Flow estimation for streams and small rivers

In order for Hydromatch to calculate scheme details and suggest products the head and flow details of the site must be input. This document covers simple methods of measuring the flow rate. For details of how to use these measurements see the document '<u>Flow characterisation for Hydromatch'</u>.

The methods explained in this document are

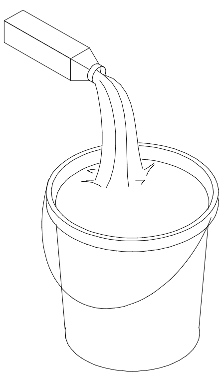
- The bucket method
- The float method
- V-notch weir

The Bucket Method

A simple method of finding small flows (up to about 15 l/s) is to use a bucket and a watch. In fact any large, waterproof, container is suitable, providing that you can first find its volume in litres. A 15 litre bucket is suitable for the smallest flows (3 litres per second or less) and larger ones for bigger flows.

STEP 1: Find the volume of the bucket

Take a smaller container with a known volume. A one litre water bottle is a good example. Count how many litres are required to fill the bucket with water using the smaller container. Mark the level in the bucket when the maximum number of complete litres has been added.



STEP 2: Find a place to measure the flow.

This can be difficult. You need to find a method of directing the water in the stream into the bucket. It is important that as little as possible escapes. If some does escape, estimate a percentage and add on to the measured flow.

STEP 3: Take the measurements.

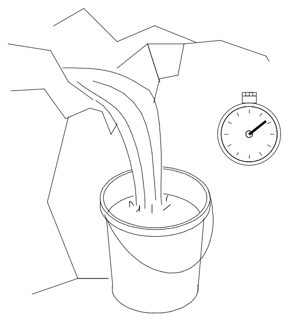
Using a stopwatch record how long the bucket takes to fill to the marked level. Repeat this at least 3 times and average the results. If you find that the bucket fills in less than 5 seconds, your results will not be very accurate. For more accuracy it is better to use the largest container which you can find or try another method of measuring the flow.

STEP 4: Work out the flow in litres per second.

If the bucket holds 15 litres and takes 8 seconds to fill then the flow is 15/8 l/s or 1.87 litres per second

Suggestions of methods to divert water into the flow measuring container

1. Natural Waterfall



2. Build a weir from available materials and use a wooden channel, a corrugated sheet or a piece of pipe to channel the water.

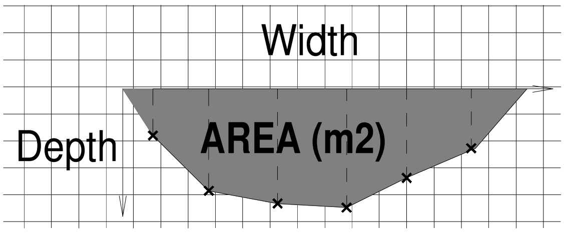
The Float Method

This works well in canals or channels. It can also be used in rivers and streams although with less accuracy. Two pieces of information are needed to calculate the flow by this method. The first is the **cross-sectional area** of the water flowing in the stream or channel. The second is the **speed** that the water is flowing. This is measured using a float and timing its travel between two points a known distance apart. A plastic bottle with the cap replaced makes an ideal float.

STEP 1: Find the cross-sectional area (CSA)

The difficulty of measuring the cross-sectional area depends on the type of flow under consideration. Estimating the CSA in a smooth-sided channel is much easier than in a shallow, rocky stream.

To estimate the area at a particular point, measure the width and then take depth measurements at regular intervals across the flow. Plot the depth measurements on squared paper. Join them up with straight lines to the width that is marked along one axis to create an enclosed area. The area can be estimated by counting the number of squares that are enclosed. Multiply the number of squares by the area which one square represents in m^2. Repeat these measurements in the middle and at the other end of the length over which the float is being timed (approximately 10 metres). Three values of the CSA will allow an average to be calculated.



