Important Safety information

BE AWARE – BE SAFE

Fieldwork Safety when working in streams or rivers

There are a number of things to consider when carrying out work in streams or rivers.

1. CHECK THE WEATHER FORECAST before you go out on fieldwork. In heavy rain rivers can rise quickly and what was a gentle trickle can become a torrent in a short space of time. Fast moving water which is higher than knee-deep can easily take you off your feet, especially if working on an uneven, or rocky river bed.

2. WEAR THE RIGHT CLOTHING for the day. If you get wet then you will get cold. Cold is unpleasant and uncomfortable at best and life threatening at worst (hypothermia).

    Always make sure you take enough clothing even in summer. You'll be surprised how quickly you can get cold if you are wet, even on a summers day.

3. NEVER WORK ALONE and always let someone else know WHERE you are working and your

    EXPECTED TIME OF RETURN.

4. Moving water is powerful, and the banks of rivers may be undercut.

    CHECK THE STABILITY OF THE BANKS before you start working on the channel so you don't fall in before you've even started!

5. River beds can be very rough, or have a bed-load of boulders which can easily move underfoot. CHECK THE CHANNEL IS SAFE before stepping into it. Water can appear deceptively shallow at times.

    Check how deep it is before stepping into the channel.

1.0 Key Components

Sturdy Carrier

Operation Manual

USB Cable

Protective Case for Flowmeter

Electronic Flowmeter

Riser Rods

Impeller Stick

Impeller Unit
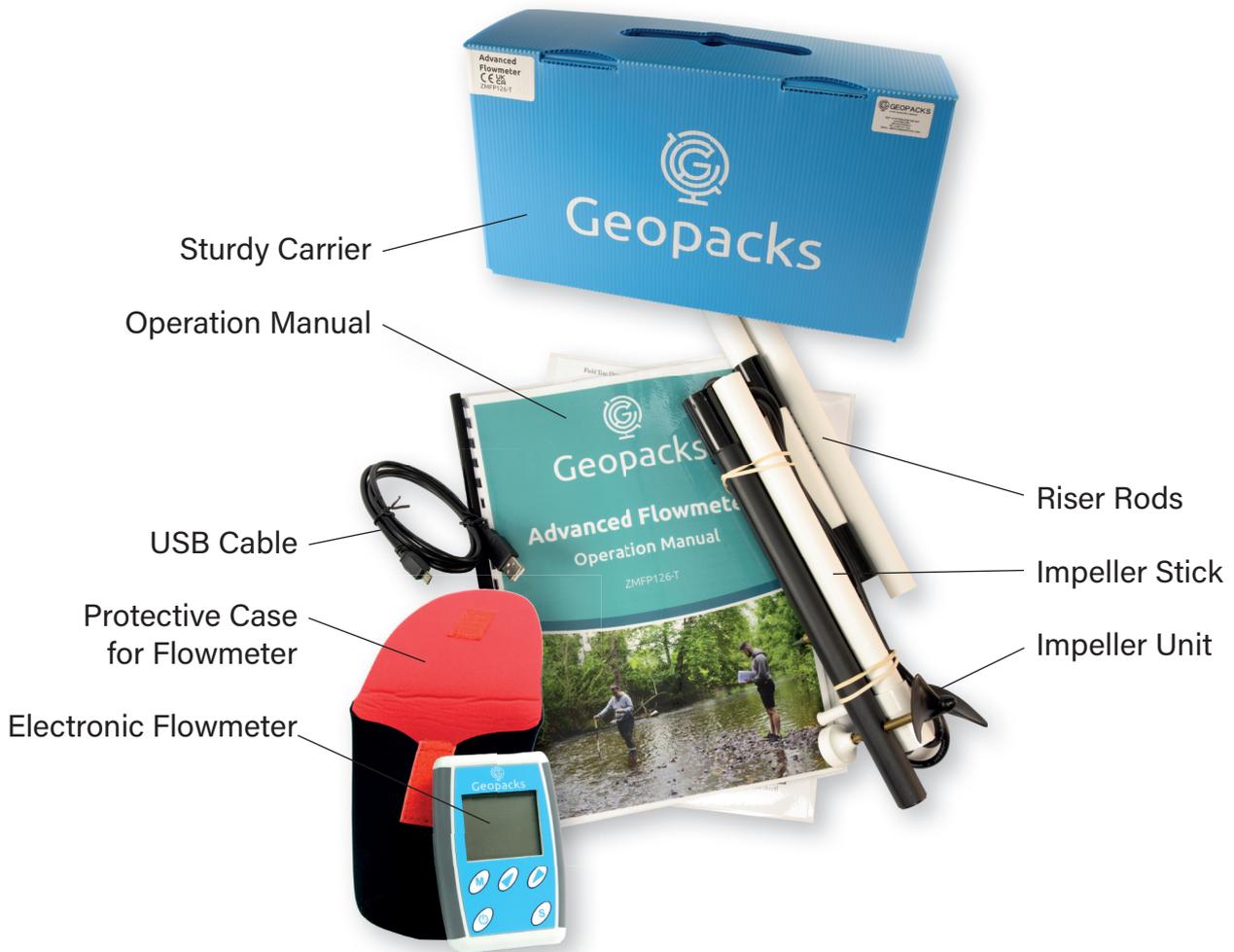
Impeller Stick

The impeller stick is used for measuring water velocity and consists of:

- An **IMPELLER** and coupled **SENSOR** in which a switch opens and closes as the impeller is rotated by the flow of water and a temperature sensor.

- Four 250mm long tube sections which slot together to make a 1m stick.

- Three "riser rods" which when slotted singly or in combination, allow the impeller to be elevated above the stream bed at fixed heights – 250mm, 125 mm and 75mm or combinations of these up to a maximum of 450mm.

- A 1m long cable which connects to a flowmeter.

- A USB cable which connects the flowmeter unit to a laptop or PC to allow data transfer. Data is stored as a CSV (comma-separated-values) file which can be used without modification in Excel, Word etc.

Cable

Impeller

Riser
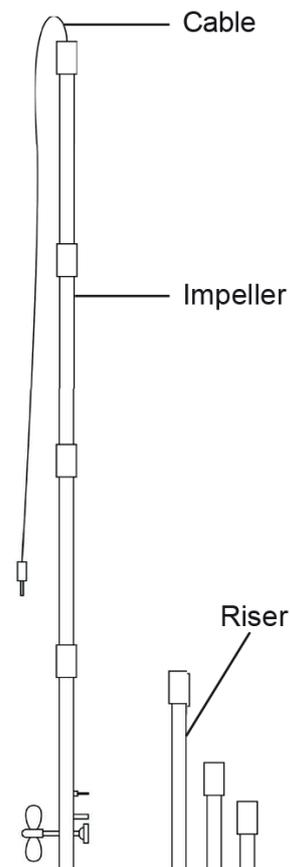
Geopacks Advanced Flowmeter Setup

Before using the flowmeter you need to:

- Assemble the stream impeller stick (see page 4).

- Insert the jack plug from the impeller stick into the socket.

- Set up the meter with the date, time and the units which you wish to use for measuring (metres/sec or mph). This action adds the date and time to your data file so you can track it later.

- Initiate motion of the sensor in the water.

- Switch the instrument On - the ⏻ button also brings the flowmeter out of sleep mode.

