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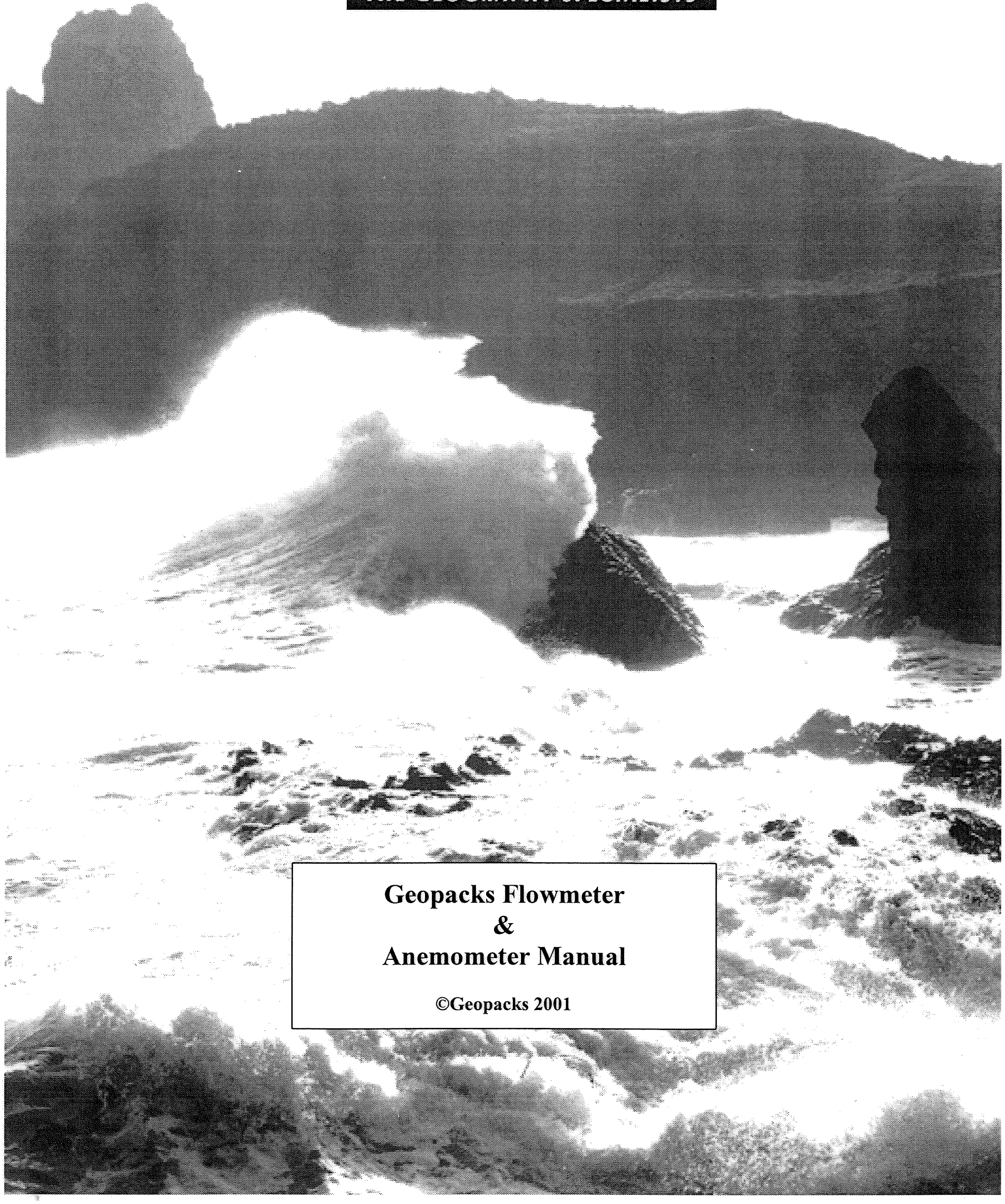


Geopacks Flowmeter & Anemometer Manual

CONTENTS

1.0 Key Components

1.1 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
- four 250 mm 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 - 250 mm, 125 mm and 62.5 mm or combinations of these
- a 1m long cable which connects to a flowmeter (see 1.3 & 1.4 below)

1.2 Anemometer

The anemometer has three cups which rotate in moving air. Minimum velocity is approx. 0.4 m/s (ms^{-1}) or 1 mph; maximum velocity exceeds 27 m/s (60 mph). Accuracy within this range is +/- 5%; erratic values may occur beyond the maximum. DO NOT IMMERSE IN WATER (but please note, exposure to light rainfall will not damage the instrument).

1.3 Basic Flowmeter

The Basic Flowmeter is an electronic device which counts signals (pulses) from the impeller stick or anemometer proportional to velocity. The total number of counts per unit of time (normally one minute) can be converted into a velocity value by referring to calibration charts or using formulae. The unit has the following features :

- an LCD (liquid crystal display) counter;
- a locking socket for the jack plug connection
- a three way switch on which the switch positions are :
    - NEUTRAL - centre switch position
    - START - flick the switch DOWN
    - STOP - flick back up to centre
    - RESET (to zero) - UP to top position
    - NEUTRAL - centre position again

The act of inserting the jack plug from the impeller stick or anemometer cable turns the meter ON. Having inserted the jack plug the locking collar should be screwed up **NO MORE THAN BARELY FINGER TIGHT**. The value in the LCD should read 0 at this time. If this is not the case, with the switch UP, rotate the impeller (or anemometer) fractionally to close the relay then move the switch to the NEUTRAL position.

1.4 Advanced Flowmeter

The LCD display on this instrument gives an average velocity in m/s or mph for WATER or AIR according to the sensor type connected and to the switch settings. There is no need to time your measurements using this instrument; nor do you have to use a calibration chart. To operate the instrument :

- select either a stream flow impeller or an anemometer
- insert the jack plug from either into the socket. Having inserted the jack plug the locking collar should be screwed up **NO MORE** THAN BARELY FINGER TIGHT
- select "WATER" or "AIR" and "mph" or "ms^{-1}" with the rotary dial
- initiate motion of the sensor in water or air as appropriate
- switch the instrument ON using the slide switch on the left side of the unit

The display should read "00.00" and there will be a flashing colon between the 00's. If the colon does not flash, replace the battery.

When using the impeller stick, the display will not change for 10 seconds, after which an average velocity will be shown in the units selected (mph or ms^{-1}). This delay is known as the Integration Time. The value shown will be held for 2 seconds (no flashing colon) then for a further 10 seconds until a new average is obtained. Naturally, a number of averages should be obtained to build up a full picture of flow rates at each point. When the anemometer is being used, the Integration Time is just 5 seconds.

The Advanced Flowmeter has an RS232-type output socket on its top edge to facilitate connection to a data logger. The output signal is 0 -1 volt. To connect to a proprietary data logger, a cable connection will be required. MJP-Geopacks does not manufacture such a cable but details of the wiring specifications are provided in Appendix III.

2.0 Operating Instructions

2.1 Impeller Stick with Basic 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 the impeller off the stream bed if necessary (Figure 1b).

Figure 1a Impeller Stick in the flow

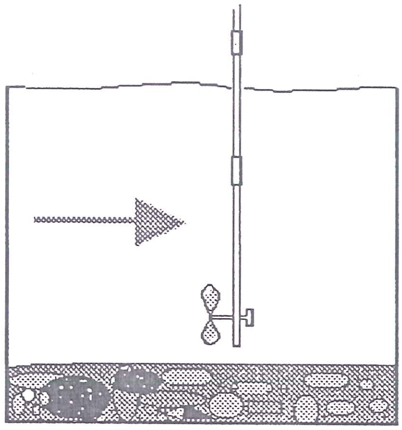
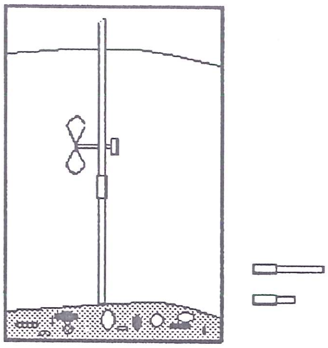


Figure 1b Using Riser Rods



When the impeller is turning at the correct depth (which will depend on the purpose of your measurements), flick the switch down to the start position and hold for 60 seconds (best to have a time keeper at hand!). Stop the count (CENTRE position) at the correct time and note the count value

Determine the flow speed via the graph provided (see section 6.1, page 19 and Appendix IV). Alternatively, the flow speed (V), in m/s is given by the following formula in which C is the number counts per minute:

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

Zero the counter - UPPER switch position (turn impeller slightly, if necessary, to close the impeller relay) and return to CENTRE switch position ready for further measurements.

2.2 Anemometer with Basic Flowmeter

- connect the anemometer - do not overtighten collar
- hold in position in the moving airstream
- start the count (DOWN switch position)
- after 60 seconds STOP the count (CENTRE switch position)
- determine the air flow velocity in m/s or mph using the graphs provided or by using the following formulae in which C is the number of counts per minute :

Air Velocity (V) m/s = 0.00105C

Air Velocity (V) mph = 2.24(0.00105C)

- zero the display - UPPER switch position (turn anemometer slightly if necessary) and return to CENTRE switch position ready for further measurement.

