3.1 Spring discharge measurement in different flow settings

MCLLMP Virtual Training
By Spring Initiative Partners

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Content

• Why to measure discharge?
• What are the different forms of discharge?
• How to measure discharge?
• How to record discharge?
• How to calculate discharge?

Simple and cost effective techniques of discharge measurements have been discussed here so that even a lay person can understand and measure discharge.
Objective

- Estimate the availability of water for water budgeting
- Understand how it varies with rainfall and in different months/seasons
- Study the effectiveness of the water conservation measures in a springshed or a watershed
- Design appropriate storage structures based on the discharge.
1. **Spring through locally engineered outlet (bamboo, pipe etc.):**

Spring water emerging along the slope is channelised using locally available material like bamboo or a pipe. The spring water emerging out through such outlets falls on the ground following a certain trajectory.

Source: ACWADAM
Forms of Spring Discharge (contd.)

2. **Spring box**: Spring water emerges out through one or several points on the ground surface and is collected in a natural depression or a constructed box or a chamber which have varying volumes.

Source: ACWADAM
3. **Surface flows**: Spring water oozes out from one or several points on the ground and flows on the surface in the form of a stream.
Measurement Unit and Conversion

For springs, where the discharge is generally less they are expressed in litres per minute or lpm.

The relation between some units is given below:

1 cum = 1,000 lt or 35.3 cft (1 m = 3.28 ft)

1 lt = 1,000 cm$^3$ = 1,000 ml. Therefore 1 cm$^3$ = 1 ml

1 cumec (cubic meter per sec) = 35.3 cusec (cubic feet per sec) = 1,000 lt/sec
= 60,000 lpm

1 lpm = 60 lph (litres per hour) = 1,440 lpd (litres per day)
Discharge Measurement methods

Stopwatch-container method

This method is used when the spring in any particular region flows following a certain trajectory through a locally engineered material like bamboo or pipe.

Equipments required
- Known volume container
- Stopwatch/timer

Steps to be followed

Place the container to capture springwater flow and start the stop watch immediately. Check the time taken for the container to fill.

Suppose a spring takes **12 seconds** to fill up the **1 litre** container.

12 sec = 12/60 min = 0.2 min

Then discharge \( Q = \frac{\text{Volume (V)}}{\text{time (t)}} = \frac{1 \text{ lt}}{0.2 \text{ min}} \)

\[ Q \text{ (discharge)} = 5 \text{ lpm} \]

Source: ACWADAM
In case of high discharge spring, make use of a container with large volume

Place the bucket vertically (it should not be tilted) below the spring flow and start the stop watch immediately. Stop the watch as soon as the bucket fills up.

Suppose it takes 1m 09sec to fill up the 10 lt bucket.

Now 9 sec = 9/60 = 0.15min.

Therefore 1m 09sec = 1 + 0.15 min = 1.15min

Therefore Discharge = \( \frac{\text{Volume (V)}}{\text{time (t)}} \) = \( \frac{10 \text{ lt}}{1.15 \text{ min}} \)

= 8.7 lpm
## Recording data

The format for collecting data for sources with low and higher discharges are given below. The first two rows are filled as example.

\[
\text{Discharge } Q = \frac{V \times 60}{t} \text{ (litre/min.)}
\]

<table>
<thead>
<tr>
<th>Date</th>
<th>Volume of water (V) litre</th>
<th>Time taken (t) sec</th>
<th>Discharge ( Q = \frac{V \times 60}{t} ) (litre/min.)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.05.20</td>
<td>1</td>
<td>15</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>16.05.20</td>
<td>1</td>
<td>21</td>
<td>2.9</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Volume of water (V) litre</th>
<th>Time taken (t) sec</th>
<th>Discharge ( Q = \frac{V \times 60}{t} ) (litre/min.)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.05.20</td>
<td>10</td>
<td>10</td>
<td>60.0</td>
<td></td>
</tr>
<tr>
<td>16.05.20</td>
<td>10</td>
<td>18</td>
<td>33.3</td>
<td></td>
</tr>
</tbody>
</table>
In case of large container and low spring discharge..

If the bucket is too large and the discharge is too less, it will take more time to fill up the bucket. In that case fill up the bucket for exactly 1 min and then remove it.

After water movement stops, measure the diameter of the bucket at the water mark. Suppose, it is 15.5 cm and the depth is 4.4 cm.

Now throw the water and measure the base diameter of the bucket. Suppose it is 12.5 cm.