The Flowmeter Display

Download

Battery Condition

USB

Main Flow Display

Logging Mode

Temperature Field

Time and Date Field

Menu Area

Logging   Session
88/88/88 88:88:88
Temp Int 88.8 Ext 88.8°C F
8.8.8 mph ms⁻¹
Man Auto 88
Time 88:88:88
Date 88/88/88
Date
Time
Units
Log
Run
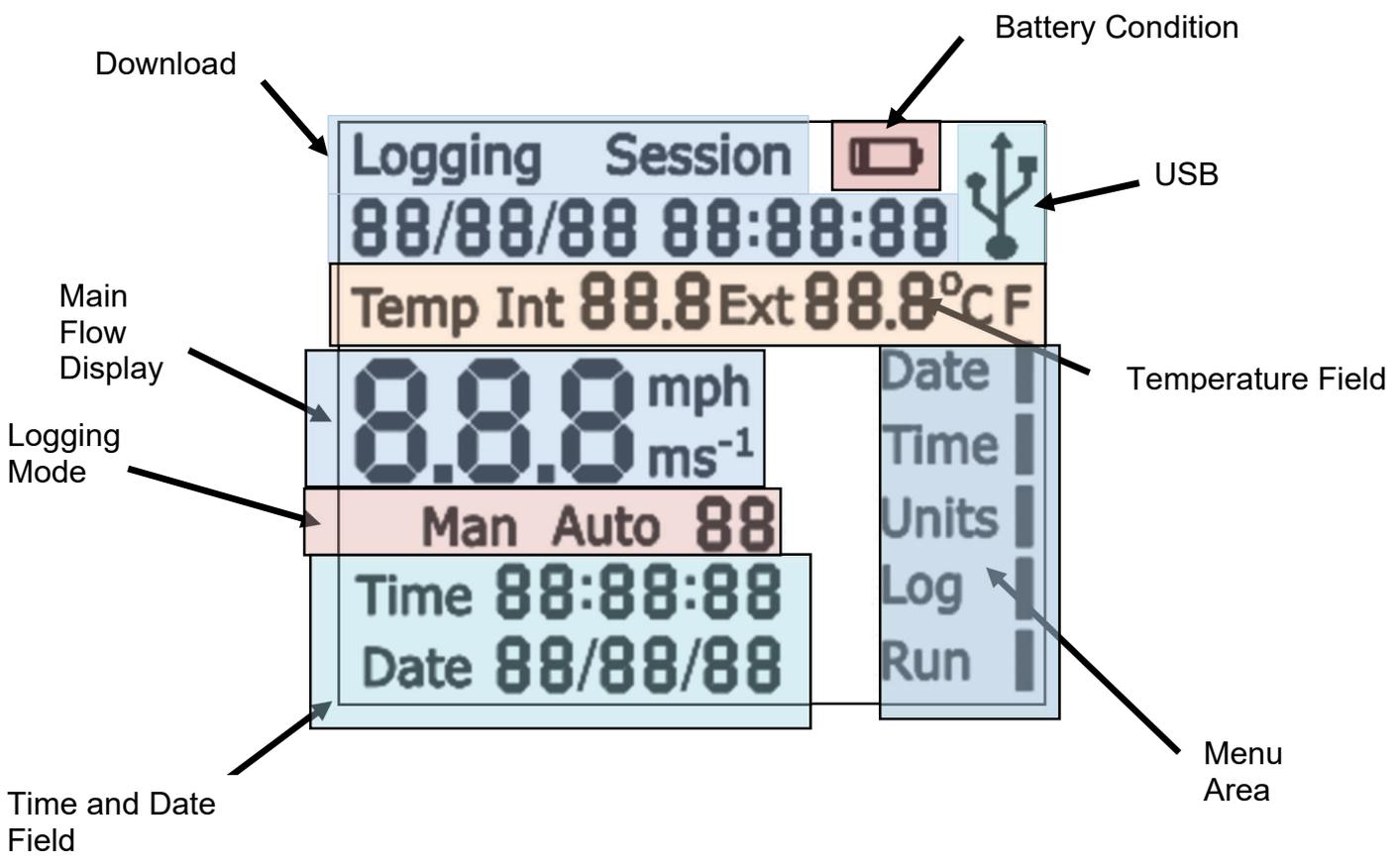
How to set up the Flowmeter

1. Remove the plastic tag from the battery compartment. Only the temperature field will be displayed.

    If the impeller is not plugged in the external temperature will be flashing 13.0. This indicates a temperature of minus 13.0 and is the lower limit of temperature measurement. If the impeller is plugged in then the internal and external temperatures will indicate the measured values.

2. To start setting up the Flowmeter press the **M** key.

    The menu area will now be displayed with the indicator bar next to the **Date**.

    Using the and keys move the indicator bar to the required menu item to be set up.

3. **Setting the Date**

    Press the or arrow keys until the indicator bar is next to the Date field.
    On opening the Menu this is the default position.

    Press the **S** key to open the Date field.
    The display will now show Date 00/00/00 with the tens of years digit flashing.

    Use the and keys to increment or decrement the digit until you arrive at the correct

    tens of years. Press **S** to confirm.

    The units of years will now start flashing so using the same process find the correct units of years and Select to confirm.

    The tens of months will now be flashing so repeat the process for the month and days until you have entered the correct date

    By entering the Year then Month then Day the Flowmeter will not give an invalid date e.g. month 13 or 30 February.

    When complete there will be no flashing digits in the Date field

4. **Setting the Time**

    If you have just set the Date then the Menu bar will still be active so move the indicator bar next to

    the Time field and press **S** to confirm.
    The display will now show Time 00:00:00 with the tens of Hours digit flashing.

    Using the and keys to increment and decrement the digit and the **S** Key to confirm

    step through the time field until you have set the correct time. When the time is set there will be no flashing digits in the time field. The time will start running when the unit is set to Run.

    You cannot set the seconds field. This is set to zero when the time is confirmed so if you need the time correct to the second set the time one minute ahead and press the final confirm as the time on your clock passes zero.

5. **Setting the DISPLAY and RECORDING UNITS**

   You must set the units for the Flowmeter to run.

   If the Menu bar is not active then press the [M] key to activate it.

   When the Menu bar is active then move the indicator bar to the Units Field

   Press [S] to confirm.

   The ms^{-1} will start flashing next to the main flow display position.

   Using the [◀] and [▶] keys you can step between ms-1 and mph.

   When you have selected the required flow units press [S] to confirm.

   At this point the main reading digits will appear with a correctly positioned decimal point.

   The C will now be flashing next to the temperature field and you can select between degrees C and F in the same way.

   Press [S] to confirm.

6. **Setting the Logging Mode**

   If the Menu bar is not active then press the [M] key to activate it.

   When the Menu bar is active then move the indicator bar to the Log Field

   Press [S] to confirm.

   Using the [◀] and [▶] keys you can step through the Log mode options.

   How these options work:

   a. **Manual Log** – the flowmeter will store the reading whenever the [S] button is pressed whilst running. The reading is stored in a file called **Flowdata.csv** which is accessible via the USB connection to a laptop or PC.

      To set up Manual Logging press the [◀] or [▶] arrow keys until MAN is flashing.

      Press [S] to confirm.

      When in Manual Log mode when the [S] is pressed the MAN icon will momentarily extinguish to indicate that the reading has been recorded.

b. **Auto Log** – the Flowmeter will record at predetermined intervals whilst unattended.

To set up Auto Logging press the [◀] or [▶] arrow keys until **Auto** is flashing.

Press [S] to confirm.

The display will now show Auto 00 with the tens of minutes flashing.

Using the [◀] and [▶] keys to increment or decrement the tens of minutes.

Press [S] to confirm.

Repeat the process for the units of minutes.

You may set any period from 1 to 59 minutes.

In AUTO Log mode the screen will go blank when the Flowmeter is set to run as the unit sleeps between Logging.

To terminate Auto Log press the [⏻] key. The flowmeter will then wake with all logging turned off.

c. **Clear Data** – Clear Data deletes ALL the data from the **Flowdata.csv** file and sets the logging 'file pointer' back to zero.

This should only be necessary when the FULL message appears at the top of the display in the download area. This indicates that the flash is full and there is no room for new data.

To Clear Data press the [◀] or [▶] arrow keys until Clr d is flashing at the top of the display.

Press [S] to confirm.

The display will now show 'surE n' at the top of the display.

If this is confirmed with the key the data will not be deleted and the meter will return to the menu.

Use the [◀] or [▶] keys to scroll to 'surE y' if you wish to proceed and delete all the data.

Press [S] to confirm.

The delete all data takes several seconds to complete in which time the 'y' will disappear. When complete the 'y' re appears and the menu becomes active for further set up or run.

d. **Logging Off** – turns off all logging.

This is only necessary when you wish to terminate a manual logging session. This will often be necessary if a new session is required for a new location, time or user.

To turn Logging Off press the ◁ or ▷ keys until LOG OFF

Is displayed at the top of the screen.

Press (S) to confirm.

The Logging Off message will now be static at the top of the screen.

7. Finish setting up the Flowmeter

To complete the setup process and start the meter running use the ◁ or ▷ arrow keys until the menu indicator bar is next to Run.

Press (S) to confirm.

The menu will now disappear and the unit is running. The main display will indicate the flow rate together with the internal and external temperatures.

8. Sleep Mode

You may put the meter into sleep mode to conserve power at any time by pressing the ⏻ key for 3 seconds.

Equally if the Flowmeter detects no input for a period of 2 minutes the display will go blank and the meter will go to sleep to conserve power.

The flowmeter can be woken up by pressing the ⏻ key.

All settings, data and time /date are preserved while the meter is asleep.

Data are stored in flash on the Flowmeter so is preserved even if the batteries are removed.

9. USB Operation

To retrieve the logged data from the Flowmeter plug the microUSB cable (supplied) into the Flowmeter and a suitable PC or Laptop.

The USB icon will be displayed along with the time and date of the most recent logged session or 'no Data' if the flash is empty.

If more than one logging session exists on the Flowmeter you can use the ◁ or ▷ keys to scroll through the available sessions.

When you have found the session you require press (S) to confirm.

The Flowmeter will now connect to the PC. This might take a few seconds.

