Manual

Starflow QSD SDI-12 Instrument

Model 6527A

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules in the U.S.A. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

This equipment has been tested for compliance with European regulations as follows:

Application of Council Directive:
2004/108/EC

Standards to which Conformity is declared:
EN-61000-6-1:2001
EN-61000-4-2:1995
EN-61000-4-3:1995
EN-61000-4-4:1995
EN-61000-4-6:1996
ENV-50204:1995

Any changes or modifications to this equipment not expressly approved by the manufacturer Unidata Pty Ltd could void the user's authority to operate this equipment.

Revision History

File name / Revision	Date	Authors & Change Details	Checked/ Approved
Unidata Manual - 6527A Starflow QSD SDI-12 User Manual Issue 1.0.docx	2016	PC	MS
Unidata Manual - 6527A Starflow QSD SDI-12 User Manual Issue 1.0.docx	16 01 17	CB First Draft	MS
Unidata Manual - 6527A Starflow QSD SDI-12 User Manual Issue 1.1	06 02 17	MS Added extended SDI 12 v 12	MS
Unidata Manual - 6527A Starflow QSD SDI-12 User Manual Issue 1.2.docx	23 08 17	CB Modified extended SDI 12	MS
Unidata Manual - 6527A Starflow QSD SDI-12 User Manual Issue 1.2a.docx	10 01 18	KC Formatting	MS
Unidata Manual - 6527A Starflow QSD SDI-12 User Manual 31 01 2019.docx	31 01 19	BCT Updated wiring specs	IM

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1.0 INTRODUCTION

The Starflow QSD Ultrasonic Doppler Instrument is a unique combination of water velocity, depth and temperature using SDI-12 as its communications.

By using digital signal processing techniques, Starflow QSD is able to perform in a wide range of environments. It is used to record flows in pipes, channels and small streams and operates in a different range of water qualities from fresh streams to primary sewage channels.

The instrument is intended for economically recording velocity in channels, culverts and pipes. It can also be used where existing techniques are unsuitable or too expensive.

Starflow QSD is mounted on (or near to) the bottom of the stream/pipe/culvert and measures the velocity and depth of the water flowing above it.

Starflow QSD system consists of:

- Model 6527A Starflow QSD instrument
- Model 6527M Stainless Steel Mounting Bracket

Accessories:

The following accessories should be purchased according to your application requirements.

- Model 6907B-14 12V, 14Ah Sealed Lead Acid Battery
- Model 6904I-10 10W Solar Recharge Panel & Mount
- Model 6904I-20 20W Solar Recharge Panel & Mount
- Model 6702S Starflow QSD Weatherproof Enclosure
- Model 6705A Small Expanding Clamp SS expanding turn-buckle and band clips. 100mm wide, 100mm long, 50mm expansion. Use in pipes up to 600mm (24") in diameter
- Model 6705B Large Expanding Clamp SS expanding turn-buckle and band clips. 100mm wide, 150mm long, 100mm expansion. Use in pipes over 600mm (24") in diameter
- Model 6705D 1800mm Band Segment 100mm wide, 0.6mm Stainless Steel band with 50mm spaced locating holes at both ends
- Model 6705F Band Joiner Stainless Steel joiner

2.0 SPECIFICATIONS

Velocity

Range	20mm/s to 1600 in either direction
Accuracy	±2% of measured velocity
Resolution	1 mm/s

2.00 MHz signal, 16mm x 1mm piezo sensors (xmit & recv)

Depth

Range	20mm to 2000mm/5000mm (Above the Starflow QSD)
Accuracy	± 1%
Resolution	1 mm

1.00 MHz signal, 25mm x 2mm piezo sensor (xmit & recv)

Temperature

Range	0°C to 60°C
Resolution	0.1°C

Power Requirements

Voltage range	10 to 24 V DC
Supply current	50uA standby, 100mA active for 1 second @12V
Source (typical)	12 V DC (external battery)

Communications

SDI-12	Velocity, depth, temperature and diagnostic features
Connection	Single three-wire cable up to 50 metres long (15m Standard)
Software	Compatible with Starlog V4

Environmental

Operating temp.	0°C to 60°C (water temperature)
Storage temp.	-20°C to 85°C
Humidity	100 %

Physical

Dimensions	Approximately L 135 mm, W 50 mm, H 20 mm
Material	Epoxy-sealed body, stainless steel mount
Weight	200g
Cable	15 metre, three-wire
Cable options	User-specified, up to 50 metres

2.1 Modes of Operation

SDI-12 Sensor – in this mode Starflow QSD operates as a standard SDI-12 sensor. Measurement commands (M! & C!) return atttn(n) response with ttt indicating the delay until measurements are ready.

2.2 SDI-12 Command Notes:

The Starflow QSD instrument has two modes of operation:

Data Logger and Sensor – in this mode STARFLOW QSD operates as a programmable data logger with the sensor measurements made periodically according to a programmed “scan rate”. These measurements are stored in internal Flash memory for subsequent retrieval.

In this mode, SDI-12 measurement commands (M! & C!) return a000n(n) response indicating that measurements are available for immediate collection with the aD0! Command (a Service Request is not sent). The R! Command returns values. The values returned are the measurements made during the most recent measurement “scan”.

Standalone SDI-12 Sensor – in this mode STARFLOW QSD operates as a standard SDI-12 sensor. Measurement commands (M! & C!) return atttn(n) response with ttt indicating the delay until measurements are ready. A Service Request is sent. The R! Command returns an acknowledge response a<CR><LF>

SDI-12 Command Notes:

1. Change Address aAb! is supported
2. Start Verification aV! returns an acknowledge response
3. Extended Command aX is supported (see below for details)
4. D/R1…9! Commands operate the same as a D/R0! command
5. M/C1...9! Commands operate the same as an M/C! command
6. MC, CC & RC commands requesting CRC are supported

Measured parameters – STARFLOW QSD measures several parameters and these are available for collection by the Recorder. There are 8 parameters (model dependant). The parameters are numbered 0…7. The parameters can be collected in any sequence (see extended commands below). The default sequence is 0 thru 5, the default number of parameters is 6 and the parameter definitions are:

Par.	Description	Units	Example	Meaning
0	Water Temperature	1/10 ºC	+152	15.2 ºC
1	Battery Voltage	1/100 Volts	+1302	13.02 Volts
2	Water Depth	mm	+123	123 mm
3	Water Velocity	+/- mm/s	-234	234 mm/s (reverse flow)
4	RSSI (signal level)	no units	+66	66 (no units)
5	Signal Spread	no units	+45	45 (no units)
6	unused			
7	unused			