Average diameter \( \frac{15.5 + 12.5}{2} = 14 \text{ cm} \)

The volume of water in the bucket

\[
V = \frac{3.14 \times d^2 \times h}{4} = \frac{3.14 \times 14 \times 14 \times 4.4}{4} = 676.98 \text{ cm}^3 \text{ or } \frac{676.98}{1000} = 0.7 \text{ lpm}
\]
Spring box measurement method

This method is used when the spring is either in the form of a spring box of a certain dimension or a natural depression (pond).

Water is removed from the box and the time taken to get it filled again is noted.

Quantity of water to be removed depends upon the capacity and surface area of the spring box.
1. Place a scale (or stick) in the spring box to measure and mark the water level (at given point of time) at a fixed location in the box.

2. Take a bucket of known volume and remove water from the spring box. As soon as the first bucket is removed from the box, start the stop watch. The water level in the spring box will drop down by few cm.

3. Keep watching the water level. As soon as the water comes to the earlier level, stop the watch and note the time.
Suppose, 40 lt of water was taken out from the spring box.

The time taken for the water level in the spring box to return back to its original level (post withdrawal) is 4min15sec.

Now 15 sec = 15/60 = 0.25min

Therefore 4min 15sec = 4.25min

Therefore Discharge of the spring = 40 lt / 4.25min

= 9.4 lpm
Recording data (Format) for springbox discharge measurement

The format for collecting data for spring box is given below.

The first row is filled as example.

<table>
<thead>
<tr>
<th>Date</th>
<th>Vol (V) of water removed (litre)</th>
<th>Time taken to reach back at same level (t) sec</th>
<th>Discharge ( Q = \frac{V \times 60}{t} ) (litre/min.)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.05.20</td>
<td>40</td>
<td>35</td>
<td>68.6</td>
<td></td>
</tr>
<tr>
<td>16.05.20</td>
<td>40</td>
<td>45</td>
<td>57.8</td>
<td></td>
</tr>
</tbody>
</table>
Stream flow measurement techniques

**Area-velocity (float) method**

For suitable location, one should walk about 100 m downstream of the source to find a **straight stretch** of the surface flow. This is essential as the velocity of flow changes drastically with cross sectional area. This stretch should be as long as possible. In the mountains, a straight stretch of about 5m is considered good. But discharge can be measured even if the straight stretch is about 1m or so.
Two markings are made on the ground – one on the upstream and other on the downstream side (Distance).
A float, which can be leaf, bush or paper is then placed/thrown on the upstream of the marking and the stop watch is started as soon as the float reaches the upstream mark point (A). The watch is stopped as soon the float reaches the downstream mark (B). The time taken by the float to flow between these markings is noted down. This process is repeated for at least 3 times and the average time taken is considered.

**Velocity** \( (v) = \text{Distance} \ (d)/\text{time} \ (t) \)

If the distance of straight stretch is 200cm and average time taken 10 seconds then the velocity of flow.
\[ V = 200/10 = 20 \text{cm/s} \]
Determining Cross sectional area of the flow.

Ideally this has to be taken at three places – one on the upstream side, one on the downstream side and one at the centre of the straight stretch. But if the sections seem to be similar, the middle section should be considered.

Measure the width of the stream at the middle section. And measure depth of the stream at different points across the stream at the cross section. Now if the depth of flow is about 2cm, then measure depth at 3-4 points and take the average depth. Multiply this depth with width to get cross sectional area of the flow.

Let the average depth be 2cm and width be 15cm.
Then Cross sectional area = avg. depth x avg. width
= 2 cm x 15 cm
= 30cm²

Now we know V = 20cm/s, therefore discharge
Q = A x V = 20 x 30 = 600cm³/s
= 0.6lps or 0.6 x 60 = 36 lpm
# Recording Surface Flow Discharge

The format for collecting data for surface flow is given below. The first two rows are filled as an example.

\[
Q = \frac{60 \times A \times V}{1000} \text{ (litre/min.)}
\]

<table>
<thead>
<tr>
<th>Date</th>
<th>Velocity (v) of water (cm/sec)</th>
<th>Area of cross section (A) (cm³)</th>
<th>Discharge Q = ( \frac{60 \times A \times V}{1000} ) (litre/min.)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.05.20</td>
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<td>487.5</td>
<td>1170.0</td>
<td></td>
</tr>
<tr>
<td>16.05.20</td>
<td>35</td>
<td>413.6</td>
<td>868.6</td>
<td></td>
</tr>
</tbody>
</table>
It should be kept in mind that the actual velocity of the flow is not at the water surface, but at about $\frac{2}{3}$ depth from the surface. For lower depths, usually this is not considered but in case the depth of flow in more than say 30cm this has to be considered. This could be the case for streams in bigger watersheds (like second or third order streams).