The Flowmeter appears on the computer as a very small flash drive named Flowmeter. The drive contains a read-only file named Flowdata.csv which contains the data for export to Excel (or any other application capable of using CSV files). If you are saving data from multiple meters onto a single PC then consider renaming each Flowdata.CSV file once it is downloaded to the PC before downloading the file from the new meter. Each meter will use the same file name for its CSV file so be careful not to overwrite one file with another. No attempt should be made to write to, delete, or format the flowmeter from a PC.

The flowdata.csv file will appear with the create date and time that was on the meter when the MAN log option was selected.

Each session in the Flowmeter can store just over 220 readings and the flash can store about 2000 sessions.

After this the data needs to be downloaded and the 'Clr d' option used to ready the meter for new logging.

10. **Battery Condition**

The battery is tested once a second at the same time as the temperatures are measured. The battery symbol at the top of the display will appear when the batteries are low. Data are retained even when the battery is flat or removed.

2.0 Operating Instructions

Impeller Stick with the Flowmeter

Slot the rods of the **IMPELLER** unit together and point the impeller up into the flow of moving water at the required depth (Figure 1a).

Use one or more of the three "riser" rods to elevate lift the impeller off the stream bed if necessary (figure 1b).
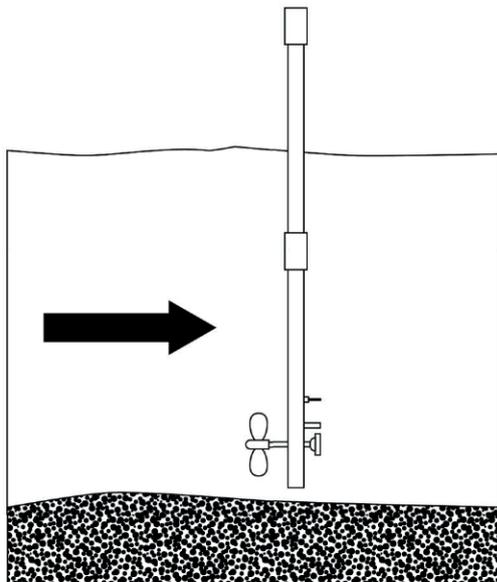
Figure 1a - Impeller Stick in the flow
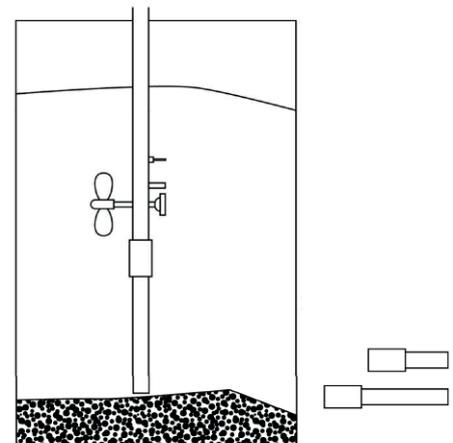
Figure 1b - Using Riser Rods

When the Impeller is turning at the correct depth (which will depend on the purpose of your measurements),

press the ⊘**S** button to log your reading.

When Manual logging, the MAN will momentarily disappear appear in the display when the button is pressed to acknowledge that data has been written to the data file.

In Auto Logging mode the display will remain blank with readings being taken at the prescribed

Interval until the session is terminated by pressing the key.

To start a new manual logging session it is necessary to stop the existing session by selecting the LOG OFF option in the Log menu and confirm; and then select the MAN option in the Log menu and confirm.

In order to have a clear record of which readings are taken at which location, river depth etc we recommend using the field observation chart included in the Appendix. See Section 4 on page 17 for further fieldwork information.

3.0 Stream Flow Velocity

3.1 Theoretical Background

A moving fluid exhibits certain important features. The flow velocity of a fluid depends upon the cross- sectional area of the flow, the roughness of the surfaces it is passing over (friction) and upon the quantity of fluid, which passes through that area in unit time. This is known as the DISCHARGE and illustrates the 'Principle of the Continuity of **MASS**'.
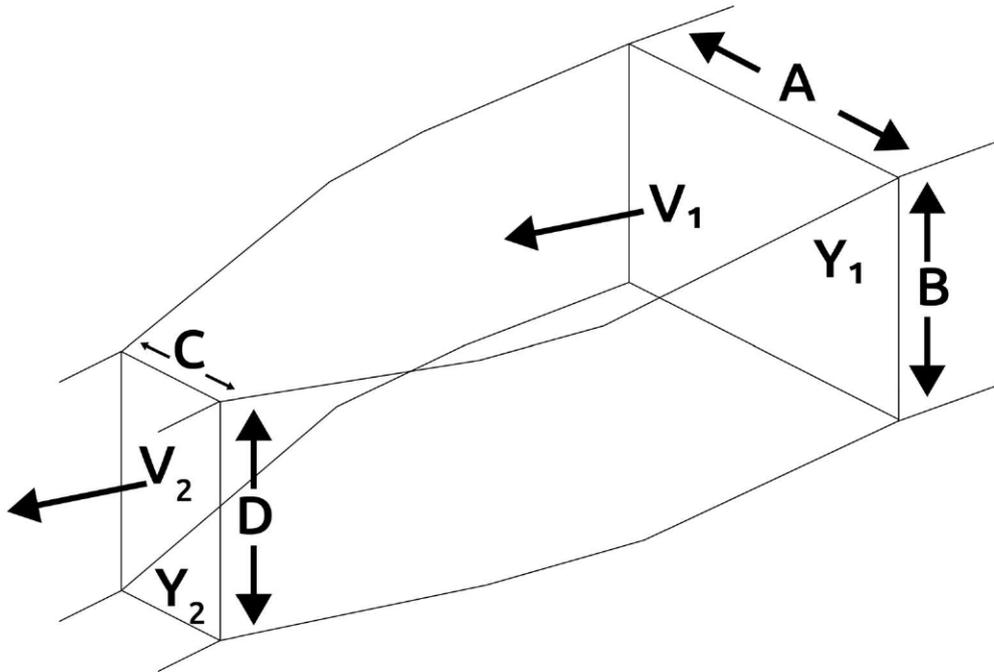
Figure 2: River Cross-sections and Flow Velocity

In the river channel depicted in Figure 2 the volume of water, which passes through section Y1 in a second, is the **DISCHARGE** (Q) and will be given by: **Q = a . b . V1**

and similarly at section Y2:   **Q = c . d . V2**

In these equations, a and c are the widths and b and d are the depths of the channel at the two sections, and V1 and V2 are the flow velocities. Since the same **DISCHARGE** (Q) passes through both of the sections then flow velocity relates to the difference between a . b and c . d (the crosssectional area); i.e. if the channel becomes either narrower or shallower then the flow velocity increases and vice versa.

This principle explains many of the variations in the river channel morphology and in flow velocity. It is therefore important that this principle be understood by anyone undertaking serious fieldwork measurements in rivers. This could be demonstrated by measuring channel cross-sectional area discharge at a number of different sections along a short stretch of river.

3.2 Describing Flows

To understand the flow characteristics within streams of moving water it is sometimes helpful to consider the flow in the form of **STREAM LINES** or **VECTOR LINES**.

Figure 3 shows how Stream Lines depict possible paths of a single fluid particle.
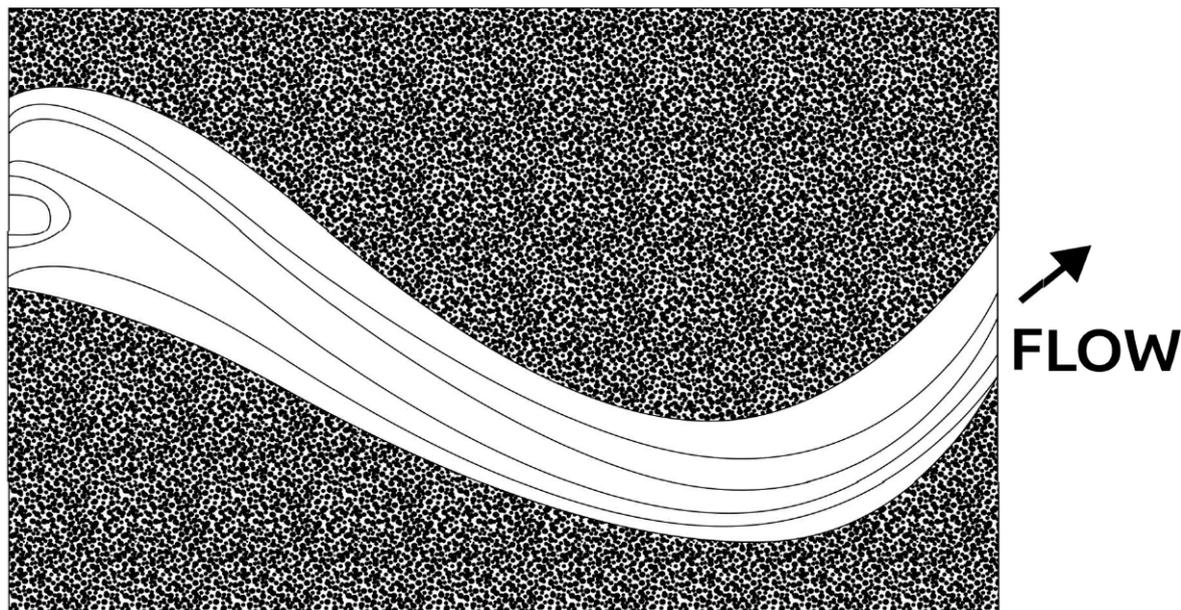
Figure 3 Stream Lines in a flow around a meander