Extended Commands – to enable various settings and adjustments to be made to STARFLOW QSD the extended command aX! is implemented. The extended command format is -

	Command	Response
Examine setting	aXn!	a<values><CR><LF>
Change setting	aXn<values>!	a<values><CR><LF>

Where n = setting number to examine or change -

0 – Sensor address in ASCII (same as a! & aAb! Commands)

1 – Number of measurements returned by aD0! or aR0! Commands

+ Sequence (order) of returned measurements (channel numbers)

2 – Min Battery (in 1/100s of Volts), below which water measurements are not made

+ Min water Depth (in mm) below which Velocity will not be measured

+ Min RSSI (signal level) below which Velocity will not be recorded

+ Max Signal Spread above which Velocity will not be recorded

<values> = integer(s) with ± sign (no decimal point) or ASCII string (no ± sign)

Examples:

Command	Response	Meaning
aX0!	aa<CR><LF>	"a" is the Sensor address **
aX03!	a3<CR><LF>	Sensor address was "a" and now "3" **
aX1!	a+6+0+1+2+3+4+5+0+0<CR><LF>	aD0/R0! will return 6 measurements from channels Nos 0,1,2,3,4,5
aX1+2!	a+2<CR><LF>	Now will return 2 measurements (max 8)
aX2!	a +1150+25+1+300<CR><LF>	Low battery limit is 11.50 Volts Depth>25mm, RSSI>1,Spread>300
aX2+1200!	a+1200+25+1+300<CR><LF>	Low battery limit changed to 12.00 Volts

Notes:** The Sensor address is an ASCII value so DOES NOT use a ± sign.
*** Only SET Options are displayed. Change order is not important.
**** Except for aX5, the order of changed parameters IS important. You MUST re-enter all parameters occurring prior to the parameter you wish to change.

Hint: If the Sensor has an unknown address, use the "?" wild card address along with the A or X0 command to reset a known address (e.g. ?A0! or ?X00! to reset the address to "0")

Signal Spread

This can be used to determine the amount of “turbulence” affecting the signal quality and used to reject the measurement if the spread (turbulence) is too great.

A good flow would provide you with a spread around 50, and anything above 100 would be considered poor.

2.3 RSSI

The RSSI channel is the measurement of the received signal power

RSSI values may change significantly each measurement because of the number of reflectors in the water at that time

RSSI	dBm	
0	-40	Threshold signal
1	-6	Good signal
4	0	
16	6	Typical signal in clean river water
64	12	
256	18	
1024	24	Typical signal in wastewater

Therefore in very laminar flow situations (perfect conditions) the RSSI value should be very low between 1-10.

In typical river situations you will be looking between the 16 and 64 value.

3.0 OPERATING PRINCIPLES

The Starflow QSD measures velocity, depth and temperature each time an SDI-12 request is sent, according to the SDI-12 specification

Water Velocity Uses Continuous Mode Doppler to detect water velocity, an ultrasonic signal is transmitted into the water flow and echoes (reflections) returned from particles suspended in the water flow are received and analysed to extract the Doppler shift (flow). The transmission is continuous and simultaneous with the returned signal reception.

Water Depth Uses an upwards-facing ultrasonic Time-of-Flight depth sensor. This eliminates the problems with pressure sensors and vented cable but requires that the instrument be mounted in the water parallel to the surface (~ +/- 10°) Ripples on the surface are okay. Depth is limited to 2m. Velocity measurement is Baseband Mixed with Period Demodulation and 0/90° flow direction decoding. The use of the FM IF receiver IC is satisfactory but it still proves impossible to extract a useable signal strength signal because of the inherent acoustic and electrical crosstalk from transmitter and receiver.

Temperature is measured to refine the acoustic recordings. These are related to the speed of sound in water, which is significantly affected by temperature.

Battery Voltage is measured to allow the Starflow QSD to stop operating if the supply voltage is below defined limits.

Analysis – The Starflow QSD performs data processing and analysis every time an SDI-12 measurement is made. This includes internal averaging of the depth and velocity readings.

Communications – uses the SDI-12 1.3 standard specification for more information on this please refer to the below link

http://www.sdi-12.org/

Datalogging – The Starflow QSD is a Stand-alone SDI-12 instrument, if data logging is required Unidata can provide many options to record data over long or short periods including the Starlogger range which will allow for non-telemetered data logging and the Unidata Neon logger range which can be used to log data using Cell and Satellite and Ethernet networks and allows the data to be displayed on a cloud website.

3.1 How Starflow QSD Measures Water Velocity and Water Depth

For Velocity the Starflow QSD uses Continuous Mode Doppler. To detect water velocity, an ultrasonic signal is transmitted into the water flow and echoes (reflections) returned from particles suspended in the water flow are received and analysed to extract the Doppler shift (flow). The transmission is continuous and simultaneous with the returned signal reception.

There are two distinct types of Doppler instruments that can be used to measure water velocity:

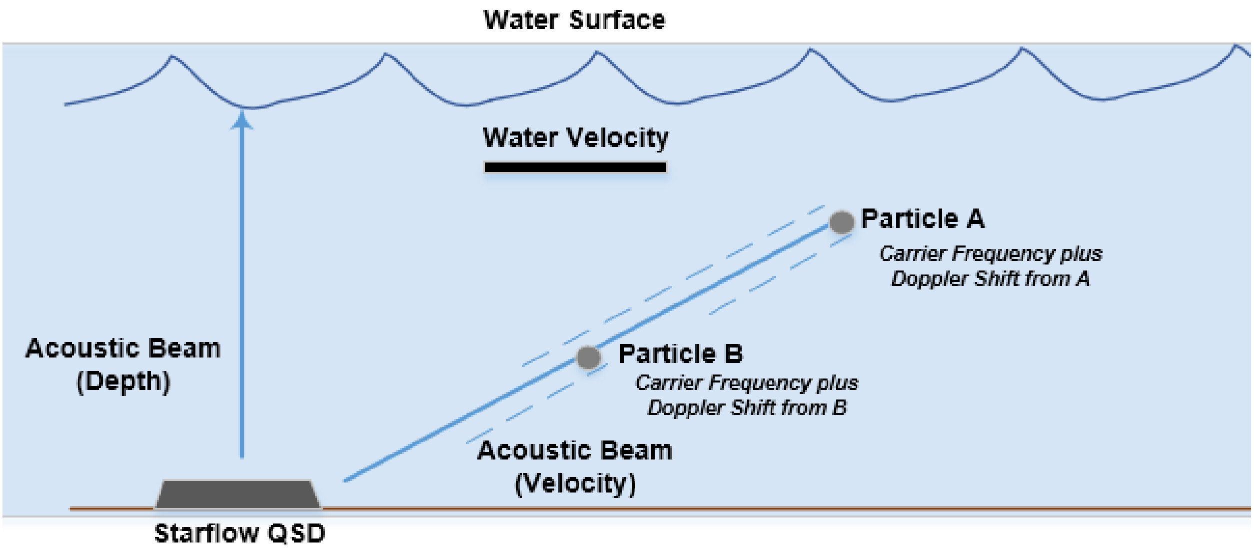
- Coherent (or profiling) Dopplers transmit encoded pulses with the carrier frequency at target locations, and only measure signals reflected from these targets. This allows the velocity in a stream to be profiled. These instruments are complex and expensive.
- Incoherent (or continuous) Dopplers like the Starflow QSD, emit a continuous signal and measure any signals returning from scatterers anywhere and everywhere along the beam. These are resolved to a mean velocity that can be related to a channel velocity at suitable sites.