2.3 Impeller or Anemometer with Advanced Flowmeter

- connect either the IMPELLER or ANEMOMETER to the counter unit BEFORE turning the instrument on : do not overtighten collar
- select WIND or AIR (depending on sensor in use) and mph or m/s and initiate movement by immersing the IMPELLER in moving water with the impeller pointing upstream
- or, alternatively, placing the ANEMOMETER in an air flow
- NOW switch the instrument ON with the switch on the left hand side of the unit. Note the flashing colon

With the IMPELLER stick attached and "WATER" selected, the colon will flash for 10 seconds before a value is displayed; it will then stop flashing for 2 seconds before flashing again for 10 seconds and displaying a revised value. The values represent average velocity in either m/s or mph as selected; the 10 second period represents the period over which the average was taken (integration time).

With the ANEMOMETER attached and "AIR" selected, the integration time is 5 seconds therefore the colon flashes for 5 seconds and is still for 2 seconds ; the mean velocity being updated at the end of each flashing period.

The first reading will almost always be low and should be disregarded.

WARNING : do not change your selection without switching the instrument off and waiting 10 seconds before switching it back on again. Repeated operation of the ON/OFF and Selector Switches is likely to cause erroneous readings to be displayed. If the colon fails to flash at all; change the battery. Battery life should be approximately 80 hours with a top quality PP3 9v alkali battery or equivalent. To change the battery remove the sliding cover on the back of the case. Be careful not to lose the battery cover as these cannot be replaced separately from the counter unit case.

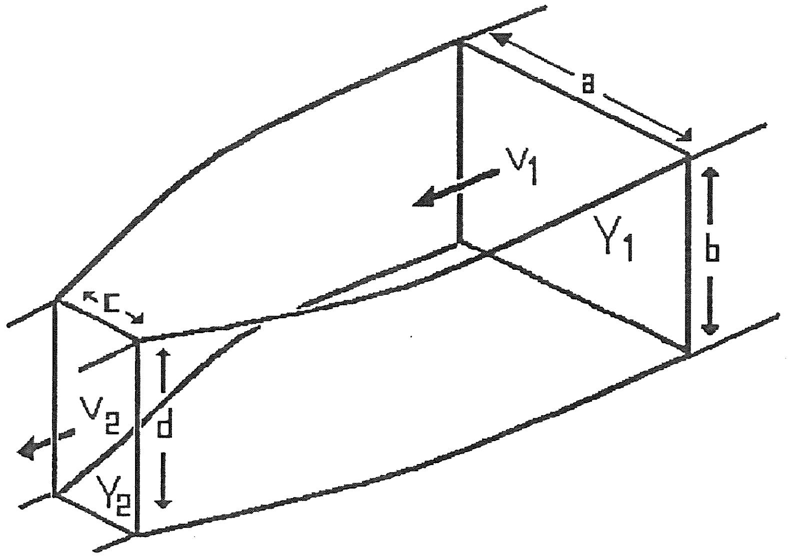
The unit should be kept dry and SHOULD NOT be immersed in water.

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 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-section and Flow Velocity



In the river channel depicted in Figure 2 the volume of water which passes through section Y_1 in a second is the DISCHARGE (Q) and will be given by:

$$Q = a \,.\, b \,.\, V_1$$

and similarly at section Y_2:

$$Q = c \,.\, d \,.\, V_2$$

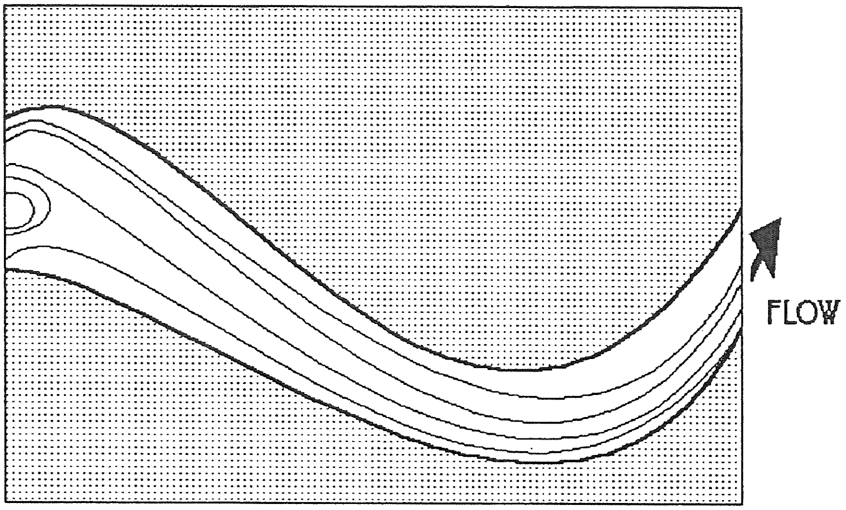
In these equations, a and c are the widths and b and d are the depths of the channel at the two sections, and V_1 and V_2 are the flow velocities. Since the same DISCHARGE (Q) passes through both of the sections then the flow velocity relates to the difference between a . b and c . d (the cross-sectional 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 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 and discharge at a number of different sections along a short stretch of river.

3.2 Describing Flows

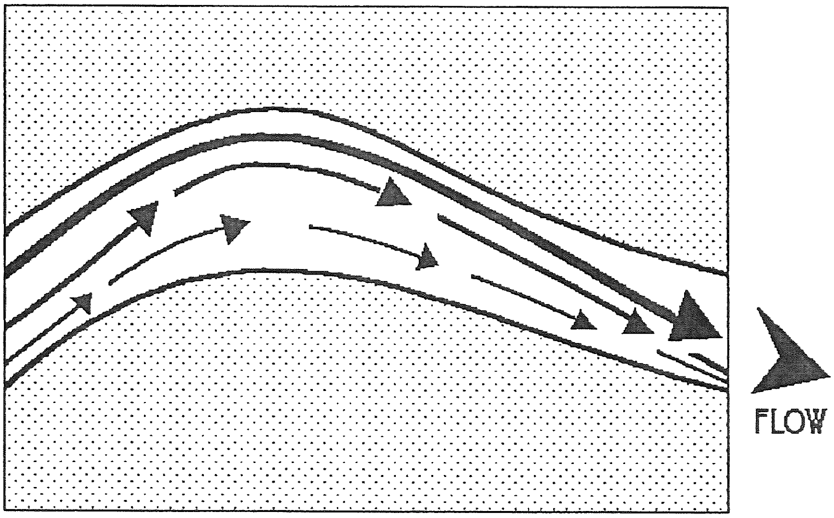
To understand the flow characteristics within streams of moving water it is helpful to construct STREAM LINES and VECTOR LINES. Figure 3 shows how Stream Lines depict possible paths of a single fluid particle.

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 a meander

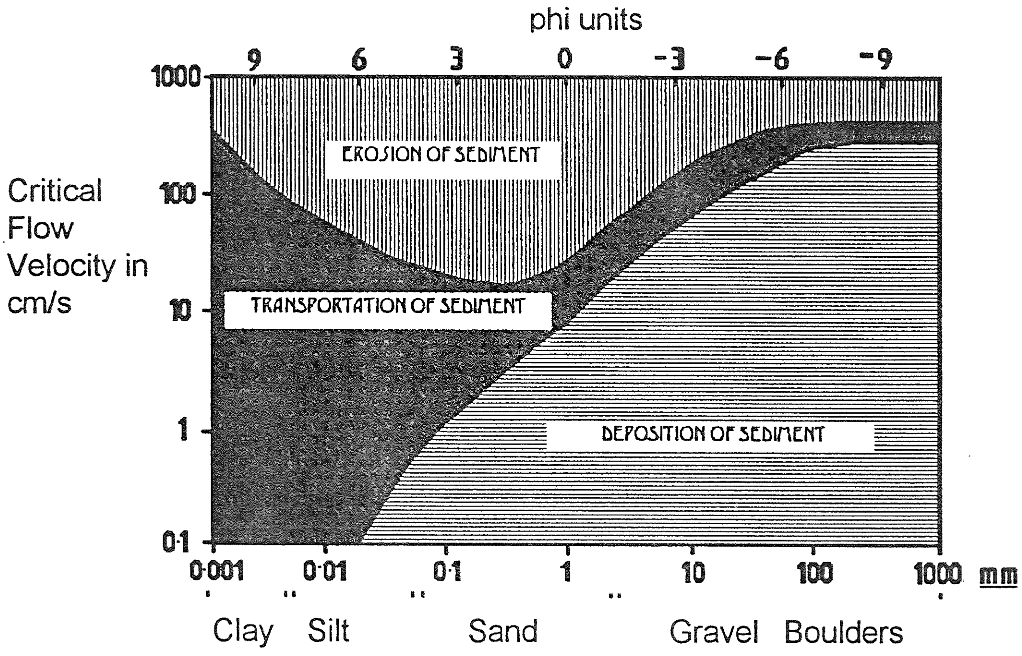


In this diagram the short thin arrows represent the slower areas of the stream and the long, thick lines the regions of faster flow.

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 particle which may be transported by the flow (Figure 5).

Figure 5 Erosion Velocities for Water



The chart, which has been derived from a mass of accumulated observed data, 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. At the same velocity, all sediment particles finer than 1 mm 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 1 mm diameter will be deposited .