Vector Lines represent both the flow direction and velocity. The longer and broader the line the greater the flow velocity. Vector lines convey useful information about the stream flow characteristics.
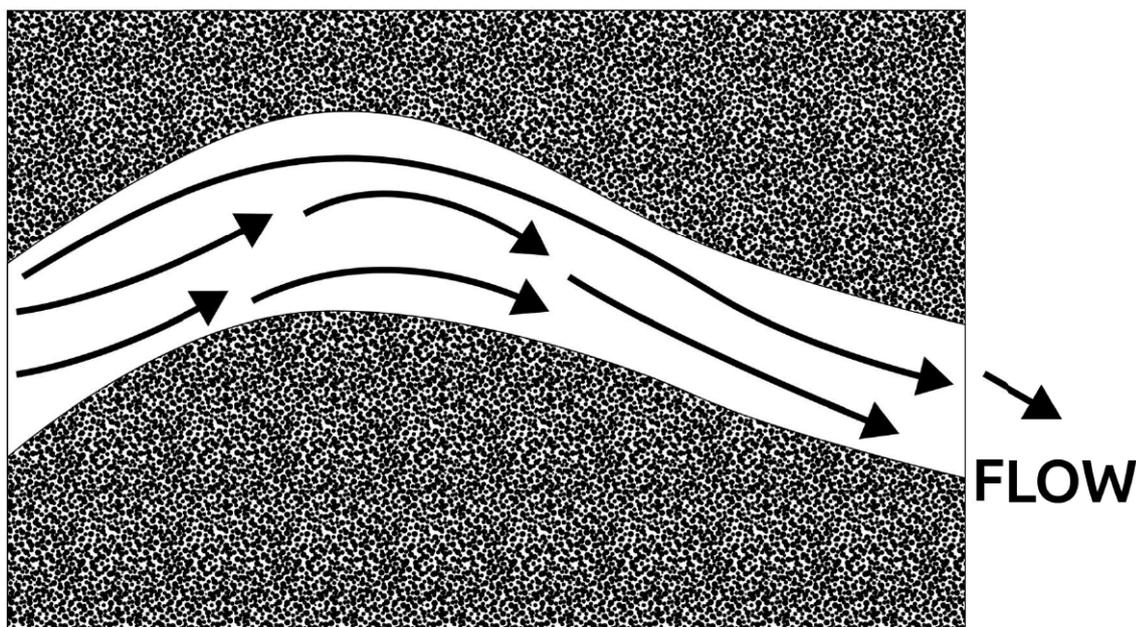
Figure 4 Vector Lines in a flow around meander

In this diagram the short thin arrows represent the slower areas of the stream and the long, thick lines the regions of faster flow.

3.3 Sediment Transport

The amount of sediment and maximum particle size that can be transported by moving water is related to the flow velocity. Therefore, measurements of velocity obtained using the flowmeter can be used to determine the maximum size of sediment particles, which may be transported by the flow (Figure 5).
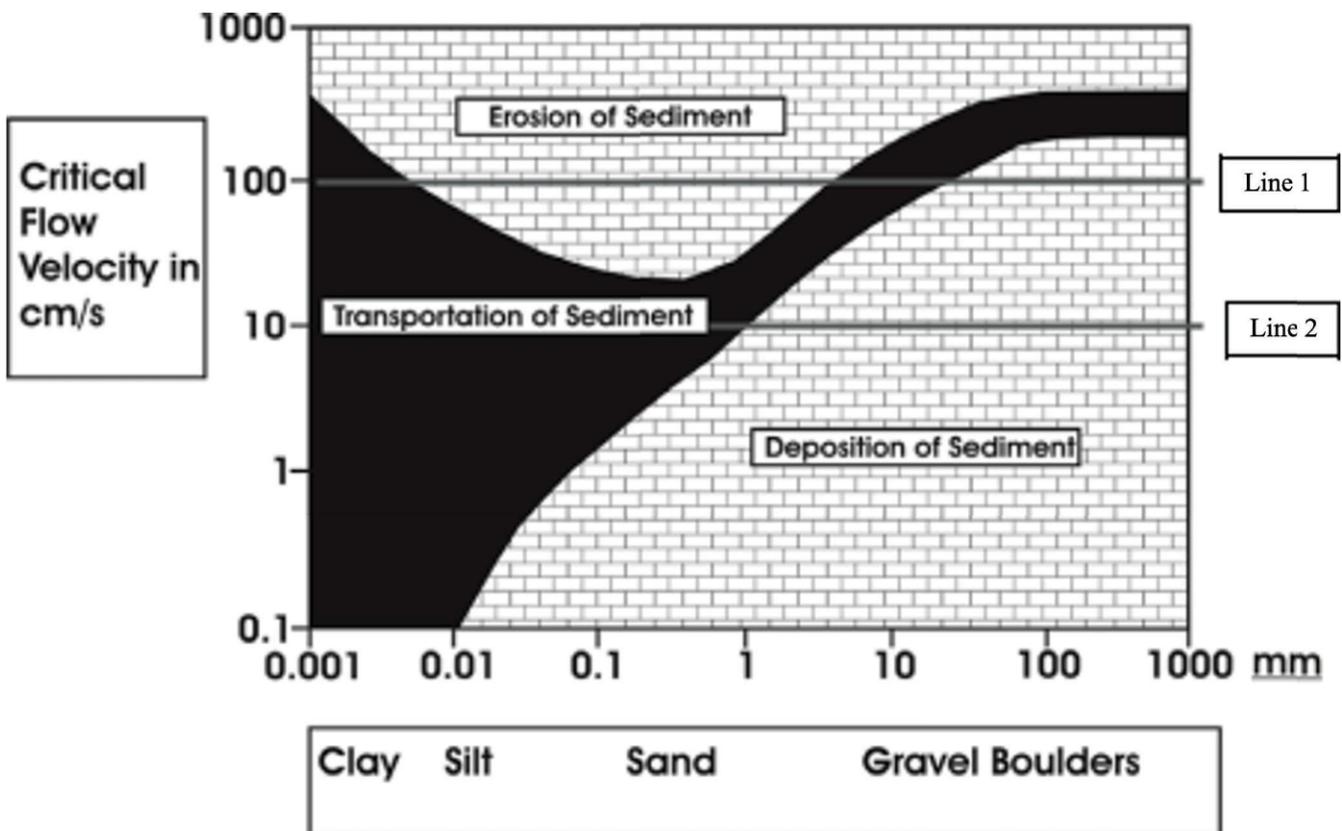
Figure 5 - Erosion Velocities for Water

The chart, which is referred to as the "Hjulstrom Curve", has been derived from a mass of accumulated observed data and shows that for a given flow velocity there are a range of behavioural possibilities for sediment particles lying on the bed, or entrained within the flow, of a stream. For example, at a measured flow velocity of 100 cm/s (1 m/s) silt and sand (though not compacted clay) will be eroded from the stream bed and transported downstream (see Line 1). At the same velocity, all sediment particles finer than 1mm, which were already in motion, will continue in motion. Where the stream velocity falls below 10 cm/s (0.1 m/s), due to, say, a widening of the channel, sediment particles greater than 1mm diameter will be deposited (see Line 2).

Thus, a stream flowmeter can be a valuable observation tool when used in sediment transportation studies. Observed flow velocities can be traced on the graph and the corresponding maximum particle size which can be transported at the velocity (the competence of the river) can be determined.

4.0 Studying Streams – Some fieldwork suggestions

4.1 Recording Stream Velocity

Equipment Needed:

> Geopacks Advanced Flowmeter
> Measuring tape
> Ranging pole
> Clipboard and pen
> Field observation chart
> Watch

Working in groups of two or three, students make rapid progress provided they work efficiently, know their objectives and have thoroughly prepared the ground. For example, one student works in, or above the stream with the meter while a second student uses a watch to note the time (and date) of the velocity recording. A third member of the group records the data, such as notes on the site, distance from the bank from which the measurements are being taken, also the depth of reading, recording time, and possibly, as a backup-plan to be on the safe side, the velocity.