During a measurement cycle, ultrasonic sound is transmitted continuously at a fixed frequency, called a carrier. A receiver listens for reflected signals from any targets. A measuring circuit detects any frequency changes. A processing system accumulates and analyses these frequency changes and calculates a representative Doppler shift from the range received.

Each Doppler shift is directly related to the water velocity component along the beam. This is a physical relationship and if you know the speed of sound in water you can calculate the velocity of the reflector and thereby the velocity of the surrounding water. Starflow QSD instruments do not need calibration for velocity measurement.

The velocity measured is the component along the beam. As the beam is at an angle to the flow, the Velocity is adjusted by the angle cosine.

For Depth the Starflow QSD uses Time-of-Flight (ToF) Ranging. This involves transmitting a burst of ultrasonic signal upwards to the surface of the water and measuring the time taken for the echo from the surface to be received by the instrument. The distance (water depth) is proportional to the transit time and the speed of sound in water (corrected for temperature and density)



3.2 Speed of Sound in Water

Velocity measurements are directly related to the speed of sound in water. The factor used to scale Starflow QSD Velocity measurement is based on the speed of sound in fresh water at 20°C (see table below). This velocity of sound gives a calibration factor of 0.550mm/sec per Hz of Doppler shift.

This calibration factor may be adjusted for other conditions, for example the calibration factor for sea water is 0.5618mm/sec/Hz.

The speed of sound varies significantly with water density. Water density is dependent on pressure, water temperature, salinity and sediment content. Of these, temperature has the most significant effect and it is measured by the Starflow QSD and applied in the correction of velocity measurements.

The Starflow QSD corrects for the variation of the speed of sound in water due to temperature using a factor of 0.00138mm/s/Hz/°C. This correction is a best fit for water temperatures between 0°C to 30°C.

The following table shows how the speed of sound varies with temperature and between fresh and sea water.

Temperature (ºC)	"Fresh Water"	"Sea Water"
0	1402	1449
5	1426	1471
10	1447	1490
15	1466	1507
20	1482	1521
25	1497	1534
30	1509	1545
35	1520	1555

Velocity of Sound in Water (m/s) at atmospheric pressure

Bubbles in the water are desirable as scatterers, but too many can affect the speed of sound. In air the speed of sound is about 350 m/s.

3.3 Factors Affecting Data Accuracy

Starflow QSD measures velocity to an accuracy of ±2% and depth to ±1% of range. This is logged to a resolution of 1 mm/sec and 1mm respectively.

The purpose of the Starflow QSD system is to produce velocity data. There are many opportunities for errors to accrue in the process and degrade the result. These can be reduced or eliminated by using the instrument properly. Some of the more significant potential error sources follow.

Alignment with Flow and Depth

For the calibration to be valid, the transducer needs to be horizontally and vertically aligned with the flow. While Starflow QSDs are calibrated pointing into the flow, they can be pointed downstream with little loss of calibration accuracy. You may want to do this when fouling of the sensor face is a problem. Any angled flow in the horizontal plane will reduce the recorded velocity.

The Starflow QSD instrument must be mounted in the water parallel to the surface for depth readings to measure accurately (~ +/- 10 deg), if not the depth may read inaccurately and therefore the recorded depth can be recording incorrectly.

Instantaneous Versus “Averaged” Velocity

When you observe Starflow QSD velocities, they will be seen to vary by 10% or more from scan to scan at some sites. Because Starflow QSD is very sensitive to variations in velocities, you are able to see the natural velocity changes in the channel.

Although the discharge in a channel may be reasonably constant for a period of time, the velocity distribution is always changing. Different velocity streams wander from side to side and bed to surface as they progress down the channel. Turbulent swirls and eddies are carried downstream for long distances while they slowly decay. Hydrographers will be used to having this action partly removed by the mechanical inertia of a current meter and the period over which a typical measurement is timed. However all will have noticed that the rate of revolutions of the current meter varies during the timing period.

Continual velocity logging at one location with a Starflow QSD will show these cyclic velocity pulsations. The characteristics will be different for different sites and will vary with discharge. Cycles will typically include short period fluctuations (a few seconds) overlaid on longer cyclic fluctuations (up to many minutes). Longer term pulsations may also be seen particularly in larger streams when in flood.

When comparing Starflow QSD velocity and mechanical current meter readings, the display should be observed long enough to estimate the mean of the readings. The Starflow QSD will do most of this processing internally but if an external logger is being used to record the readings averaging could also be done here this will help attenuate short frequency variations.

Conversion of Logged to Mean Velocity

The logged velocity data may have to be adjusted during post processing to reflect a mean velocity for the channel. The factors used will be site specific and have to be determined by the operator. This is done by obtaining a mean channel velocity by conventional techniques and comparing it with the average logged velocity. If necessary this process should be repeated at various discharges.

Where the relationship is complex or unstable, the accuracy of this method is compromised.

In laminar flow conditions the channel mean velocity could be expected to be between 90% and 110% of the logged velocity.

In small channels (say a 500mm diameter pipe) the factor may be close to 100% as a representative area of flow will have been “seen” by Starflow QSD and contributed to the logged velocity.