STEP 2: Measure the speed of the flow (surface velocity)

A length (L) of 10 metres between the marking points should be sufficient. Put the float in the water several meters upstream of the first marking point. Begin to time the float when it passes the first marker and stop as soon as it passes the second. Repeat at least three times for consistent results. For the test, choose the straightest section of stream with the most even cross-sectional area.

STEP 3: Calculate the flow in litres per second

The flow is the product of the average stream area and the average velocity of the flow: Since the water moves more quickly on the surface than in other parts of the stream, an additional factor must be introduced which takes this difference into account. The difference between the surface velocity and the average stream velocity depends on the type of stream. Guideline "velocity correction factors" are given below. The table also gives an indication of the accuracy that can be expected. Divide the answer by 1000 for a flow rate in litres per second. Clearly, the accuracy of the float method is limited because of the requirement for correction factors and the difficulty of measuring the cross-sectional area of many streams.

Type of stream	Velocity correction factor	Accuracy
A rectangular channel with smooth sides and bed	0.85	Good
A deep, slow moving stream	0.75	Reasonable
A small stream with a smooth bed	0.65	Poor
A quick, turbulent stream	0.45	Very poor
A very shallow, rocky stream	0.25	Very poor

The equation to calculate the flow is:

$$Q = A_{ave} \times V_{surface} \times \text{Correction Factor}$$

where

Q= Flow rate (m^3/s)

A_{ave}= Average cross-sectional area (m^2)

$V_{surface}$= Surface velocity (m/s)

Example Calculation: Finding the Flowrate using the Float Method

What is the flow in a small channel where the following information has been obtained?

1) The water in the channel is 25 cm deep, the sides of the channel are approximately square and the width is 40 cm. The side are quite smooth.

2) When a plastic bottle was floated down a 20m section of the channel it took a) 36 b) 40 and c) 44 seconds

Answer:

(i) Cross sectional area of the water in the channel

= 0.25 x 0.4

= **0.1 m^2**

(ii) Average time taken

= (36+40+44)/3

= **40 seconds**

Average surface velocity

= 20metres/40seconds

= **0.5 m/s**

(iii) Correction Factor for a smooth channel

= 0.85

(iv) **Flow = Area x velocity x correction factor**

= 0.1 x 0.5 x 0.85

= **0.0425 m^3/s**

The flow in litres per second

= 0.0425 x 1000

= **42.5 litres per second**.