Thus, a stream flowmeter can be a valuable observational 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 that velocity can be determined.

4.0 Studying Streams - some fieldwork suggestions

4.1 Recording Stream Velocity

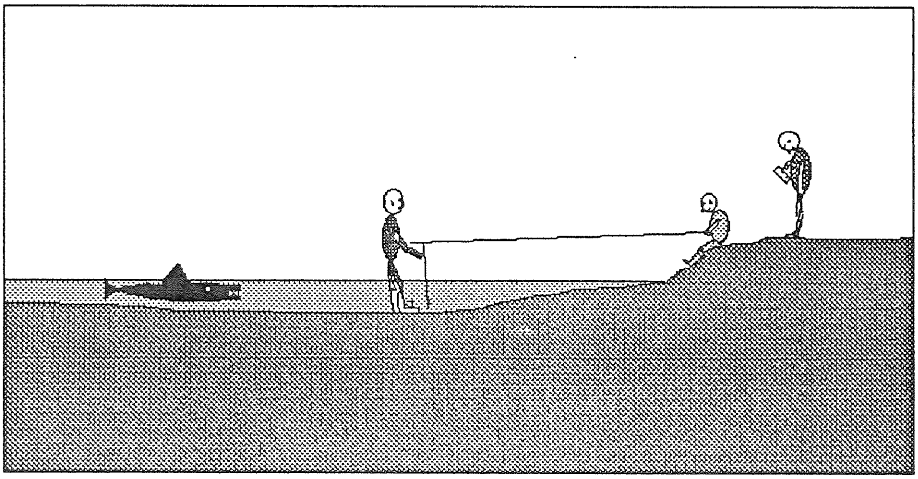
Equipment Needed:

MJP stream flowmeter
Stopwatch (if using Basic flowmeter)
Measuring tape
Ranging poles
Clipboard and pen
Data collection sheets

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 stopwatch to control the velocity recording time. 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 finally of course, the number of counts per minute or velocity.

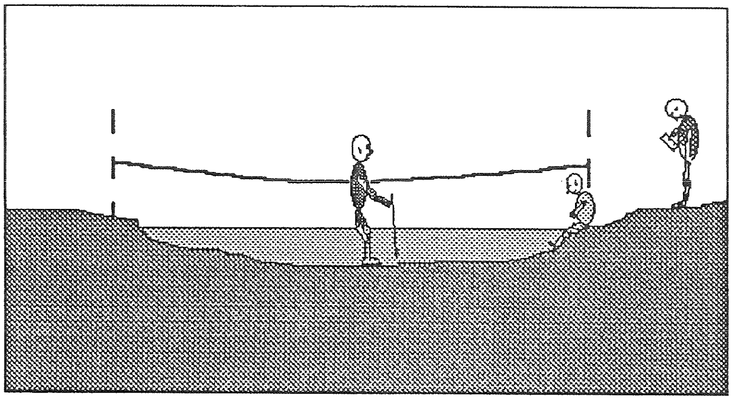
Measurements of the distance from the banks and the position of the meter in the stream are vital. For systematic collection of stream velocity data, the position of the meter readings should always be recorded with reference to one bank - DISTANCE OUT. For example, in larger channels this may be determined 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 bank to bank. The ends of the tape can be attached to ranging poles on the banks .

Figure 7 Measuring "Distance Out" using tape stretched between poles



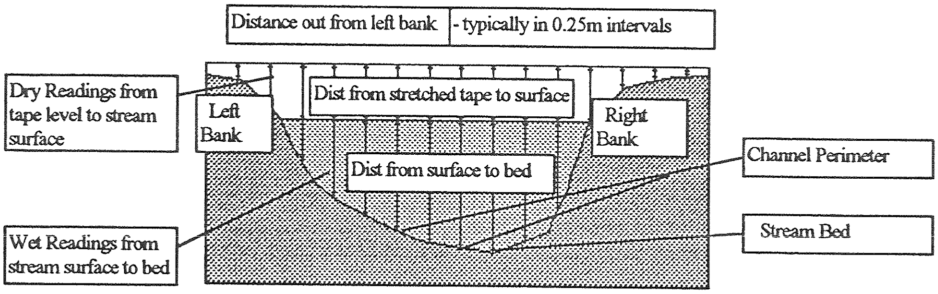
Depth of measurement (DISTANCE DOWN) can easily be measured if the flowmeter tubes are simply calibrated beforehand using tape or water-resistant paint or ink, or more accurately, by using a staff. In estimating water depth please note that each section of the flowmeter stem is 250 mm long. Total water 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 (see section 4.3) for mean water column velocity measurement, the band can be moved to the appropriate position along the stem.

4.2 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 then be measured vertically down from the tautly stretched tape to the stream surface (or channel perimeter) - see Figure 8. Measurements of channel widths and depths are then recorded using the 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. This depth can be measured using the calibrated stem of the flowmeter, but more accurately by using a rule or staff. The greater the number of measurements taken at each cross-section, the more accurate the representation of the channel.

Figure 8 - Measuring & Plotting the Channel Cross-Section



4.3 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-sectional 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 $1m^3/s$ (1 cumec). If, after heavy rain the channel area increased to 2 m^2 and the flow velocity to 1.5 m/s then the Discharge (Q) would be 3 m^3/s or 3 cumec. Discharge is a very important variable. Unfortunately, it is not always easy to measure.

Figure 9a Semi-Circular Channel

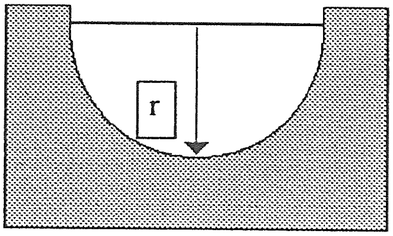
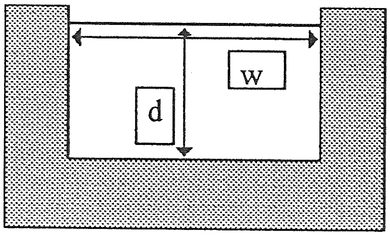


Figure 9b Rectangular Channel



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 :

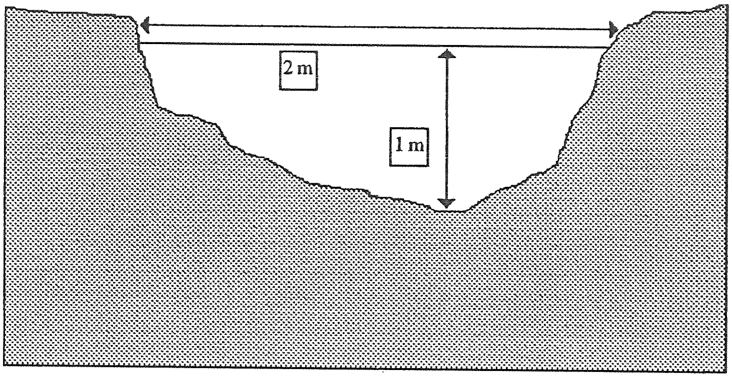
Radius of Channel (r)	=	1 m
Cross-sectional area (Δ)	=	$\pi r^2 \div 2$
	=	1.57 m^2
Mean Velocity (V)	=	1 m/s
Discharge (Q)	=	Δ x V
	=	1.57 m^3/s

Similarly, in the rectangular channel, if the :

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

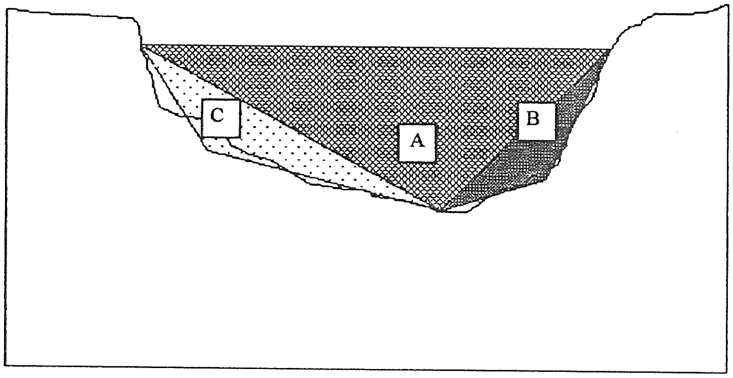
In a real-life situation, however, the channel geometry will be far from regular.