In larger channels only the area adjacent to Starflow QSD will be “seen” and the relationship will depend on how this portion relates to the vertical and horizontal velocity distribution in the channel. An instrument located in the centre of the stream would normally be in a higher velocity area. However in a deep channel Starflow QSD may only see the slower portion of the velocity profile.

4.0 POWER AND WIRING SPECIFICATIONS

4.1 Power

Voltage range 10 to 24 V DC

Supply current 50uA standby, 100mA active for 1 second @12V

Source (typical) 12 V DC (external battery)

Battery duration table

	SDI-12 Interrogation Interval		
12V Battery Capacity	**5 min**	**1 min**	**15 sec**
7Ah	760 days	169 days	43 days
12Ah	1304 days	291 days	74 days

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4.2 Starflow QSD Wiring Table

Starflow QSD Wire	Logger
White	SDI-12
Brown	+12V
Green	GND

5.0 INSTALLATION

Starflow QSD is a very effective alternative to conventional flow measuring installations for small streams and pipes. It is unobtrusive and ideally suited to flow conditions in culverts, channels and drains and open pipes. Cost, maintenance and environmental impact of new installations is minimized by avoiding the construction of conventional flow measuring structures.

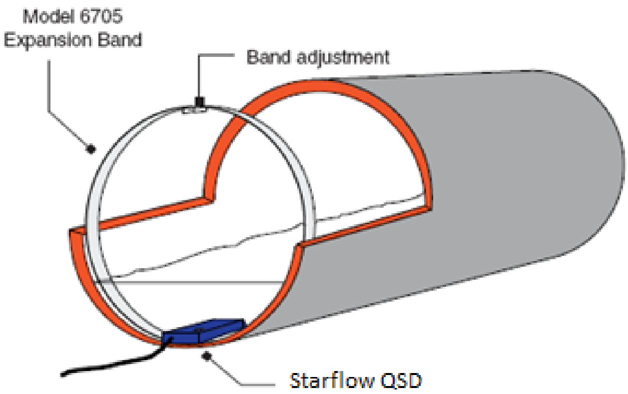
5.1 Site Considerations

The Doppler signal received, and the accuracy of the computed velocity, is related to the flow and cross-section characteristics of the site. A suitable site has the following features:

Feature	Description
Flows are laminar and the velocity measured by the transducer can be related to the mean velocity of the channel.	Velocity is measured from a limited path in front of and above the acoustic sensors. This area varies with the amount of suspended material in the water and the channel characteristics. The user has to determine the relationship between the measured and mean velocity.
The channel cross section is stable.	The relationship between water level and the cross-sectional area is used as part of the flow computation.
Velocities are greater than 20 mm / second.	The transducer does not process velocities slower than this. The maximum velocity is 5 metres / second. The transducer will measure velocities in both directions.
Reflectors are present in the water.	Generally the more material in the water the better. Starflow QSD generally works well in clean natural streams but problems may be encountered in extremely clean water.
No excessive aeration.	Bubbles are good scatterers and occasional small bubbles will enhance the signal. However the speed of sound can be affected if there are excessive amounts of air entrapped in the flow.
The bed is stable and Starflow QSD will not be buried by deposits.	Some coating and partial burying has little effect on the measured velocity but it should be avoided. Any burying or sediment covering the depth transducer will affect the depth reading results.
Starflow QSD Pointing Upstream or Downstream?	Pointing the sensor end downstream will stop it accumulating debris; however in some channels the sensor body may disturb the velocity distribution unacceptably. The velocity reading will be positive when pointing upstream and negative when pointing downstream. The Starflow QSD may be configured to only read positive velocities regardless of water flow direction.
Starflow QSD Depth sensor not situated parallel to the surface?	If Depth sensor is not parallel to the surface (~ ±10 °) the readings could be compromised

5.2 Starflow QSD Mounting

A typical installation is in a pipe or culvert with diameters between 150mm and 2000 mm. The Starflow QSD should be located near the downstream end of a straight and clean culvert, where non-turbulent flow conditions are maximised. The mounting should ensure the unit sits right on the bottom to avoid debris catching beneath it. It is also recommended that in open pipe situations that the Starflow QSD is situated 5 times the diameter inside the pipe if possible this will allow the Starflow QSD to measure the best possible laminar flow.



In culverts the sensor can be mounted on a stainless steel band that is slipped inside the pipe and expanded to lock it in position. In open channels special mounting brackets may be required.
The Model 6705 Expanding Band kit allows you to install a Starflow QSD instrument into a pipe.
Kit design is modular, allowing it to fit into any size pipe. The band is flexible enough to fit irregular shapes, such as ovoid (egg shaped) sections.
All components are made from stainless steel and the band fittings are 100mm wide to fit the standard Starflow QSD mount.