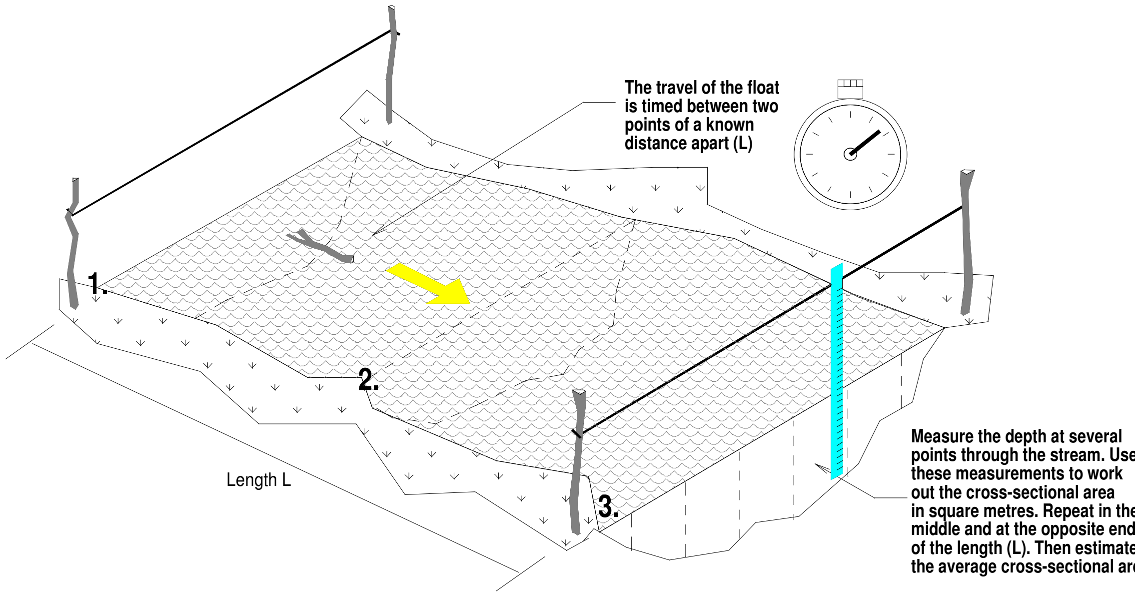


Figure 1: The float method of flow measurement

Flow measurement using a V-notch weir

STEP 1: Weir design

For measurement of small flows (up to 150 litres per second) a weir of V-notch design is usually the most appropriate. This gives a greater level change for an increase in flow when compared with a rectangular weir and allows accurate estimation of flows with relative ease.

It is important that the guideline proportions detailed in Figure 2 are adhered to. The V- notch should preferably be made as thin as possible. A carefully cut metal sheet attached to a heavy marine plywood board for rigidity is ideal. The plywood notch should be cut larger than the sheet to allow a sharp weir crest to be formed. Also of particular importance is that the water height over the weir is measured some distance away from the weir crest. The recommended distance at least 4 times the maximum water height over the notch. A spirit level will be required when fixing the measuring gauge in place to ensure that its base corresponds with the bottom of the notch as shown in the diagram.

How the weir is constructed will depend on the nature of the bank and available materials. Fence posts driven into the stream bed to hold the sheet in place are one solution to achieving stability under varying flow conditions. Another is to position large stones either side. A heavy polythene sheet fastened over the weir and held in place with stones and gravel across the stream bed a couple of metres upstream and up both banks can be used to provide an effective seal although some experimentation will probably be required to provide the most workable and robust solution.

Note: *Anyone proposing to install a weir in the UK, whether permanent or temporary, should first seek Flood Defence Consent (sometimes called Land Drainage Consent).*