Measurements of the distance from the banks and the position of the meter in the stream are vital. For systematic collection of stream velocity data, the position of the meter readings should always be recorded with reference to one bank – **DISTANCE OUT**. For example, in larger channels, where stretching a tape across is impractical, this may be determined by attaching a tape to the waist or belt of the student working in the stream with the meter. By standing on the bank, and holding the tape out horizontally across the channel one person can determine the position of the meter from the bank.
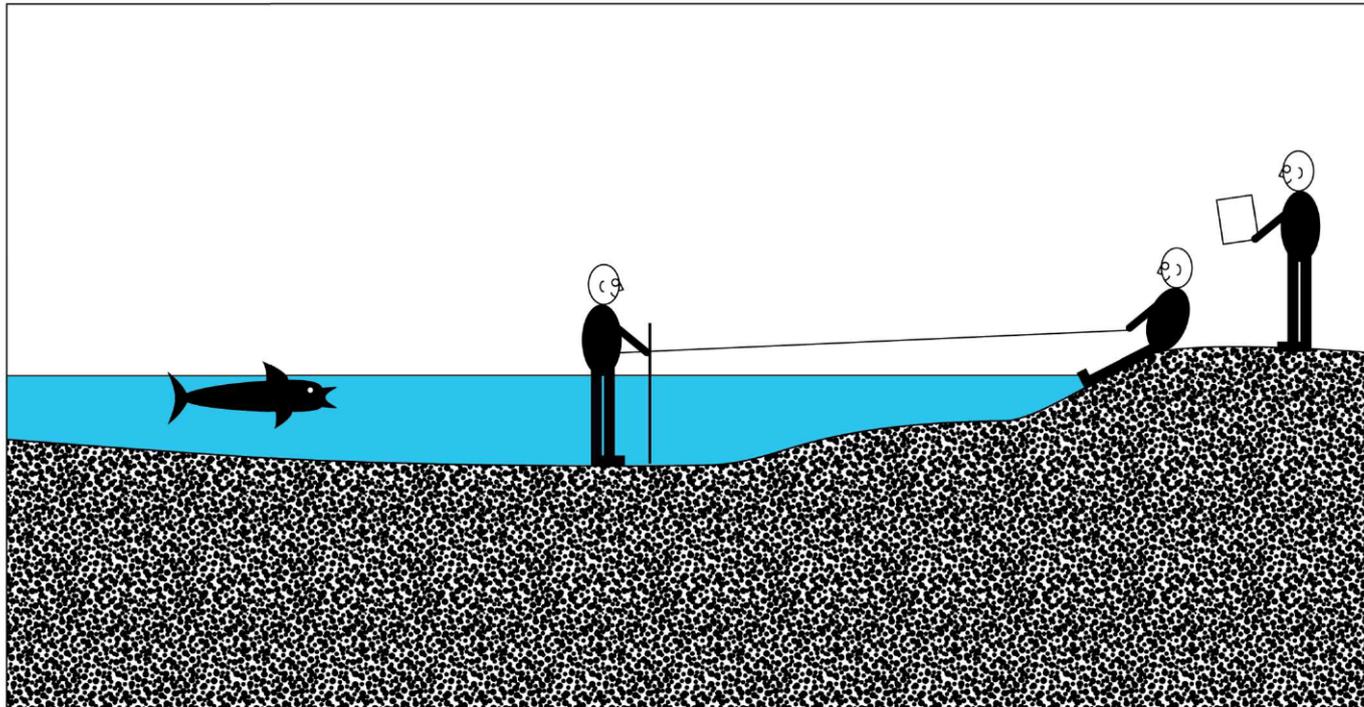
Figure 6 – Measuring "Distance Out" using tape attached to student's belt

In smaller channels it maybe more convenient to stretch the tape measure across the channel horizontally from the bank to bank. The ends of the tape can be attached to ranging poles on the bank or secured with heavy stones at each end.

Figure 7 - Measuring "Distance Out" using tape secured at each end

Depth of measurement (**DISTANCE DOWN**) can easily be measured if the flowmeter tubes are simply calibrated beforehand using tape or water-resistant paint or ink, or more accurately, by taping a meter ruler to them. In estimating water depth please note that each section of the flowmeter stem is 250 mm long. Total water depth from surface to bed (sometimes called the **WET READING**) can be measured with the impeller stick if less than 1M. It is useful to have an elastic band or some other device on the impeller stick which can be moved up and down the stem to the water level. This allows a reasonably accurate estimate of depth to be made visually. Alternatively, if calculating the position of 0.6 of the depth for mean water column velocity measurement, the band can be moved to the appropriate position along the stem.

Plotting the Channel Cross-Section

This is essential for meaningful stream velocity recording. A plan or "map" of the stream cross-section at each point where measurements are to be made forms the basis for recording observations.

One method of measuring and plotting the channel form is by stretching a tape measure across the channel as described above. Depths can be measured vertically down from the tautly stretched tape to the stream bed.

Measurements of channel widths and depths are then recorded using data sheet provided. At regular intervals along the tape, two measurements should be noted. Firstly, the distance from the tape to the ground or water surface known as the **DRY READING**. Secondly, the **WET READING** should be recorded. This is the depth of the water at each point.

Distance from Bank	Dry Reading	Wet Reading	Total
0m	0cm	0cm	0cm
0.25m	14cm	3cm	17cm
0.5m	14cm	15cm	29cm
0.75m	14cm	22cm	36cm
1.00m	14cm	31cm	45cm
1.25m	14cm	35cm	49cm
1.50m	14cm	38cm	52cm
1.75m			

This depth can be measured using the calibrated stem of the flowmeter, but more accurately by using a meter rule.

The greater the number of measurements taken at each cross-section, the more accurate the representation of the channel, however, the closer the readings are together the longer it will take. In small channels, which are less than say 2 metres wide, a horizontal interval of 10cms would be workable.

However, in a larger channel, maybe 5 or 6 metres across an interval of 20 or 25cms would give sufficient accuracy.
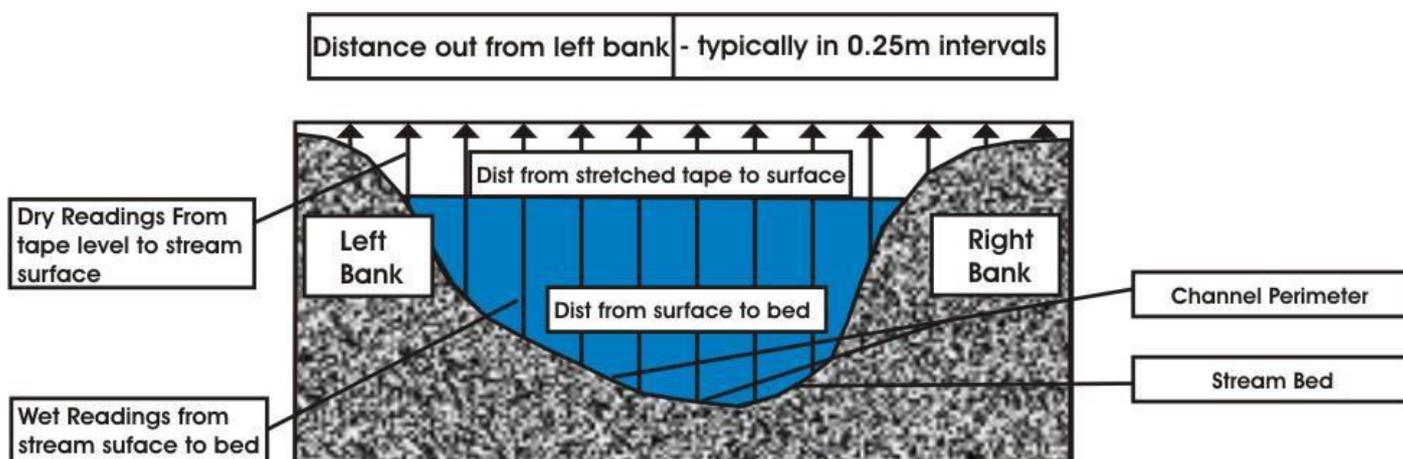
Figure 8 – Measuring & Plotting the Channel Cross-Section

Calculating Stream Discharge

In section 3.1 it was demonstrated (Figure 2) that:

DISCHARGE (Q) = Cross-Sectional Area x Flow Velocity

So, if the cross section area of a channel was 1 m^2 and the rate of flow was measured at 1 m/s, then the Discharge Q would be 1 m3/s (1 cumec). If, after heavy rain the channel area increased to 2m^2 and the flow velocity to 1.5 m/s then the discharge (Q) would be 3 m3/s or 3 cumec. Discharge is an important variable, unfortunately, it's not always easy to measure.
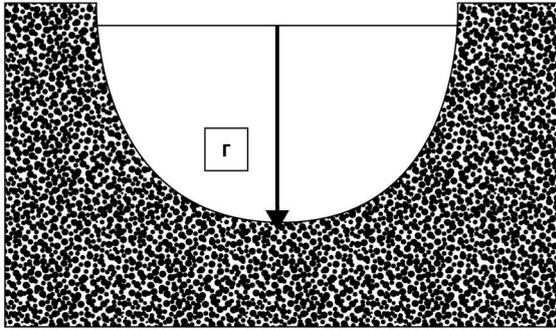
Figure 9a Semi-Circular Channel   *Figure 9b Rectangular Channel*
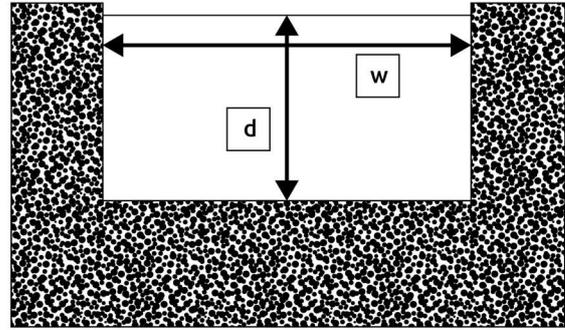
Calculating discharge in the case of either the semi-circular channel (Figure 9a) or the rectangular channel (Figure 9b) is relatively simple. In the semi-circular channel, if we take:

Radius of Channel (r)	=	1 m
Cross-sectional area (Δ)	=	ϖ^2) 2 = 1.57m^2
Mean Velocity (V)	=	1 m/s
Discharge (Q)	=	x V = 1.57 m^3/s

Similarly, in the rectangular channel, if the:

Depth (d)	=	1 m
Width (w)	=	1.5 m
Cross-sectional area (Δ)	=	1.5m^2
Mean Velocity (V)	=	1 m/s
Discharge (Q)	=	x V = 1.57 m^3/s

In a real-life situation, however, the channel geometry will be far from regular.
However, there is a "work around" which allows fairly accurate estimates to be made of these channel variables with a minimum of calculation. Try this...

Measured

Width	=	as measured (in metres)
Wet Readings	=	as measured (use metres – convert from cms if necessary)
Velocity	=	as measured (metres per second)

Calculated

Mean Depth	=	the mean average of all wet readings taken (in metres)
Cross Sectional Area	=	Width * Mean Depth (metres^2)
Wetted Perimeter	=	Width + (2 * Mean Depth)
Hydraulic Radius	=	Cross Sectional Area / Wetted Perimeter (metres)
Discharge	=	Cross Sectional Area * Velocity (metres^3 per second)

Unfortunately, there remains the problem of measuring the flow velocity in the channel. Because of friction with the bed and banks (the **WETTED PERIMETER**) and because of internal turbulence, stream velocity varies from point to point. Large numbers of observations under controlled conditions suggest that in water depths of less than 0.6m, a reliable average velocity can be recorded at a point, which is **0.6 of the depth of the water below the surface**. At this depth the faster surface flow is averaged out against the slower bed flow and this figure is an acceptable **EMPIRICAL GUIDELINE** (i.e. one derived from observation and experiment under a variety of circumstances).

A quick way of finding 0.6 of the depth requires a special piece of equipment – a rubber band! Follow this simple procedure:

Step 1   Rest impeller on stream bed

Step 2   Mark the water surface level with finger and thumb

Step 3   Remove stick from the water keeping water surface mark

Step 4   Visually estimate (or measure) 0.4 of the distance down the stick between the water surface mark and the base

Step 5   Place a mark (e.g. rubber band) at this point

Step 6   Submerge the impeller stick to this point on the stem

Step 7   The impeller will be approximately 0.6 of the depth from the surface down
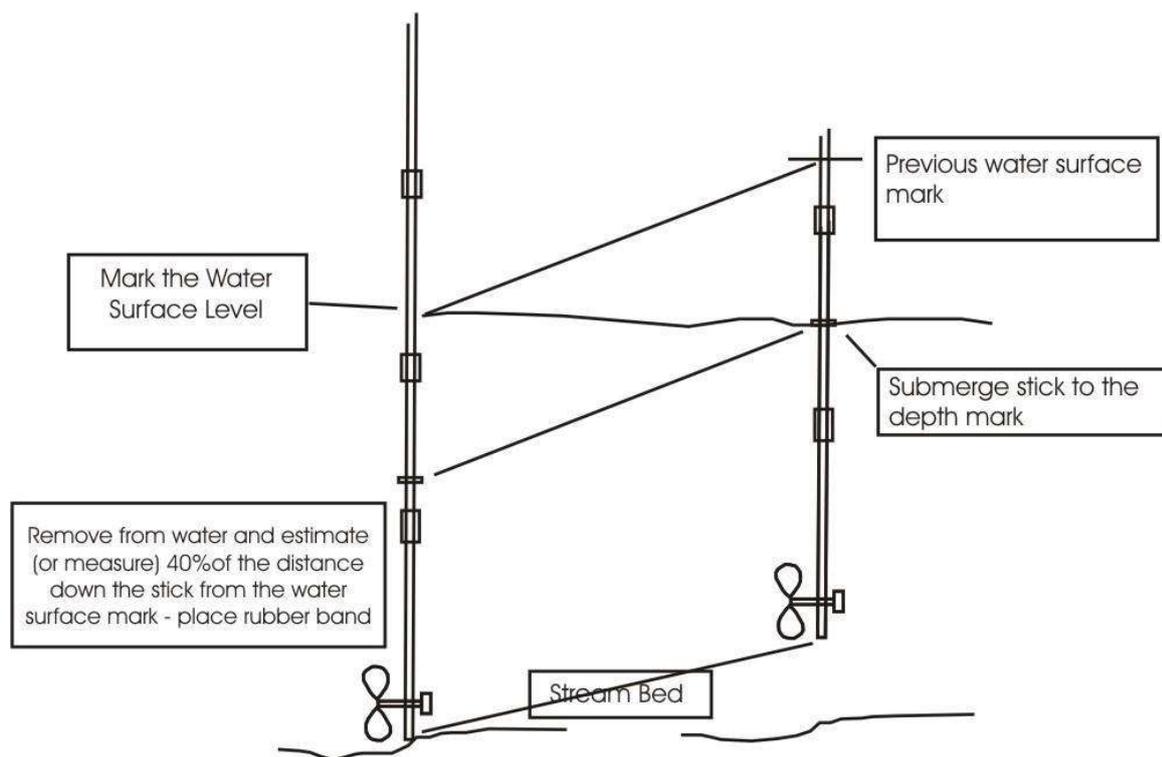
Figure 11 Finding 0.6 of the depth

But the problems aren't over yet! In the semi-circular and rectangular channel sections shown in Figures 9a and 9b, an impeller placed in the centre of the channel at 0.6 of the depth, would give a reasonable average flow velocity. In the real-life section shown in figure 10b, the channel geometry is much less regular. Where should the mean velocity be measured? The most likely choice would probably be in the vicinity of the label letter "A".

Thus, if the flow velocity (V) at this point was recorded as being 1 m/s and with a cross-sectional area of
1.45 m² then the DISCHARGE (Q) would be 1.45 m³ / s

To do the job properly however, it would be necessary to make a series of average flow velocity measurements, and this would require the channel cross-section to be subdivided into a series of columns like those in Figure 12.
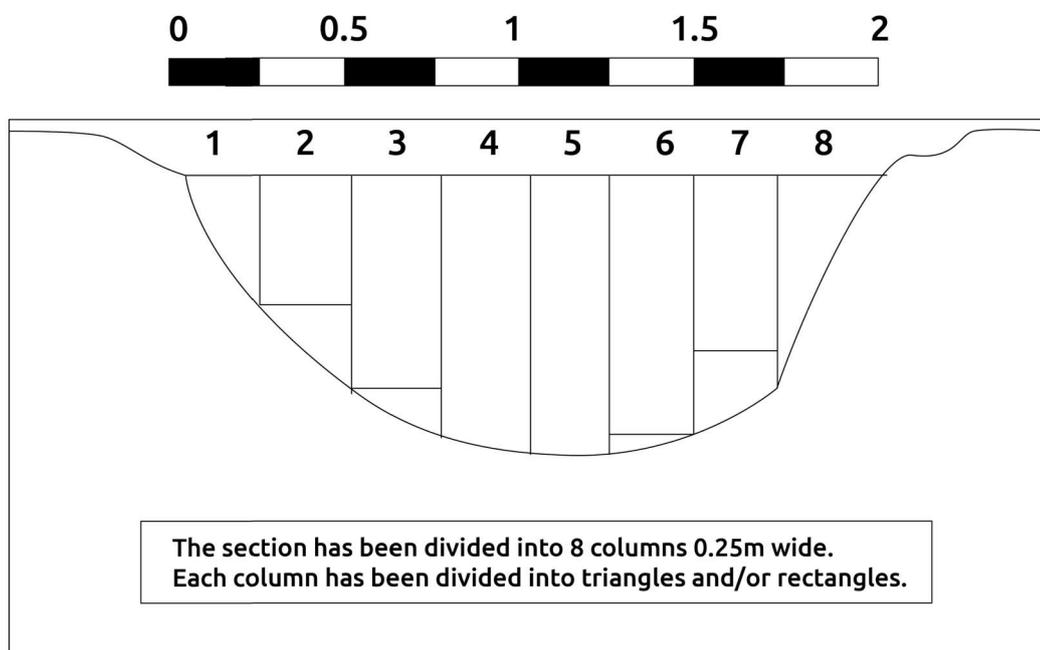
Figure 12 Constructing Water Columns in a Stream Cross-Section

Figure 12 shows a stream cross-section which is 2 m wide. The section has been subdivided into columns (**WATER COLUMNS**) 0.25 m wide. According to the geometry of the channel, each column consists of a triangle and/or a rectangle. The area of each column has been calculated using the techniques described earlier and using the scale provided on the diagram. At an appropriate point within each column, the flow velocity would be measured with an impeller. A set of hypothetical velocities and the area measurements are displayed in Table 1, along with the calculations necessary to determine **DISCHARGE** (Q).