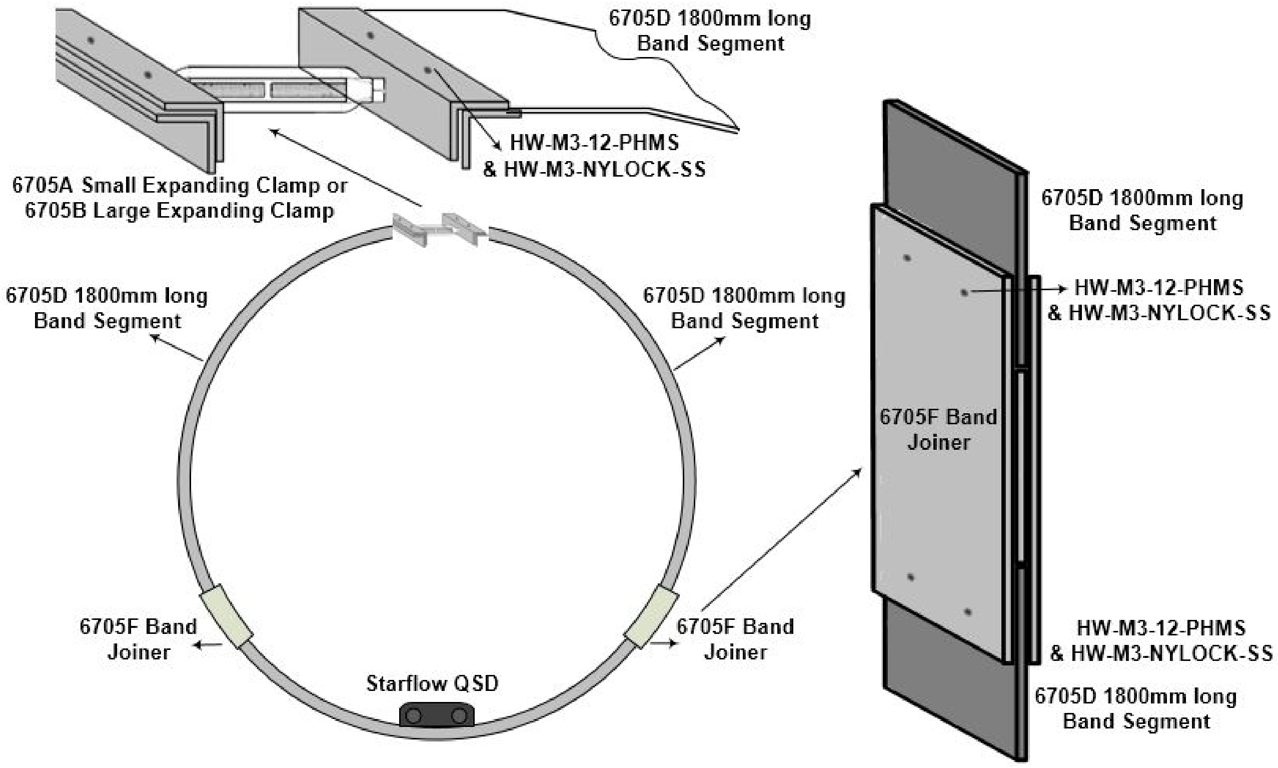
Although pipes come in standard diameters, their dimensions are not always accurate. This means that an expanding band system must allow the installer to make adjustments on site. To achieve this, the Model 6705 system is made so that general assembly can be done in the workshop, whilst adjustments can be made in the field with hand tools. An expanding turn-buckle locks the band into the pipe.
To determine what components are needed for a Starflow QSD pipe installation, you need to know the pipe diameter.

Pipe Diameter	Clamp	Bands	Joiners
Up to 600mm	6705A	6705D	-
600 - 1200mm	6705B	2 x 6705D	1
1200 - 1800mm	6705B	3 x 6705D	2

Note: Pipes less than 150mm diameter are NOT RECOMMENDED for Starflow QSD installation due to the instrument's size.

Do the following:

1. If the inside circumference of the pipe is ACCURATELY known, then cut the band assembly to this length LESS 25mm for fitting clearance. Circumference (length) = Diameter x 3.14
2. Arrange the clamp, band(s) and joiner(s) so that Starflow QSD unit will be positioned at the bottom (invert) of the pipe and an Expanding Clamp at the top (obvert) of pipe (see diagram).



3. Drill 4 x 5mm holes, 85mm spaced in the centre of the band to locate the Starflow QSD instrument Use the Starflow QSD mounting clamp 6527M as a guide.

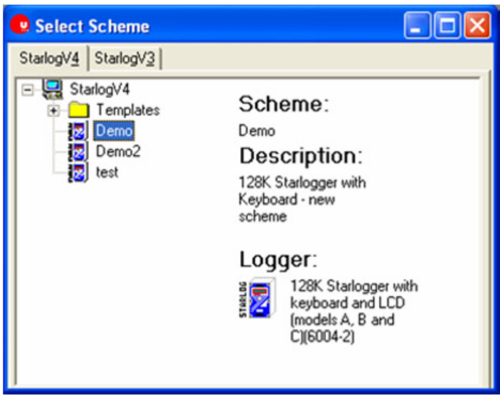
   Use a small pilot drill bit (about 2mm) then finish with the 5mm bit. (When drilling stainless steel, DO NOT stop once drilling has begun, as this will immediately blunt the drill bit.
4. Use M3 x 12mm stainless steel machine screws and M3 nylocks (supplied) to connect all parts. (If pop rivets and the pop rivet gun are available they can be used as the replacement for the screws and nuts sets)

Note: the band length must be measured to include the Expanding Clamp (fully closed), bands and joiners all together as shown.

5. Position and tighten Starflow QSD and band, the bolt the Starflow QSD mount to the band
6. Fold the band into a circle to easily fit inside the pipe and position into place inside the pipe
7. Slip the loose end of the band into the expanding clamp
8. Adjust clamp until band is tight inside pipe (use spanner if necessary)

6.0 STARFLOW QSD SCHEME MANAGEMENT

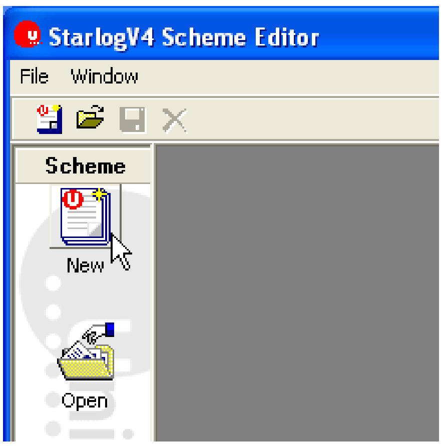
To select existing scheme open StarlogV4, click on Select icon and created schemes will be displayed. The tabs at the top allow you to view all your version 4. Select a scheme by double-click its name