For this either we use a correction factor of 0.8 to get the discharge or get the velocity by using a float with attached pebble at $\frac{2}{3}$ depth from the surface of the flow.
Measuring Flow Data

Source: Arizona Department of Environmental Quality (ADEQ)
V-notch method

High stream flow discharges (even low) can also be measured by using triangular notch also called as ‘V’ notch. Earlier it used to be a masonry structure, usually constructed at the lowest point of a watershed. Now this can be easily made using GI sheet by the local fabricator and installed at the lowest point of the watershed at the narrowest part of the stream.

The simplest way to make a V notch is to make it at 90°. This also simplifies the discharge calculation. It has to be ensured that all the water from the stream passes through the notch and not out side the instrument. The height of water from the tip of the notch is measured called the head. The head of water changes with the discharge. It is measured with the use of a scale.
The discharge can be measured by using Thompson’s equation for 90° notch.

\[ Q = 0.8388H^{5/2} \]

where

- \( Q \) = Discharge in lpm and
- \( H \) = Head in cm

The discharge measurement table provided in the next slide can also be used to calculate the discharge from the stream.

Source: ACWADAM
## Surface Flow Discharge through $90^\circ$ V Notch

<table>
<thead>
<tr>
<th>Head in cms</th>
<th>Discharge (lpm)</th>
<th>Head in cms</th>
<th>Discharge (lpm)</th>
<th>Head in cms</th>
<th>Discharge (lpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.9</td>
<td>9.5</td>
<td>246.0</td>
<td>18.0</td>
<td>1213.6</td>
</tr>
<tr>
<td>1.5</td>
<td>2.4</td>
<td>10.0</td>
<td>279.2</td>
<td>18.5</td>
<td>1299.7</td>
</tr>
<tr>
<td>2.0</td>
<td>5.0</td>
<td>10.5</td>
<td>315.4</td>
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<td>1389.3</td>
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<td>2.5</td>
<td>8.74</td>
<td>11.0</td>
<td>354.3</td>
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<td>1579.3</td>
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<tr>
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<td>12.0</td>
<td>440.4</td>
<td>20.5</td>
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<tr>
<td>4.0</td>
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<td>487.7</td>
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<td>1784.2</td>
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<td>37.9</td>
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<td>49.4</td>
<td>13.5</td>
<td>591.2</td>
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<td>2004.3</td>
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<td>95.1</td>
<td>15.0</td>
<td>769.4</td>
<td>23.5</td>
<td>2363.6</td>
</tr>
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<td>7.0</td>
<td>114.5</td>
<td>15.5</td>
<td>835.1</td>
<td>24.0</td>
<td>2491.3</td>
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<td>7.5</td>
<td>136.0</td>
<td>16.0</td>
<td>904.0</td>
<td>24.5</td>
<td>2623.1</td>
</tr>
<tr>
<td>8.0</td>
<td>159.8</td>
<td>16.5</td>
<td>976.4</td>
<td>25.0</td>
<td>2759.0</td>
</tr>
<tr>
<td>8.5</td>
<td>186.0</td>
<td>17.0</td>
<td>1052.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.0</td>
<td>214.5</td>
<td>17.5</td>
<td>1131.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Rectangular weir method

High discharges can also be measured using a rectangular weir which are usually constructed at the lowest point of the watershed. These are masonry structures.

During measurement from rectangular weir, the following things should be ensured,

1) The base of the weir surface should be uniform and smooth.
2) The length of the weir should be measured precisely.

Using Francis equation,

\[ Q = 1.84 \times L \times H^{3/2} \]

where,

\[ Q = \text{Discharge in m}^3/\text{sec} \]
\[ L = \text{Length of the weir (or channel width) in ft} \]
\[ H = \text{Head of water over of the weir in ft} \]

Taking \[ H = 0.16 \text{ ft.} \] and \[ L = 0.9 \text{ ft.} \]

\[ Q = 3.33 \times (0.9 - 0.2 \times 0.16)^{1.5} \]
\[ Q = 3.33 \times (0.87)^{1.5} \]
\[ Q = 0.17 \text{ cu.ft/sec} \]

Converting it in lpm

\[ 288 \text{ lpm} \]
Questions

• What are the different forms of springs discharge?

• What is the benefit of spring discharge measurement?

• What is the most common unit of spring discharge?

• What is the benefit of stream discharge measurement?

• How is stream velocity measured?

• At what depth is the average velocity of stream located?

• How are high stream discharge measured?
Links to the videos

Springbox discharge measurement method

https://drive.google.com/open?id=1fQF85CzYaLiDoQ9Nt_fEcF4XSQ-kQY60

Stopwatch-container method

https://drive.google.com/open?id=13f7jvZhLTf1ZAGyxpYpOUSQuvCWOfDWhn
Thank You

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