Engineering Hydrology (ECIV 4323)

Lecture 18

Runoff

Instructors:

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Flow mass curve
5.6 Flow mass curve

- Unit is volume million $m^3$ or $m^3$/s day, cm over a catchment area

- Slope of the mass curve $= \frac{dv}{dt} = Q =$ flow rate

- Average flow rate in the time between $t_m$ and $t_n$

- Slope of line AB is the average over whole period records
Calculation of storage volume

- Assume there is a reservoir on stream where FM curve is shown in figure and it full at the beginning of dry period, the storage \( (S) \) of the reservoir

\[
s = \text{Maximum of } \left( \sum V_D - \sum V_S \right)
\]

- \( \sum V_D \) = demand volume (with drawal)
- \( \sum V_S \) = supply volume (Inflow)

-Demand rate: withdrawal rate

-S: the maximum difference in the ordinate between mass curves of supply & demand
Calculation of storage volume

- The minimum storage volume required by a reservoir is the largest value of S

- Refer to Figure 5.9
  - CD is drawn tangential to the first part of curve
  - $Q_d$ slope of CD is constant rate of withdrawal from the reservoir
  - The lowest capacity is reached at E where EF is tangential at E
  - $S_1$: the water volume needed as storage to meet the maximum demand (reservoir is full)
  - $S_2$: is for C’D’
  - Then the minimum reservoir storage required is the largest storage $S_2 > S_1$
The following table gives the mean monthly flows in a river during 1981. Calculate the minimum storage required to maintain a demand rate of 40 m³/s.

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Flow (m³/s)</td>
<td>60</td>
<td>45</td>
<td>35</td>
<td>25</td>
<td>15</td>
<td>22</td>
<td>50</td>
<td>80</td>
<td>105</td>
<td>90</td>
<td>80</td>
<td>70</td>
</tr>
</tbody>
</table>
Calculation of storage volume

From the given data the monthly flow volume and accumulated volumes are calculated as in Table. The actual number of days in the month are

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean flow (m³/s)</th>
<th>Monthly flow volume (cumec-day)</th>
<th>Accumulated volume (cumec-day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>60</td>
<td>1860</td>
<td>1860</td>
</tr>
<tr>
<td>Feb</td>
<td>45</td>
<td>1260</td>
<td>3120</td>
</tr>
<tr>
<td>Mar</td>
<td>35</td>
<td>1085</td>
<td>4205</td>
</tr>
<tr>
<td>April</td>
<td>25</td>
<td>750</td>
<td>4955</td>
</tr>
<tr>
<td>May</td>
<td>15</td>
<td>465</td>
<td>5420</td>
</tr>
<tr>
<td>June</td>
<td>22</td>
<td>660</td>
<td>6080</td>
</tr>
<tr>
<td>July</td>
<td>50</td>
<td>1550</td>
<td>7630</td>
</tr>
<tr>
<td>Aug</td>
<td>80</td>
<td>2480</td>
<td>10.110</td>
</tr>
<tr>
<td>Sep</td>
<td>105</td>
<td>3150</td>
<td>13.260</td>
</tr>
<tr>
<td>Oct</td>
<td>90</td>
<td>2790</td>
<td>16.050</td>
</tr>
<tr>
<td>Nov</td>
<td>80</td>
<td>2400</td>
<td>18.450</td>
</tr>
<tr>
<td>Dec</td>
<td>70</td>
<td>2170</td>
<td>20.620</td>
</tr>
</tbody>
</table>
Calculation of storage volume

-Used in calculating the monthly flow volume. Volumes are calculated in units of cumec. Day (\(= 8.64 \times 10^4 \text{ m}^3\))
Calculation of storage volume

- Refer to Example
  
  ➢ Compute the monthly flow volume by using the actual days in each month
  
  ➢ Compute the accumulated volume in (cumec – day)
  
  ➢ Plot the flow mass curve (cumulated flow volume and time)
  
  ➢ Draw a tangential line with slope of 40 m³/s

  ➢ Slope = \( y/x \) ➢ \( y = x \times \text{slope} \)

  ➢ \( y = 60.8 \text{ days} \times 40 \text{ (m³/s)} = 2432 \text{ cumec-day} \)
Calculation of storage volume

- Refer to Example 5.5
- Flow mass curve (Figure 5.10)

- Draw parallel line to AB in the valley point A’B’

- Vertical value $S_1$ the storage required to maintain the demand

- From figure 5.10  $\Rightarrow$  2100 m$^3$/s.day