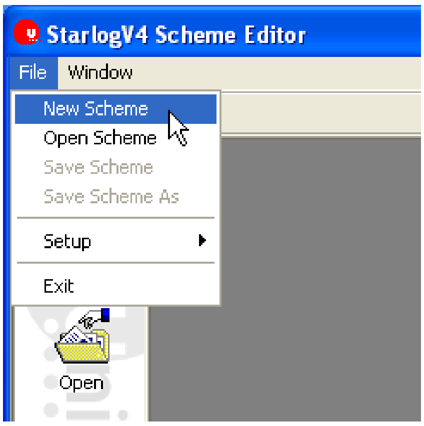


6.1 Scheme Editor

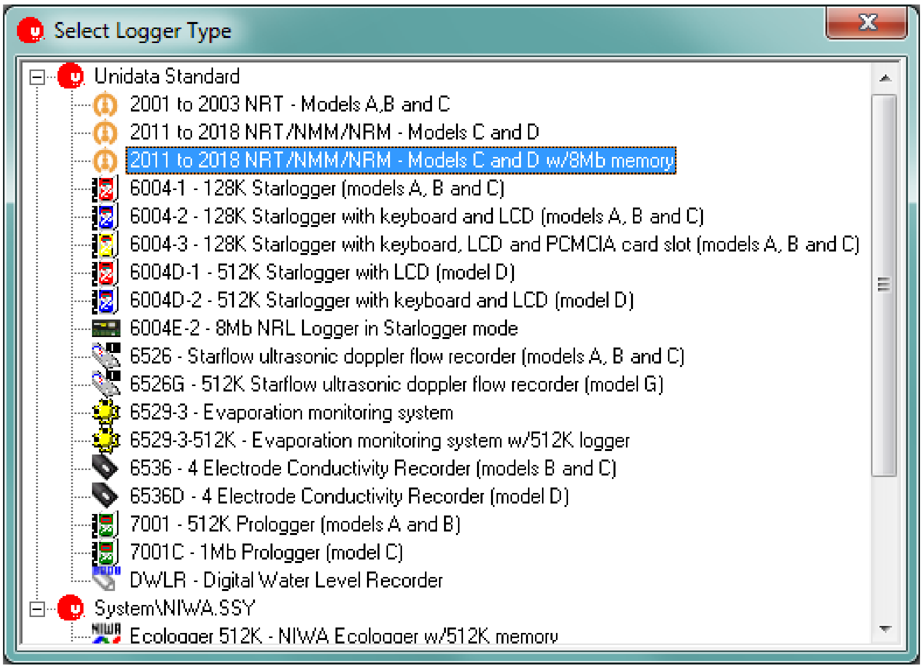
To create a scheme, you need to open the Scheme Editor. Click on the **Scheme Editor** icon in the main window.

When the Scheme Editor is open, select New Scheme from the File menu, or click the New icon on either of the toolbars.





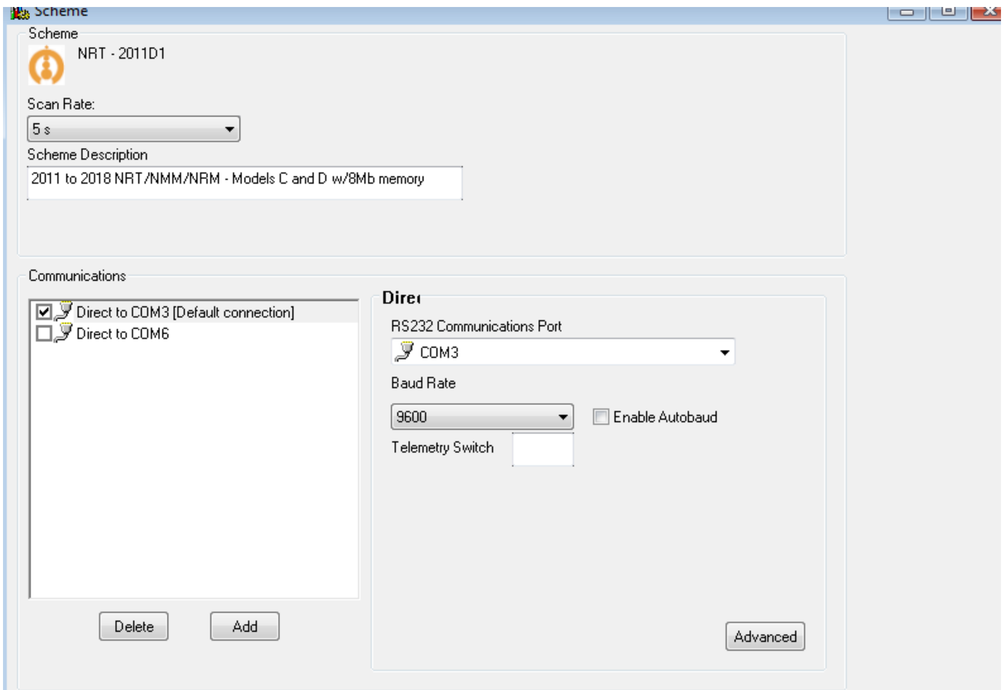
A list of data loggers will appear. Select the Unidata logger that will connect to the Starflow QSD in this example we will use an NRT with 8M memory, double click on the logger.



Three new icons will appear inside the left toolbar: **Settings, Instruments**, and **Log Buffer**.

6.1.1 Settings

To control basic logger functionality click on the Settings icon:



One of the most important settings is the **Scan Rate**. This defines how often the logger scans (samples) its inputs. Faster scan rates make it more likely the data logger will capture accurate minimum and maximum, but will shorten the battery life.

The **Scheme Description** should be set to something that will assist you in remember what the scheme is for. Apart from the **Scan Rate**, the **Communication** settings are the next most critical. If they're wrong, you won't be able to program or unload your logger!

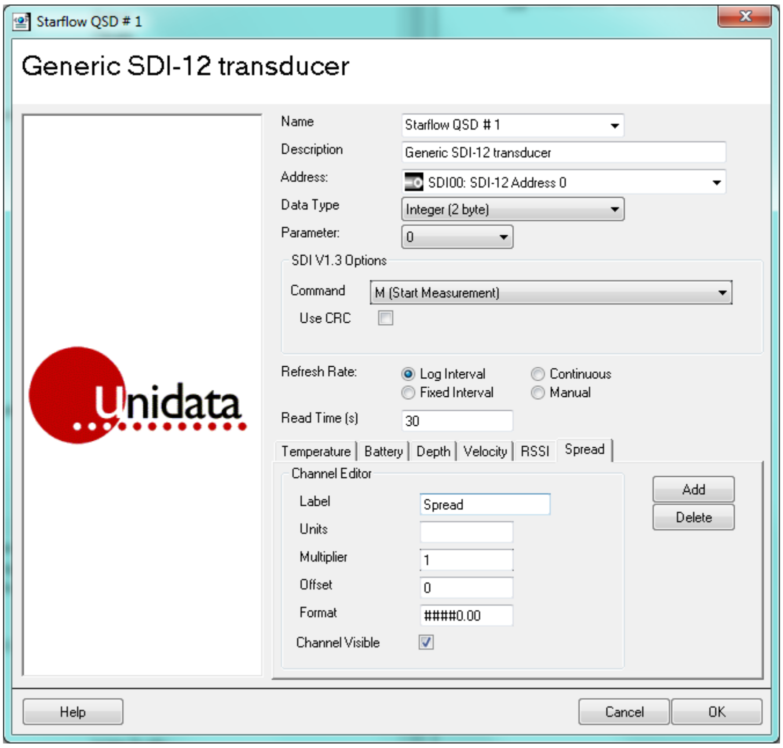
6.1.2 Instruments

Click on the **Instruments** icon. Adding the Starflow QSD as an instrument:

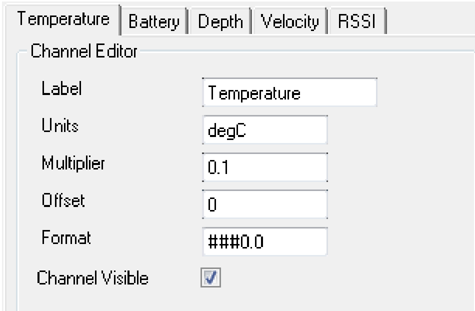
Add new SDI-12 transducer to your logger scheme in the PDLTRANS library.