Figure 10a Irregular Stream Channel Cross-Section



In these cases, the calculation of the cross-sectional area is more complex as the following example shows :

Figure 10b Calculating the Cross-Sectional Area of an Irregular Channel



In this example, the channel area beneath the water line has been divided into three triangular shapes. The largest triangle is whole, while the other two approximate the geometry of the area which they respectively cover by a judicious mix of inclusion and exclusion. By finding the area of each triangle by the formula :

Area of Triangle = (Length of Base) x (Half the Height)

it is possible to calculate the cross-sectional area of the channel by summing the areas of the triangles (the values used are notional, for illustration only) :

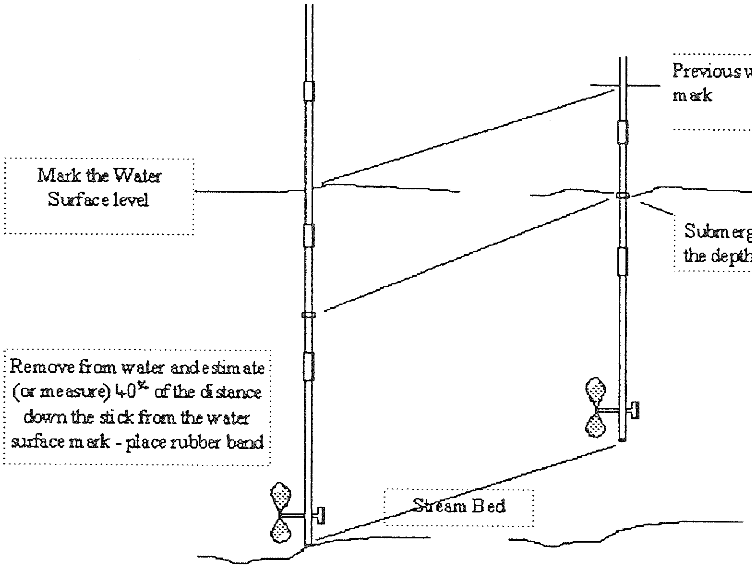
Area of triangle A	=	1.00 m^2
Area of triangle B	=	0.15 m^2
Area of triangle C	=	0.30 m^2
Total Channel Area	=	1.45 m^2

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 0.6 m, 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 base 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 at the 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 m^2 then the DISCHARGE (Q) would be 1.45 m^3/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 shown in Figure 12.

Figure 12 Constructing Water Columns in a Stream Cross-Section

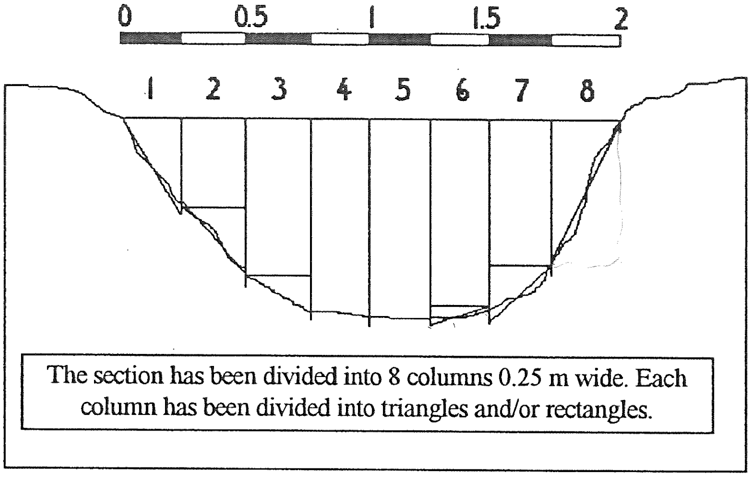


Figure 12 shows a stream cross-section which is 2 m wide. The section has been subdivided into columns (WATER COLUMNS) 0.25 m wide. According to the geometry of the channel, each column consists of a triangle and/or a rectangle. The area of each column has been calculated using the techniques described 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).

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

	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	
Area 1+2	0.07	0.13	0.15	0.22	0.23	0.21	0.15	0.11	**1.27**	Cross-Section area (m^2)
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^3/s)

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

From the table :

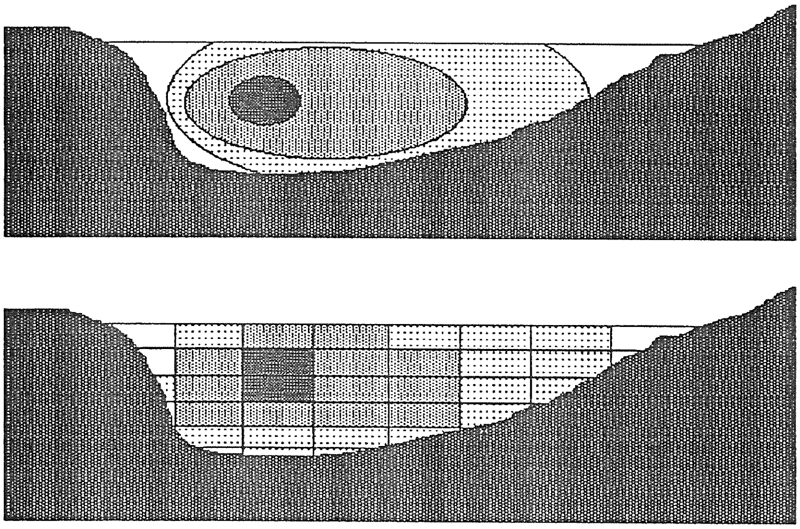
the total cross-sectional area has been calculated as	1.27 m^2
the mean flow velocity through the section is	0.58 m/s
the total Discharge (Q) through the section is	0.86 m^3/s

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.

4.4 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

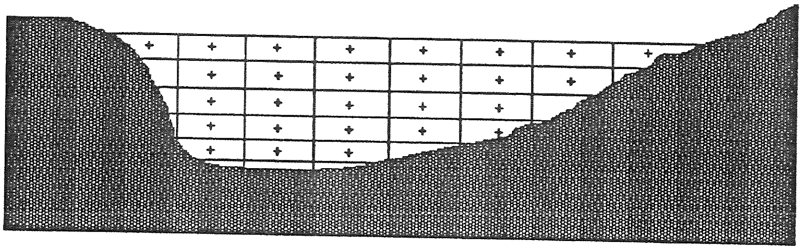


Key : dark shades = high velocity; light shades = low velocity

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 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 midpoints 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.

Table 2 Stream Velocity Data collected in Cells

			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			
		Cells are 0.25 wide and .125m 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).

MJP Geopacks publishes a computer software package called "Channel Analysis for WINDOWS™" which not only plots choropleths from fieldwork data but also draws channel cross-sections and calculates discharge among a wide range of other functions. For details see Appendix VI.

5.0 Using Anemometers

The anemometer can be used in a number of ways to monitor variations in wind speed. Here are some suggestions :

5.1 Measuring Variations in Wind Speed

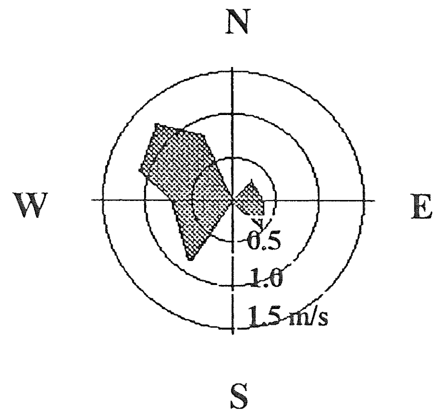
Anemometers can be used to measure wind speed at various positions around buildings (e.g. the school), over a transect, above different types of terrain and ground cover and at various points under variable meteorological conditions. Ideally, a number of anemometers should be employed for simultaneous measurements in different positions. Wind direction using a vane and compass should be recorded alongside wind speed.

The following data show considerable variation in wind speed and direction at eight sites round the buildings of a school in West Cornwall. The observations were all taken during the mid morning break on a day in February 1997. The MJP Anemometer is sensitive enough to measure the relatively low wind speeds experienced in the sheltered sites of the school compound.

Table 3 Wind Speed and Wind Direction at selected Sites

Location	Mean Wind Speed m/s	Mean Wind Direction
Site 1	1.2	NW
Site 2	0.3	NE
Site 3	0.7	W
Site 4	1.1	WNW
Site 5	0.8	NNW
Site 6	0.3	E
Site 7	0.5	SE
Site 8	0.8	SW

Figure 15 Kite diagram showing Wind Speed and Direction at eight sites

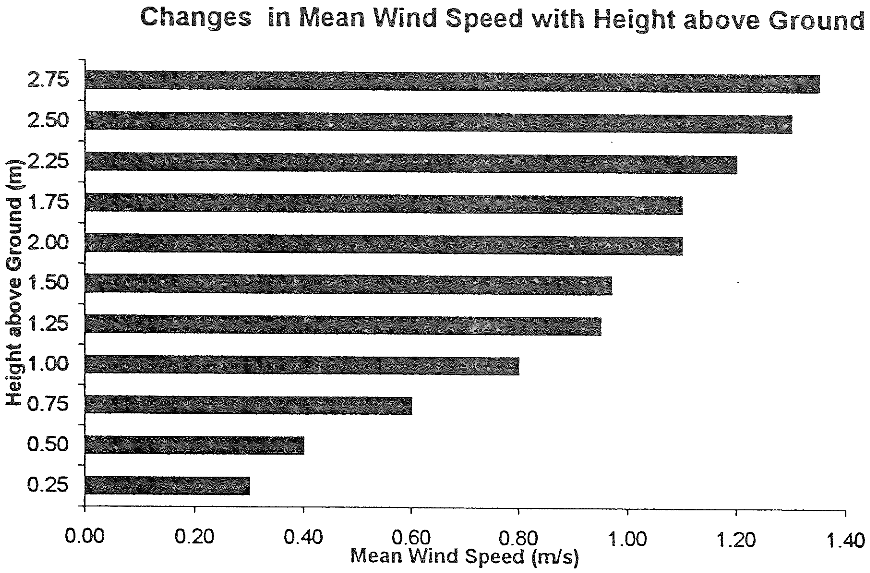


5.2 Measuring Vertical Changes in Wind Speed and Direction

Professional meteorologists can measure vertical changes in wind speed and direction using instrument bearing balloons which are released into the atmosphere. The various high profile attempts by balloonists in late 1996 and early 1997 to fly around the world highlighted the vertical changes in wind speed and direction which the balloonists were attempting to exploit. Fieldworkers with their feet more firmly planted on the ground must be less ambitious but can, nevertheless, make some interesting investigations using one or more anemometers.