	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Cols 1-8	
Area 1	0.00	0.07	0.12	0.22	0.23	0.19	0.13	0.00	0.96	
Area 2	0.07	0.06	0.03	0.00	0.00	0.02	0.02	0.11	0.31	
Areas 1+2	0.07	0.13	0.15	0.22	0.23	0.21	0.15	0.11	1.27	Cross-Section area(M²)
V	0.05	0.60	0.90	1.10	1.00	0.50	0.40	0.10	0.58	Mean Velocity (M/S)
Q	0.00	0.08	0.14	0.24	0.23	0.10	0.06	0.01	0.86	Discharge (M/S³)

Table 1   Table of Measurements and Calculations for the Cross-Section

In the Table, Area 1 refers to rectangles and Area 2 to triangles.

From the table:

> The total cross-sectional area has been calculated as 1.27 m^2
> The mean flow velocity through the section is 0.58 m/s
> The total discharge (Q) through the section is 0.86 m^3/s

These procedures ensure that the best possible results are obtained from fieldwork. Once the hard work of surveying the channel section has been done, the profile can be used repeatedly under varying circumstances (e.g. before and after heavy rain) though adjustments for changes in depth and in-channel geometry due to erosion and deposition must be made. The exact position of the cross-section(s) must be fixed by inserting discrete stakes into the river banks.

Plotting Flow Patterns within a Stream

Using the cross-section channel profile(s) constructed for discharge measurements (or survey some new sections), it is possible to collect data to illustrate the internal flow characteristics of channelled flow. There are a number of techniques, most common being the construction of **ISOVELS** or **CHOROPLETHS**. Isovels are lines joining points of equal velocity and Choropleths involve shaded areas of like and unlike velocity.
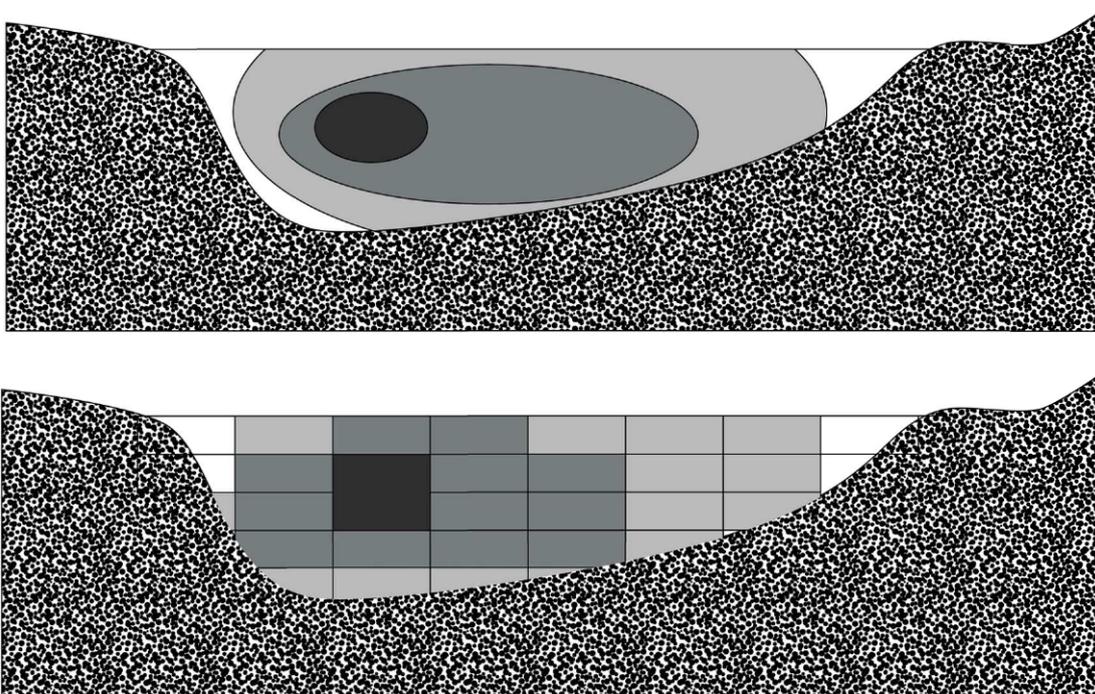
Figure 13   Showing internal flow patterns – Isovels (above) & Choropleths (below)

Key: dark shades = high velocity; light shades = low velocity

The isovels and choropleths represent lines and areas of equal velocity respectively. The highest velocity occurs usually in the centre of the channel near to the surface, while it is often lower nearer the bed and banks (Figure 13). However, the pattern displayed by the isovels and choropleths also reflects the shape of the channel i.e. its width, depth and symmetry (Figure 13). The spacing of the isovels and choropleths represents the velocity gradient.

Both methods can be effective in showing internal flow patterns. The degree of refinement depends on the number of readings which are taken – the more the better. Three values must be collected at each point – distance out from one or other bank; depth; and velocity at that point.

The stream cross-section must be surveyed as meticulously as for the calculation of discharge and readings are collected systematically in a transect across the stream channel. Instead of taking just one velocity reading 0.6 of the depth, a number of readings are taken at regular points within the water column.
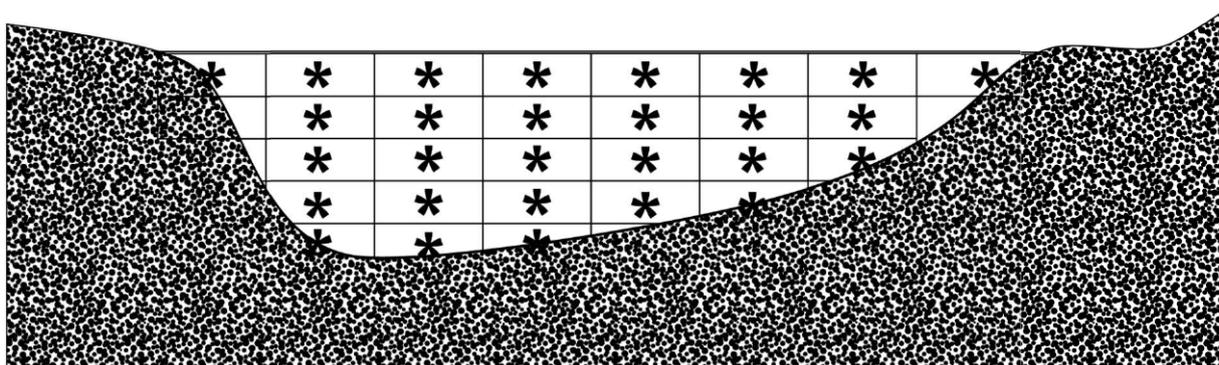
Figure 14   Data collection grid for Isovel and Choropleth Construction

In Figure 14, the * signs indicate the midpoint of each "cell" in the grid. Typically a grid would consist of cells 0.25 m wide and 0.125 m deep. The size is determined by the size and scale of the channel and degree of accuracy required.

Stream Velocity in m/s								
Depth	Col.1	Col.2	Col.3	Col.4	Col.5	Col.6	Col.7	Col.8
to 0.125	0.00	0.06	0.12	0.11	0.07	0.05	0.05	0.00
to 0.25	0.00	0.09	0.17	0.10	0.10	0.05	0.06	
to 0.375	0.05	0.11	0.16	0.10	0.10	0.10	0.04	
to 0.5	0.00	0.09	0.12	0.09	0.08	0.04		
to 0.625		0.06	0.07	0.06	0.06			

Table 2   Stream Velocity Data collected in Cells

Cells are 0.25 wide and 1.25m deep

The data shown in this grid are ideally suited to constructing choropleths. For a representative and refined Isovel construction, at least twice as many velocity readings would be required (typically in a grid with 0.1 by 0.1 m cells).