This will consist of 6 channels as shown in below screen shots. All values will be an Integer data type.

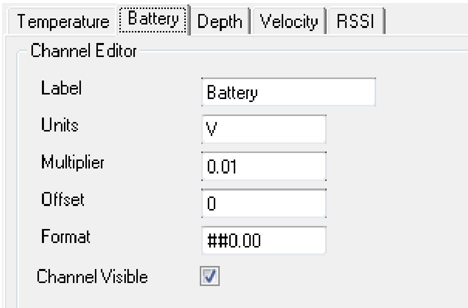
Par.	**Description**	**Units**	**Example**	**Meaning**
0	Water Temperature	1/10 ºC	+152	15.2 ºC
1	Battery Voltage	1/100 Volts	+1302	13.02 Volts
2	Water Depth	mm	+123	123 mm
3	Water Velocity	+/- mm/s	-234	234 mm/s (reverse flow)
4	RSSI (signal level)	no units	+66	66 (no units)
5	Signal Spread	no units	+45	45 (no units)



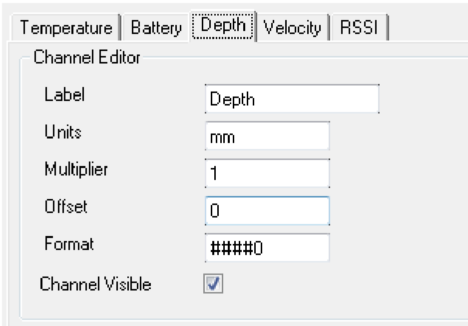
Temperature



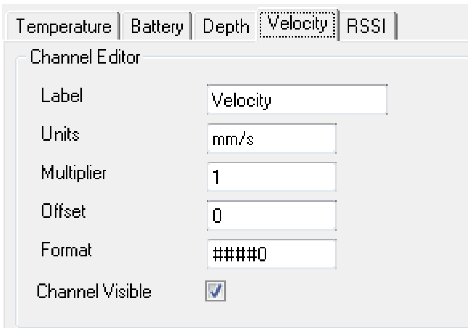
Battery



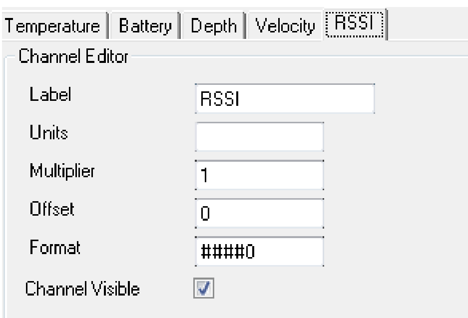
Depth



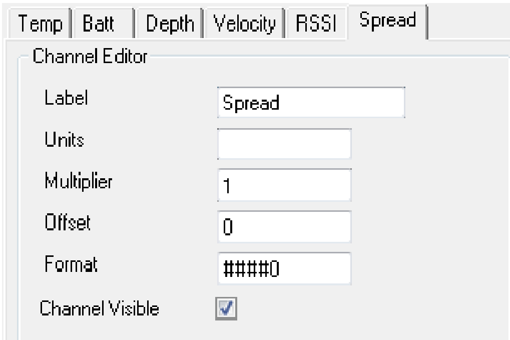
Velocity



RSSI

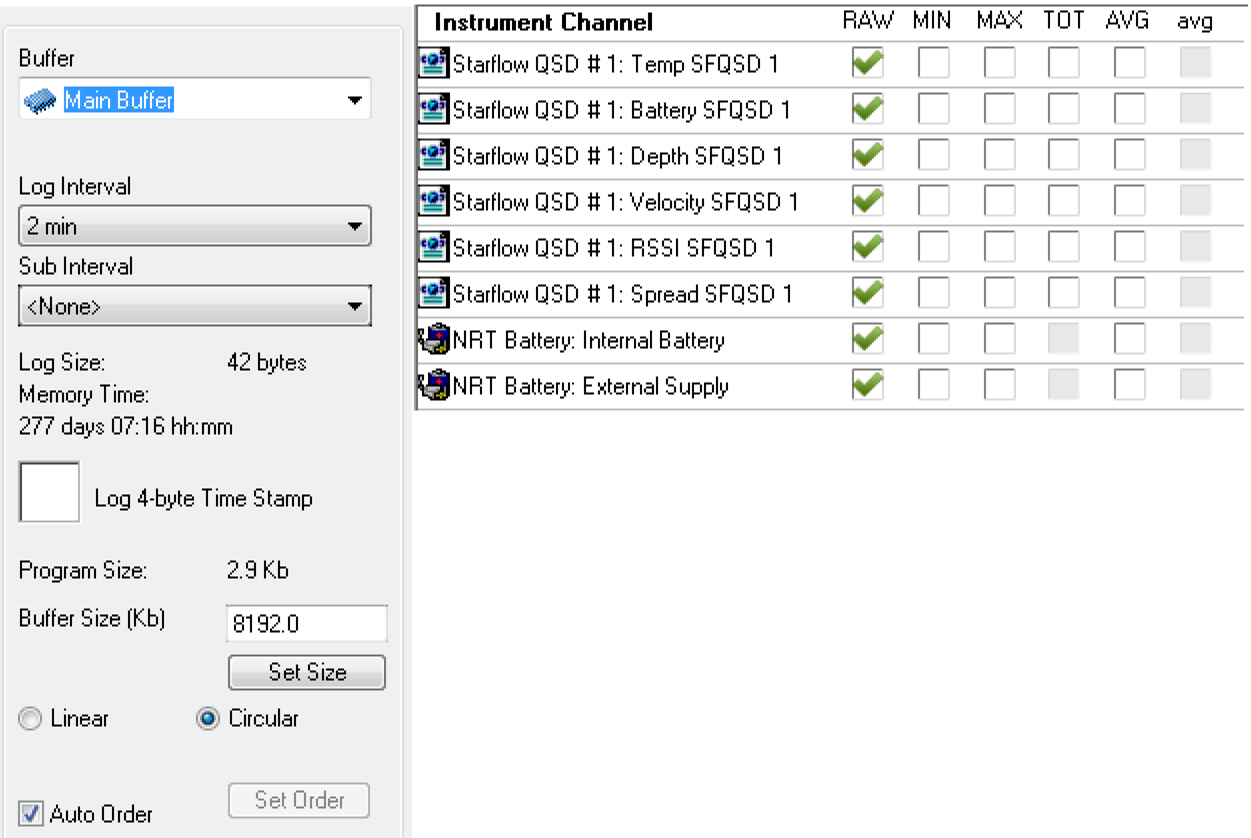


Spread



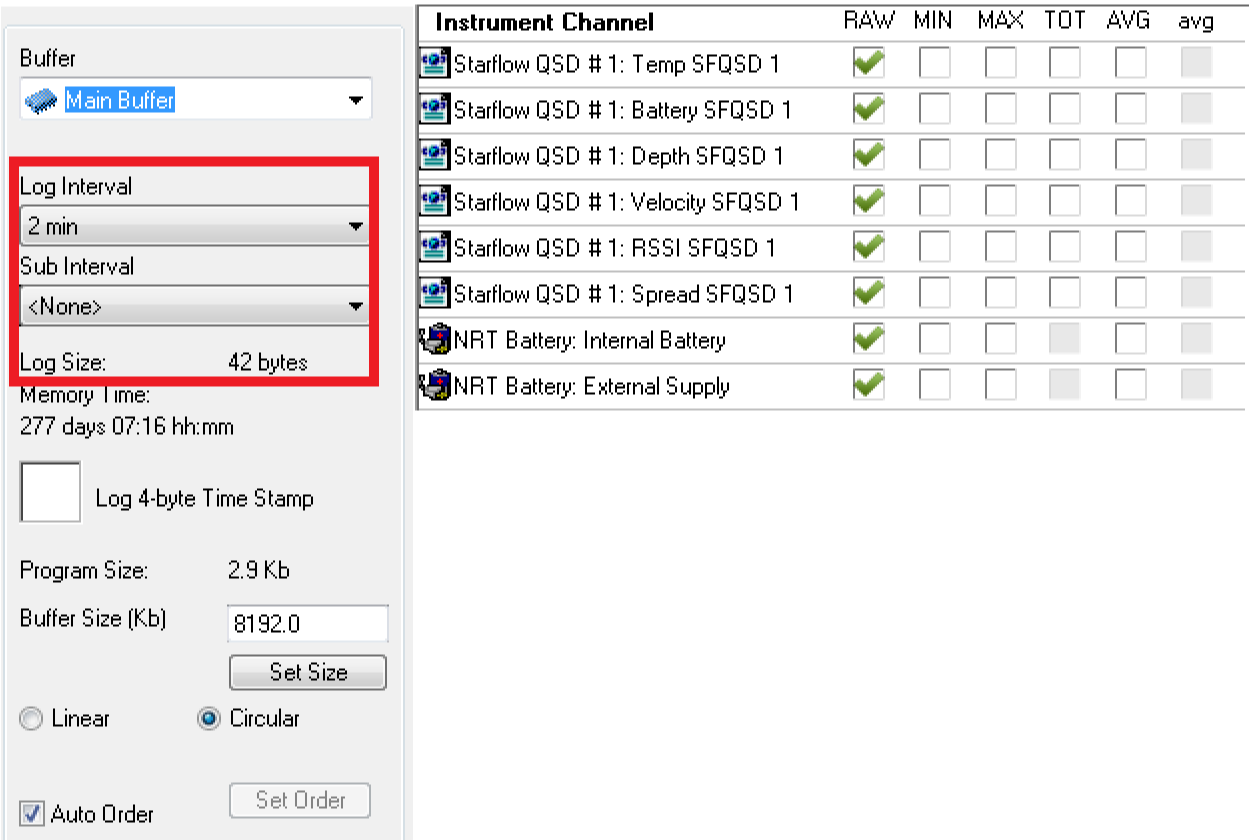
6.1.3 Log Buffer