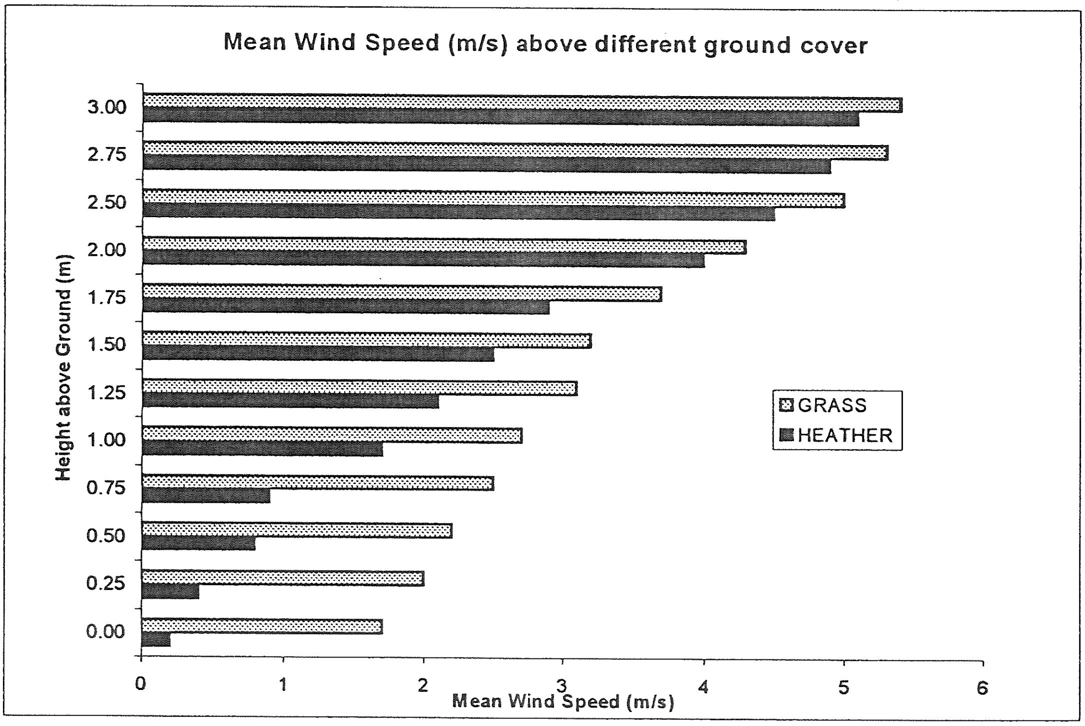
The Meteorological Office recommends that anemometers be sited 10m above open level ground. The MJP anemometer is portable and is not designed to be kept in a fixed position but can be moved from place to place and to different heights. Using a wooden pole and some clamps (retort clamps used in science laboratories will do), the anemometer can be positioned at a variety of heights above ground level and the wind speed - averaged over a suitable period - can be found. Because wind speed can be very variable, the simultaneous use of more than one anemometer is desirable.

Figure 16 Graph showing Changes in Mean Wind Speed above ground level



The graph shows a clear increase in mean wind speed as distance above ground increases up to a height of 2.75 m.. This line of enquiry could be developed further by taking a number of measurements over different types of ground surface as illustrated in the following example :

Figure 17 Graph showing Variations in Wind Speed above different ground cover

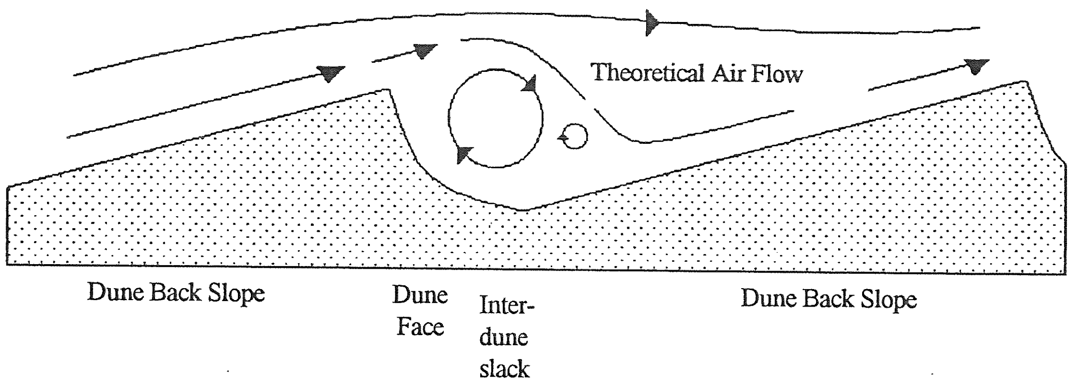


These graphs show clearly, why wind speed should be measured well above open level ground!

5.3 Measuring Wind Speed Variations in Complex Terrains - Sand Dunes

Sand dune areas offer great opportunities for fieldwork using anemometers. Dunes develop as accumulations of wind blown sand grains up to 1 mm in diameter. Of particular interest are the ways in which the geomorphology of the sand accumulation changes in response to variations in wind force and direction. Anemometers can be used to measure these variations and to assist in the measurement of sediment transport within dune areas.

Figure 18 Theoretical Air Flow across active Sand Dunes

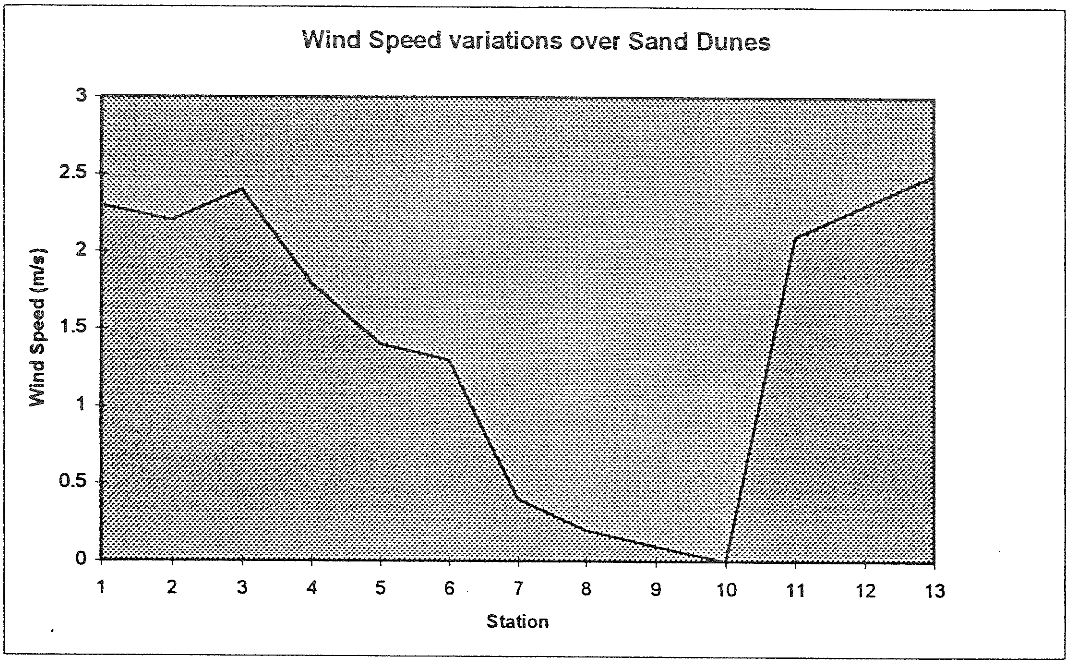


An interesting exercise would be to measure the speed and direction of air flow at various points within the dune system - along the back slope, in the dune face area and in the inter-dune slack area (so called because of the low wind speeds in the lee of the dune face).

Table 4 Mean Wind speed variations across a series of Sand Dunes

Station	Dune Zone	Location	mws (m/s)
1	1st Back slope	foot at 0.5 m	2.3
2		mid point at 0.5 m	2.2
3		crest at 0.5 m	2.4
4	Dune Face	at 2.0 m	1.8
5		at 1.5 m	1.4
6		at 0.5m	1.3
7	Inter-dune slack	at 2.0 m	0.4
8		at 1.5 m	0.2
9		at 1.0 m	0.1
10		at 0.5 m	0
11	2nd Back slope	foot at 0.5 m	2.1
12		mid point at 0.5 m	2.3
13		crest at 0.5 m	2.5

Figure 19 Graph of Wind Speed variations over Sand Dunes



Even more interesting at a more advanced level would be to measure the amount of sediment being transported and/or deposited at various points across a sand dune system. Details of the techniques and skills required are illustrated in the MJP Geopacks video "Studying Sediments in Motion - a Practical Approach". Details are given in Appendix VI.