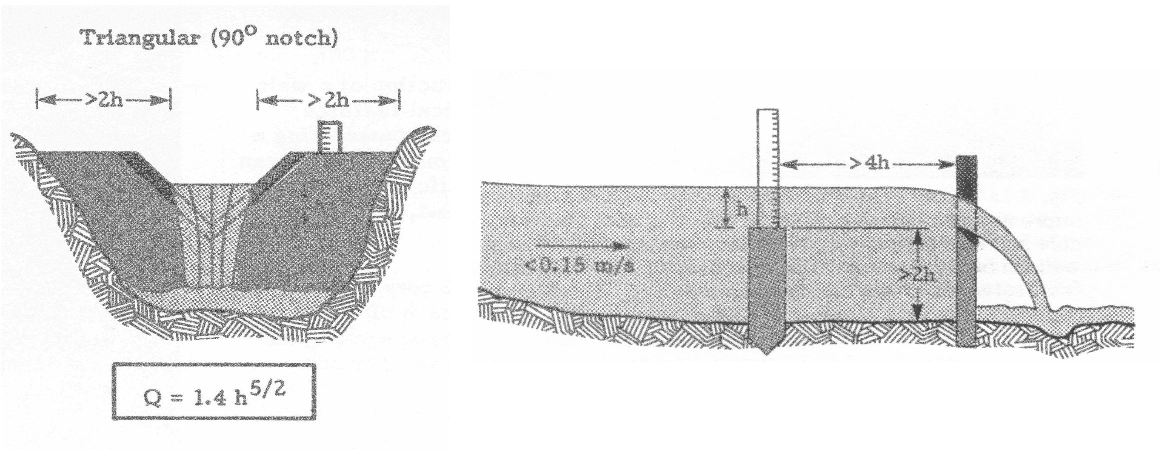


Figure 2: Correct proportions of a V-notch weir

Figure 3: Suggested method of V-notch weir construction

STEP 2: Calculating the flow rate

The graph below may be used to covert the level measurements into a flow in litres per second. Alternatively, use the formula in Figure 2 to calculate the flow rate from the level measurement. Note that measured height ‘h’ must be given in metres. The flow rate, Q, is calculated in cubic meters per second (m^3/s). Divide this value by 1000 to give a flow in litres per second if the formula is used.

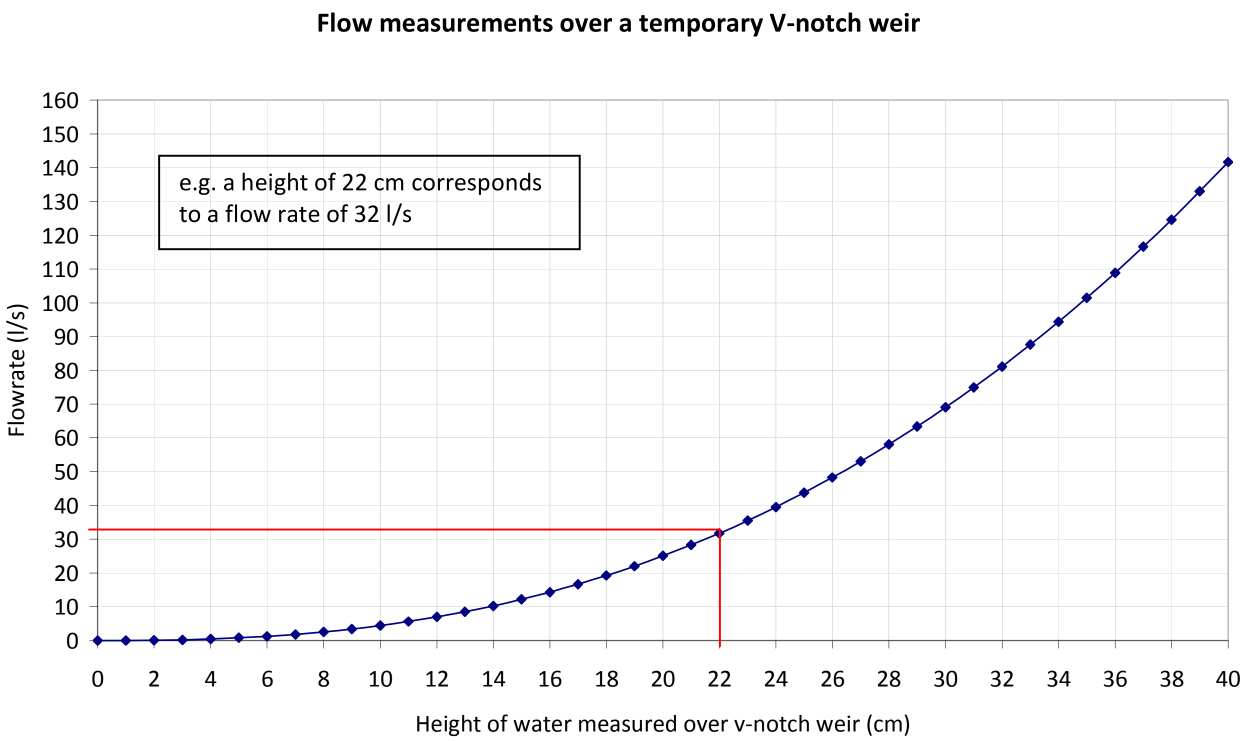


Figure 4: Flow rates from a level measurement over a V-notch weir

For details of how to use these measurements see the document ‘[Flow characterisation for Hydromatch’](Flow characterisation for Hydromatch).