5.0 Calibration

Before shipment the impeller unit has been carefully calibrated under laboratory conditions. The formulae and graphs from what we call the Calibration Data which was essential for users of the earlier Flowmeters. The latest Flowmeter has the relevant calibration data built into electronics so that direct velocity data is generated in m/s or mph as selected.

Pre –shipment Impeller Stick Calibration

The impeller sticks have been calibrated in a flume where flow velocities can be strictly controlled by combined variations in discharge, gradient and weir height adjustments. Flow rate was monitored by a miniature Nixon electronic flowmeter and an Ott flowmeter. The formula required to convert counts per minute (C) recorded by the Flowmeter to water velocity (V) in m/s is:

Water Velocity (V) m/s = (0.000854C) + 0.05

Alternative units can be calculated using the following conversion factors:

> **m/s to kph   x   3.60**
> **m/s to mph   x   2.24**
> **m/s to ft/s   x   3.28**

Values in this manual are given in metres per second (m/s).

The chart below (Figure 15) shows the relationship between revolutions of the impeller and calculated velocity displayed on the meter. This is for information only.
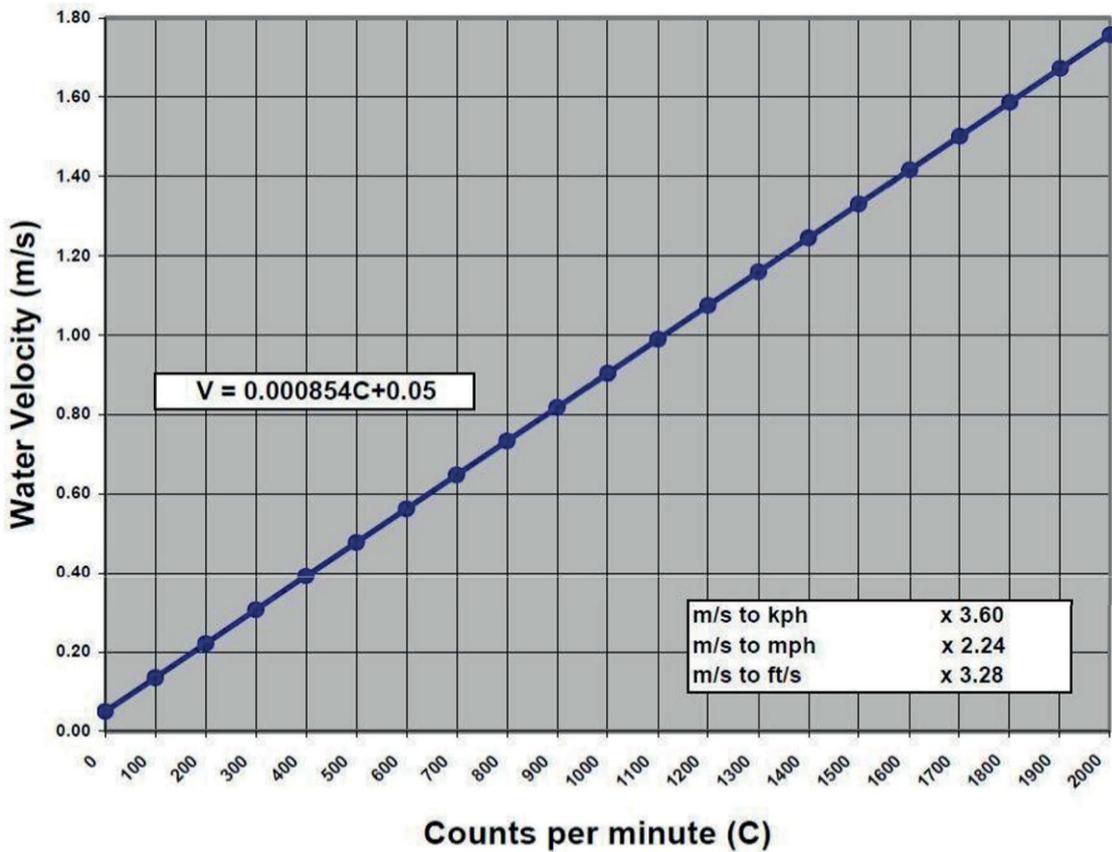

Figure 15   Calibration Chart showing the relationship between revolutions of the impeller and Water Velocity

Appendix I

TAKING CARE OF YOUR FLOWMETER

Check your equipment before you start work.

BEFORE leaving for fieldwork check your equipment as follows:

> Switch on the meter by plugging the impeller jack-plug into the socket then use the ON switch to activate the meter.
>
> If nothing is displayed, check the batteries are correctly fitted. Batteries are accessed in the flowmeter by carefully removing the sliding panel on the back of the unit (take care not to lose the cover).
>
> Fit new batteries if necessary: always carry spares (Two by "AA"– average life several months depending on how often the meter is used). The battery is tested at the point of waking up.
>
> A battery symbol on the display indicates a low battery please replace as soon as possible.

Although your flowmeter has been designed for use by fieldwork parties under a wide range of conditions and is reasonably robust, it can be damaged by rough treatment or immersion in water. Should the meter be immersed in water, **REMOVE** the batteries **IMMEDIATELY**; the flowmeter can be left open to dry in a warm room, do not attempt to open the meter compartment. Just remove the batteries, leave the battery panel off and leave it to dry slowly. In case of a serious dunking then, after removing the batteries, wipe dry with a towel and cover the meter entirely with dry rice and leave for 24 hours. The rice will absorb any moisture, discard the rice and replace the batteries.

Should the flowmeter (impeller stick and/or meter) be damaged or otherwise malfunction we can repair/ replace damaged parts at a very reasonable cost and will also provide repairs under guarantee where appropriate.

Please telephone Geopacks on **01837 811 319** and speak to customer services or email us on **service@geopacks.com** before returning the meter to the address below:

> **GEOPACKS**
> **Unit 4A, Hatchmoor Industrial Estate**
> **Holsworthy Road**
> **Hatherleigh**
> **Devon, EX20 3LP**

We can also customise your Flowmeter for any special requirements.

After each field session we recommend that the flowstick and impeller are rinsed in clean water and allowed to dry before being stored back in the carry case. Also, the batteries should be removed if the equipment is not being used for any length of time.

<div align="center">

**YOUR FLOWMETER IS GUARANTEED AGAINST
DEFECTS IN MATERIALS AND WORKMANSHIP
FOR 12 MONTHS FROM THE DATE OF PURCHASE.**

</div>

Appendix II

Field Observation Sheet

Keep a log of your readings by river depth and distance from bank. Use this sheet to keep a track of the different sets of data that your meter will log so that you can use it in conjunction with the .csv file when back in the classroom.

Enclosed – 1 laminated sheet – please photocopy as required.

Field Trip Date		Reading Location		Student Names	

Obsevaton number	Location number	Distance from bank	Channel depth	Internal temperature	External temperature
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
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Field Observation Sheet for use with Geopacks Advanced Flowmeter (users may copy this sheet)

Appendix III

Resources

Geopacks manufacture and distribute a wide range of products associated with the flowmeter discussed in this manual. We have measuring tapes, stop watches, ranging poles, a wide range of other survey equipment as well as the more specialized items.

Be sure to ask for our full Geopacks catalogue. If you don't already have a copy, our address and telephone number given in Appendix I.

Why buy from Geopacks?

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- No minimum order value

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- Stocked goods will be dispatched within 24 hours

- If items are out of stock we will inform you

- Geopacks branded products are UK designed and manufactured

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"Fast, helpful and efficient service as always. Thoroughly recommend the company and it's products."

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01837 811 319

Mon-Fri, 9am-5pm
if you need help or
product advice

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and order online!

Email:
service@geopacks.com

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please email through
your Purchase Order

Appendix IV

CSV Formatting

The Duo-Meter records data in a CSV format which can be read by any suitable software. The example below shows the typical data displayed in Microsoft Excel.

The header starts with a capital S this is just the session marker and is used internally to mark the start of a new session.

The date and time is shown in the format **yy:mm:dd:hh:mm**

The example below shows 09:59 on the 29th April 2021

The next two lines show the recording units and the final line the logging period if auto logging is used.

The data fields are Flowrate in the format x.xx internal meter temperature +/- x.xx and probe tip temperature

+/- x.xx

Each session can contain 220 records.

	A	B	C	D	E	F	G
1	S21:04:29:09:59						
2	Flow units = m/s						
3	Temp units = C						
4	Log Period = 03mins						
5	0	23.3	-0.8				
6	0	23.6	-0.9				
7	1.31	23.8	13.8				
8	1.32	23.8	13.8				
9	1.34	23.7	13.9				
10	1.36	23.7	13.9				
11	1.36	23.6	13.8				
12	1.35	23.6	13.9				
13	1.35	23.5	13.8				
14	1.31	23.5	13.8				
15							
16							