6.0 Calibration

Both the impeller stick and the anemometer have been carefully calibrated under laboratory conditions. The formulae and graphs form what we call the Calibration Data which are essential for users of the Basic Flowmeter with impeller stick or anemometer. The Advanced Flowmeter has the relevant calibration data built into its electronics so that direct velocity data is generated in m/s or mph as selected.

6.1 Impeller Stick Calibration

The impeller sticks have been calibrated in a flume where the velocity of flow 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 Basic Flowmeter to water velocity (V) in m/s is :

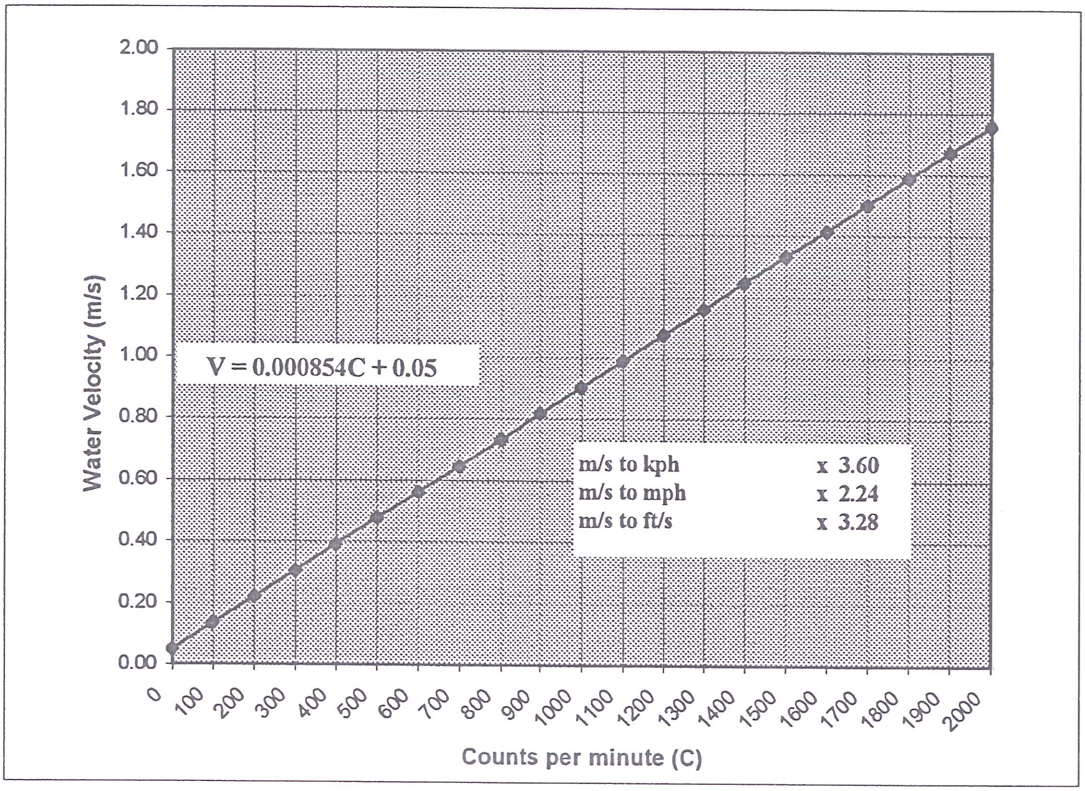
Water Velocity (V) m/s = (0.000854C) + 0.05

Alternative units of velocity 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 formula can be entered into a spread sheet or other computer program and used to convert counts per minute into the desired unit of velocity. Alternatively, a Calibration Chart can be used. The chart (Figure 20) and chart overleaf (Figure 21) are reproduced in laminated format with this manual for use in the field.

Figure 20 Calibration Chart for Water Velocity



6.2 Anemometer Calibration

The anemometer has been factory calibrated by our supplier. The Advanced Flowmeter has been pre-calibrated with the relevant equations for mph and m/s. For the Basic Flowmeter, the equation for wind velocity in m/s is as follows, where C stands for counts per minute :

Wind Velocity (m/s) = 0.00105C

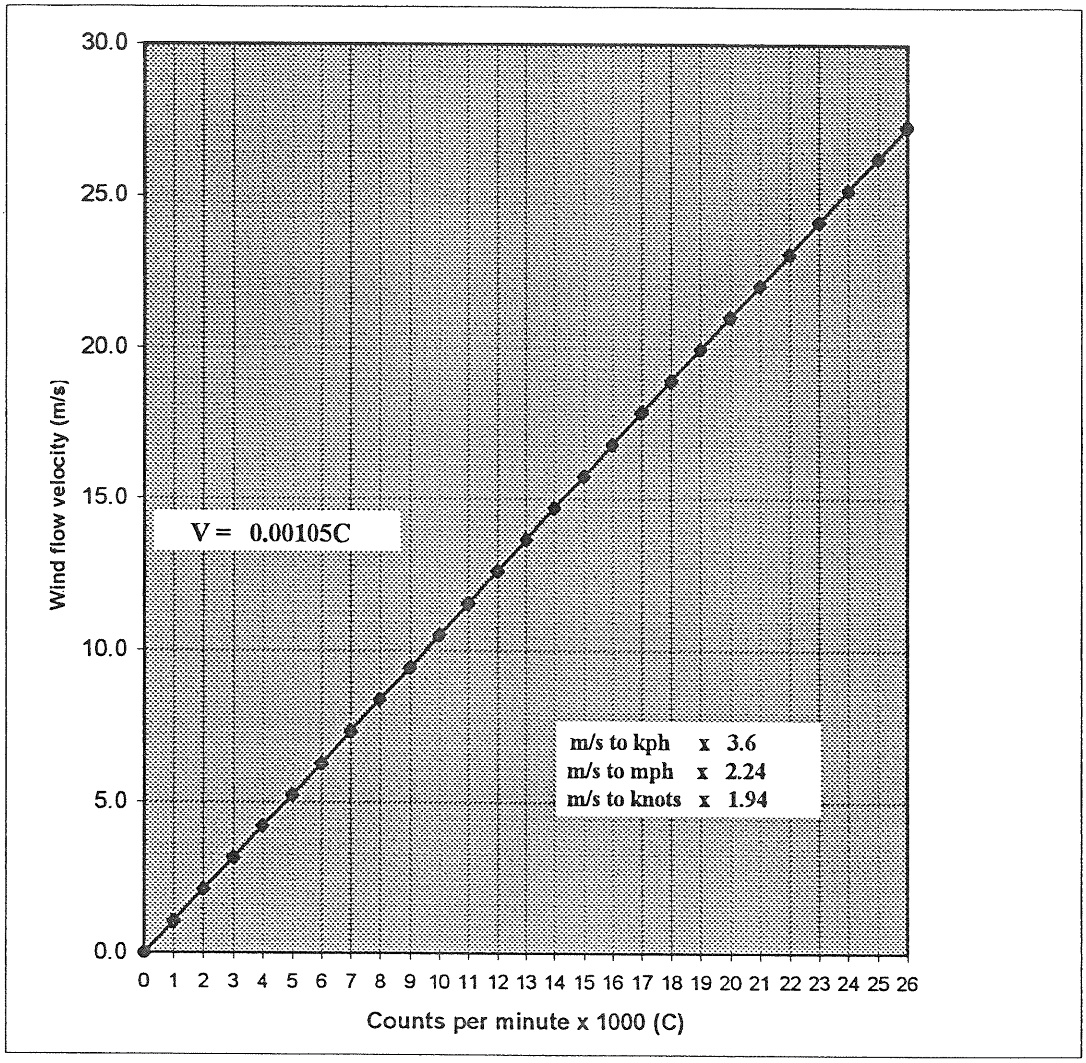
Equivalents for mph, kph and knots are as follows :

Wind Velocity (V) (mph) = 0.00235C

Wind Velocity (kph) = 0.00105C x 3.6

Wind Velocity (knots) = 0.00105C x 1.94

Figure 21 Calibration Chart for Wind Velocity



Appendix I

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 or anemometer jackplug into the socket and **LIGHTLY TIGHTEN** the locking collar (use the ON-OFF switch on the Advanced flowmeter)
>
> If nothing is displayed, check that the batteries are correctly fitted. Batteries are accessed in the Basic flowmeter by undoing the small cross-headed screws on the back of the unit (try not to lose the screws!). On the Advanced flowmeter, un-clip the battery cover on the back of the instrument (take care not to lose the cover). Fit new batteries if necessary; always carry spares ("AAA" for the Basic - average life several months; PP3 (9 volt) for the Advanced - average life 80 hours continuous use).

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 either meter be immersed in water, REMOVE the batteries IMMEDIATELY; the Basic meter can be left open to dry in a warm room, do not attempt to open the Advanced meter but leave it to dry slowly.

The impeller shaft can easily be bent, and will result in low readings. Check that the impeller assembly spins freely with no eccentric "swirl" of either the impeller or magnet housing. It is often possible to straighten the shaft by bending it with either the impeller or magnet housing. If unsuccessful contact MJP and a replacement assembly can be provided. We can repair/replace damaged parts at a very reasonable cost and will also provide repairs under guarantee.

Please telephone MJP - GEOPACKS on 0990 13 31 68 and ask for the Technical Production Manager prior to returning the meter to:

MJP - GEOPACKS
Unit 5 Hatchmoor Industrial Estate
Hatherleigh
Okehampton
Devon EX20 3LP

We can also customise your Flowmeter for any special requirements.

