performed starting with the 8–9 time period.

a. The first step is to compute the liquid volume in the equalization basin at the end of each time period. The volume required is obtained by subtracting the equalized hourly flowrate expressed as a volume from the inflow flowrate also expressed as a volume. The volume corresponding to the equalized flowrate for a period of 1 h is $0.307\ \text{m}^3/\text{s} \times 3600\ \text{s/h} = 1106\ \text{m}^3$. Using this value, the volume in storage is computed using the following expression:

$$V_{sc} = V_{sp} + V_{ic} - V_{oc}$$

where V_{sc} = volume in the equalization basin at the end of current time period

V_{sp} = volume in the equalization basin at the end of previous time period

V_{ic} = volume of inflow during the current time period

V_{oc} = volume of outflow during the current time period

Thus, using the values in the original data table, the volume in the equalization basin for the time period 8–9 is as follows:

$$V_{sc} = 0 + 1278\ \text{m}^3 - 1106\ \text{m}^3 = 172\ \text{m}^3$$

For time period 9–10:

$$V_{sc} = 172\ \text{m}^3 + 1476\ \text{m}^3 - 1106\ \text{m}^3 = 542\ \text{m}^3$$

The volume in storage at the end of each time period has been computed in a similar way (see the following computation table).

Time period	Volume of flow during time period, m³	Volume in storage at end of time period, m³	Average BOD concentration during time period, mg/L	Equalized BOD concentration during time period, mg/L	Equalized BOD mass loading during time period, kg/h
8–9	1278	172	175	175	193
9–10	1476	542	200	197	218
10–11	1530	966	215	210	232
11–N	1548	1408	220	216	239

(continued)

(Continued)

Time period	Volume of flow during time period, m³	Volume in storage at end of time period, m³	Average BOD concentration during time period, mg/L	Equalized BOD concentration during time period, mg/L	Equalized BOD mass loading during time period, kg/h
N–1	1530	1832	220	218	241
1–2	1458	2184	210	214	237
2–3	1386	2464	200	209	231
3–4	1260	2618	190	203	224
4–5	1170	2680	180	196	217
5–6	1170	2746	170	188	208
6–7	1188	2828	175	184	203
7–8	1314	3036	210	192	212
8–9	1440	3370	280	220	243
9–10	1440	3704	305	245	271
10–11	1368	3966	245	245	271
11–M	1242	4102	180	230	254
M–1	990	3986	150	214	237
1–2	792	3972	115	196	217
2–3	594	3160	75	179	198
3–4	468	2522	50	162	179
4–5	378	1794	45	147	162
5–6	360	1048	60	132	146
6–7	432	374	90	119	132
7–8	738	0	130	126	139
Average					213

Note: m³ × 35.3147 = ft³
kg × 2.2046 = lb
g/m³ = mg/L

b. The second step is to compute the average concentration leaving the storage basin. Using the following expression, which is based on the assumption that the contents of the equalization basin are mixed completely, the average concentration leaving the storage basin is

$$X_{oc} = \frac{(V_{ic})(X_{ic}) + (V_{sp})(X_{sp})}{V_{ic} + V_{sp}}$$

where X_{oc} = average concentration of BOD in the outflow from the storage basin during the current time period, g/m³ (mg/L)

V_{ic} = volume of wastewater inflow during the current period, m³

X_{ic} = average concentration of BOD in the inflow wastewater volume, g/m³

V_{sp} = volume of wastewater on storage basin at the end of the previous time period, m³

X_{sp} = concentration of BOD in wastewater in storage basin at the end of the previous time period, g/m³

Using the data given in column 2 of the above computation table, the effluent concentration is computed as follows:

For the time period 8–9:

$$X_{oc} = \frac{(1278\ m^3)(175\ g/m^3) + (0)(0)}{1278\ m^3} = 175\ g/m^3$$

For the time period 9–10:

$$X_{oc} = \frac{(1476\ m^3)(200\ g/m^3) + (172\ m^3)(175\ g/m^3)}{(1476 + 172)\ m^3} = 197\ g/m^3$$

All the concentration values computed in a similar manner are reported in the above computation table.

c. The third step is to compute the hourly mass loading rate using the following expression:

$$\text{Mass loading rate, kg/h} = \frac{(X_{oc},\ g/m^3)(q_i,\ m^3/s)(3600\ s/h)}{(10^3\ g/kg)}$$

For example, for the time period 8–9, the mass loading rate is

$$\frac{(175\ g/m^3)(0.307\ m^3/s)(3600\ s/h)}{(10^3\ g/kg)} = 193\ kg/h$$

All hourly values are summarized in the computation table. The corresponding values without flow equalization are reported in the original data table.

d. The effect of flow equalization can be shown best graphically by plotting the hourly unequalized and equalized BOD mass loading (see the following plot). The following flowrate ratios, derived from the data presented in the table given in the problem statement and the computation table prepared in Step 2a, are also helpful in assessing the benefits derived from flow equalization:

	BOD mass loading	
Ratio	**Unequalized**	**Equalized**
Peak / Average	$\frac{439}{213} = 2.06$	$\frac{271}{213} = 1.27$
Minimum / Average	$\frac{17}{213} = 0.08$	$\frac{132}{213} = 0.62$
Peak / Minimum	$\frac{439}{17} = 25.82$	$\frac{271}{132} = 2.05$