We recommend that the moving parts be lubricated with WD 40, or similar, after each field session. Also, the battery should be removed if the equipment is not being used for any length of time.

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

Appendix II

Safety Considerations

BE AWARE - BE SAFE

When undertaking fieldwork in and around streams, please heed the following safety first points :

1. Never work alone. Let someone responsible know where and when you will be working; and don't go elsewhere.

2. Always work with others - 3 is a sensible minimum.

3. Never work in fast flowing or deep water - as a general guide FAST means greater than 0.5 m/s and DEEP means where the water level comes above the knee.

4. Always survey the stream for : unstable banks, dangerous obstacles on the bed, overhanging trees and other "common-sense" dangers.

5. Never risk HYPOTHERMIA - wear warm, waterproof clothes and even in summer, have these to hand - stream water can be very cold, almost all year round. If you don't know what the term HYPOTHERMIA means, please seek advice, it is a life threatening, though avoidable, medical condition caused by loss of body heat due to cold and wet and or exhausting conditions.

6. Always take the utmost precaution when attempting to cross streams - if in doubt, don't.

7. Never attempt to cross or work in streams prone to flash flooding.

Using anemometers should involve little in the way of risk BUT :

1. High winds can be dangerous - be alert.

2. Do not work close to cliff edges in windy weather.

3. Beware of flying debris and falling objects in very windy weather.

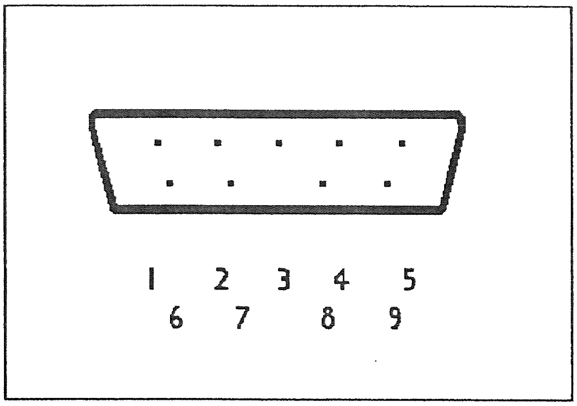
BE AWARE - BE SAFE

Appendix III

Technical Data regarding the Advanced Flowmeter

The Advanced Flowmeter has an RS232-type output port which may be used for connecting to a data logger. The following information will be required :

Figure 19 Pin Diagram - socket as seen in the meter unit



The output port is "D" shaped and has 9 pins. The following table shows which pins do what and which are not used :

Pin #	Function	Pin #	Function
1	Not Used	2	Not Used
3	Not Used	4	Not Used
5	Not Used	6	Reference Voltage
7	Not Used	8	0-1v analogue output
9	Ground / Earth		

For further information contact our Technical Production Manager at the address shown in Appendix I

Appendix IV Calibration Charts

The large charts enclosed have been laminated for your convenience. Please make photocopies for your records in case the originals become mislaid or damaged in use.

Enclosed - water and wind speed calibration charts - 1 of each laminated

Appendix V

Data Collection Sheets

Insert units of measurement as appropriate (e.g. m and m/s)

V.1 For use with MJP Basic Flowmeter - stream velocity

V.2 For use with MJP Advanced Flowmeter - stream velocity

V.3 For use with MJP Basic Flowmeter - wind velocity

V.4 For use with the MJP Advanced Flowmeter - wind velocity

Enclosed - 1 each of the above sheets, laminated.

Appendix VI

Resources

MJP Geopacks manufactures and distributes a wide range of products associated with the flowmeters and anemometers 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 described below.

Of particular interest are the following products - but be sure to ask for our full GEOPACKS catalogue if you don't already have a copy; our address and telephone number are given in Appendix 1.

Videos :

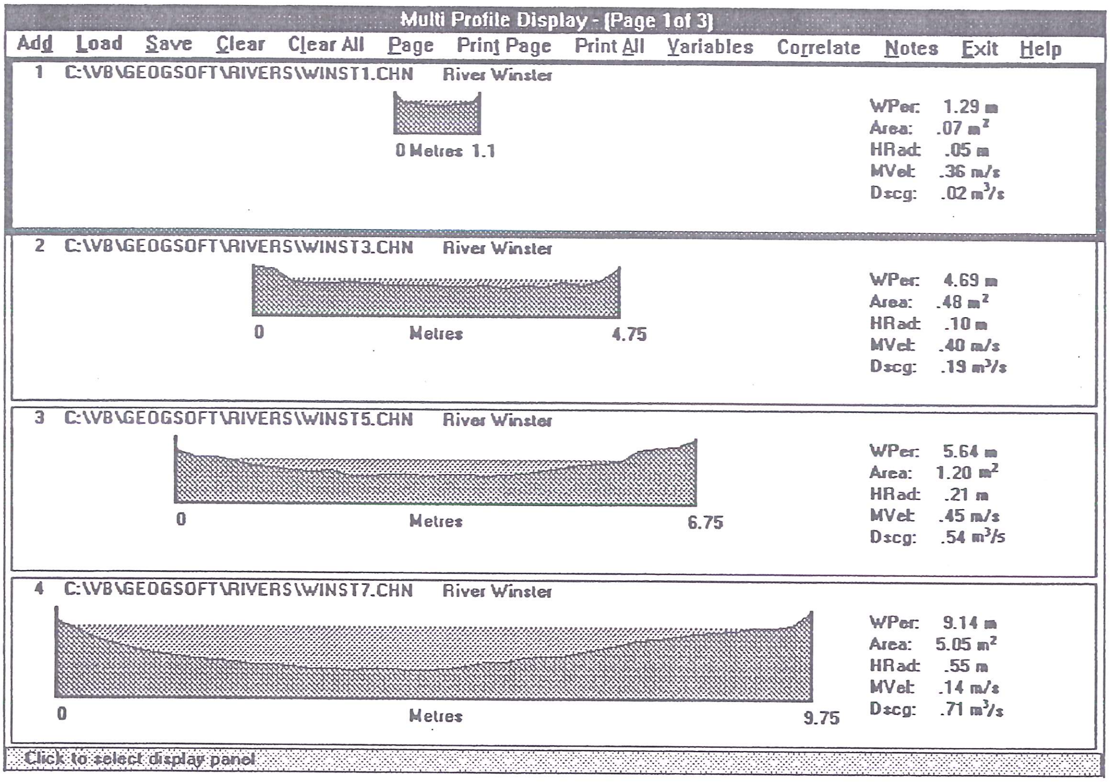
"Studying Rivers, a Practical Approach" - a 60 minute compilation for teachers and students. Practical guidance in using the flowmeter to test simple hypotheses moving on to develop skills in plotting internal flow characteristics and undertake full scale discharge measurement. Based on fieldwork in South Wales but incorporating background material from other locations especially the Colorado Plateau area of the American South West. PAL for VHS; GPV2 - £19.95 (plus VAT where appropriate).

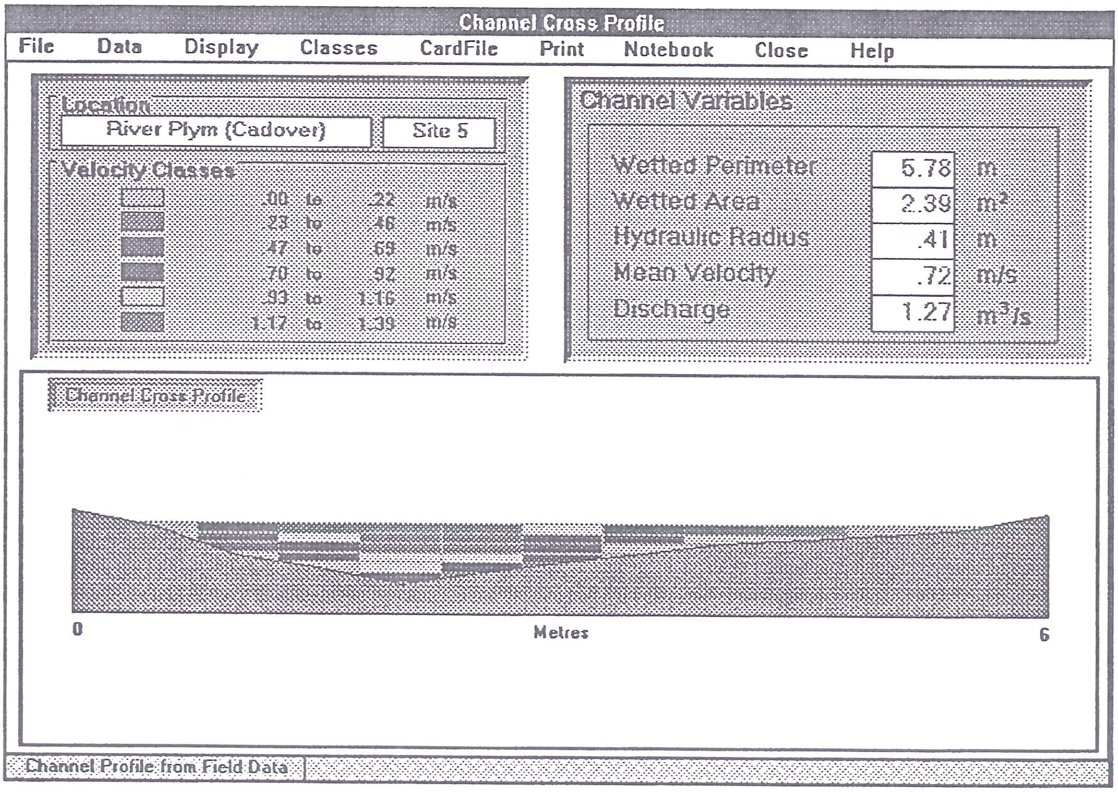
"Studying Sediments in Motion, a Practical Approach" - 45 minutes of instruction and demonstration on how to measure sediment transportation in streams and in moving air using flowmeters/anemometers. Filmed on location in South Wales, the video aims at students in the 13 to 18 age range of the UK education system (KS3 through GCSE to A level) through a series of staged experiments. Laboratory follow-up to field work is especially emphasised in this compilation. PAL for VHS; GPV1 - £19.95 (plus VAT where appropriate).

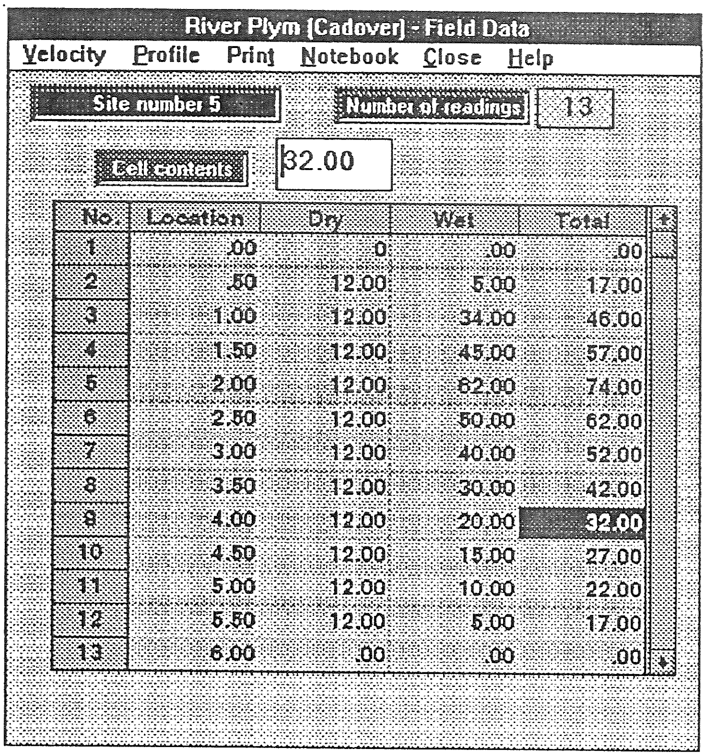
Computer Software :

"Channel Analysis for WINDOWS™" by Rick Cope. The essential software tool for guiding, processing, presenting the fruits of your river based field studies. "Channel Analysis" has been written for modern Windows™ environments by Rick Cope, a geography teacher well known for his expertise in field studies. This is available in single user, 2 to 10 users, or 11+ users Please contact MJP GEOPACKS for more information and costs.

Some illustrations from "Channel Analysis" appear on the following pages. Please note the last illustration which highlights the unique facility in this program for storing "card file" data clips on a whole range of river features.


Multi Profile Display - [Page 1of 3]
Add Load Save Clear Clear All Page Print Page Print All Variables Correlate Notes Exit Help
1 C:\VB\GEOGSOFT\RIVERS\WINST1.CHN River Winster
0 Metres 1.1
WPer: 1.29 m
Area: .07 m²
HRad: .05 m
MVel: .36 m/s
Dscg: .02 m³/s
2 C:\VB\GEOGSOFT\RIVERS\WINST3.CHN River Winster
0 Metres 4.75
WPer: 4.69 m
Area: .48 m²
HRad: .10 m
MVel: .40 m/s
Dscg: .19 m³/s
3 C:\VB\GEOGSOFT\RIVERS\WINST5.CHN River Winster
0 Metres 6.75
WPer: 5.64 m
Area: 1.20 m²
HRad: .21 m
MVel: .45 m/s
Dscg: .54 m³/s
4 C:\VB\GEOGSOFT\RIVERS\WINST7.CHN River Winster
0 Metres 9.75
WPer: 9.14 m
Area: 5.05 m²
HRad: .55 m
MVel: .14 m/s
Dscg: .71 m³/s
Click to select display panel


Channel Cross Profile
File Data Display Classes CardFile Print Notebook Close Help
Location
River Plym (Cadover)
Site 5
Velocity Classes
.00 to .22 m/s
.23 to .46 m/s
.47 to .69 m/s
.70 to .92 m/s
.93 to 1.16 m/s
1.17 to 1.39 m/s
Channel Variables
Wetted Perimeter 5.78 m
Wetted Area 2.39 m²
Hydraulic Radius .41 m
Mean Velocity .72 m/s
Discharge 1.27 m³/s
Channel Cross Profile
0 Metres 6
Channel Profile from Field Data


River Plym [Cadover] - Field Data
Velocity Profile Print Notebook Close Help
Site number 5
Number of readings 13
Cell contents 32.00
No. Location Dry Wet Total
1 .00 0 .00 .00
2 .50 12.00 5.00 17.00
3 1.00 12.00 34.00 46.00
4 1.50 12.00 45.00 57.00
5 2.00 12.00 62.00 74.00
6 2.50 12.00 50.00 62.00
7 3.00 12.00 40.00 52.00
8 3.50 12.00 30.00 42.00
9 4.00 12.00 20.00 32.00
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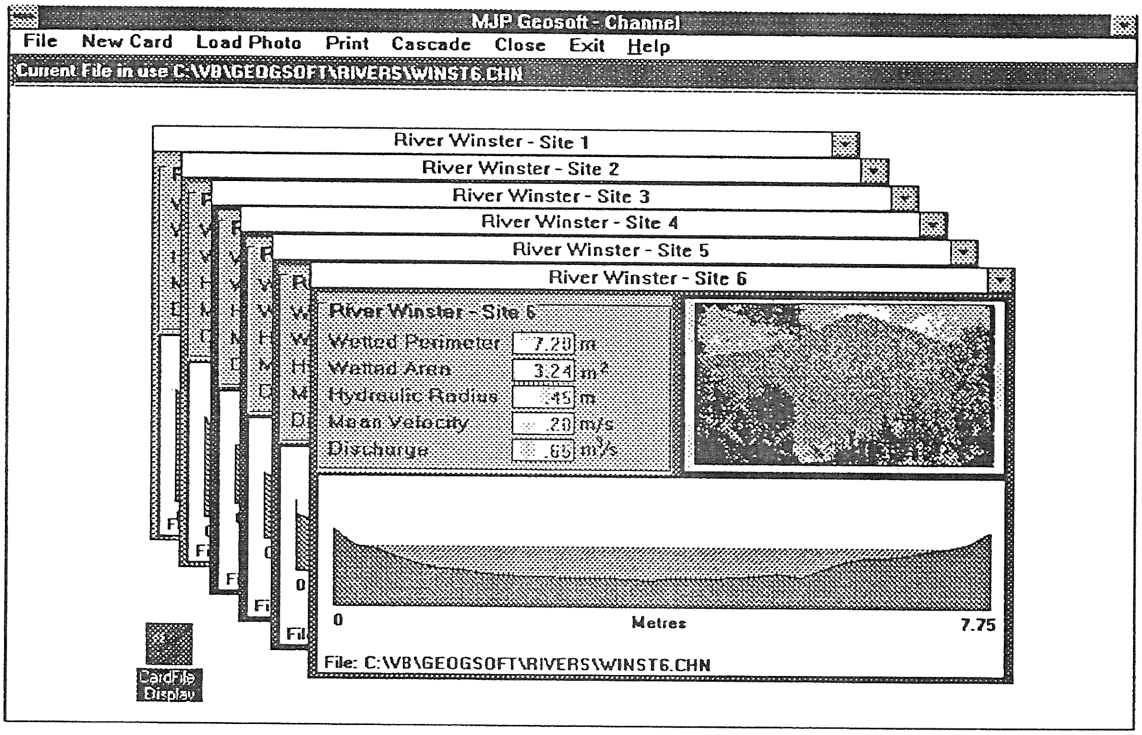
11 5.00 12.00 10.00 22.00
12 5.50 12.00 5.00 17.00
13 6.00 .00 .00 .00


MJP Geosoft - Channel
File New Card Load Photo Print Cascade Close Exit Help
Current File in use C:\VB\GEOGSOFT\RIVERS\WINST6.CHN
River Winster - Site 1
River Winster - Site 2
River Winster - Site 3
River Winster - Site 4
River Winster - Site 5
River Winster - Site 6
River Winster - Site 6
Wetted Perimeter 7.28 m
Wetted Area 3.24 m²
Hydraulic Radius .45 m
Mean Velocity .20 m/s
Discharge .65 m³/s
0
Metres
7.75
File: C:\VB\GEOGSOFT\RIVERS\WINST6.CHN
CardFile Display