Open the Log Buffer window by clicking on the Log Buffer icon.
The Log Buffer window is where you set up the logger memory for recording data by selecting what to log and how often to log it.



6.1.4 Buffer Log Intervals

The Log Interval is the time between logs. Only the Main Buffer has a Log Interval setting. At each log, all the instrument Channels ticked will be recorded into the Log Buffer.



Settings common to all buffers are:

Linear / Circular: When linear buffers fill up, they stop accepting new logged data.
When Circular buffers full up, they wrap around to the beginning and start overwriting the oldest data.

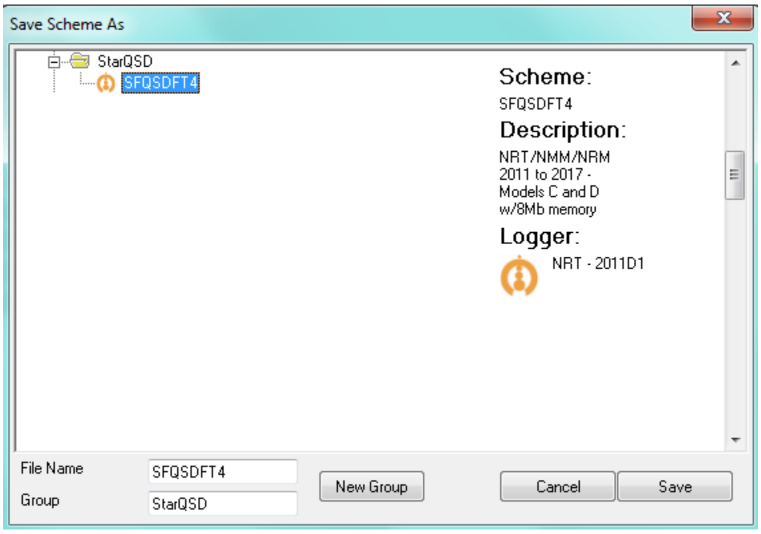
6.1.5 Saving the Scheme

To save your scheme, click the **Save** icon.

If you've saved your scheme before it will immediately save. If you've never saved the scheme before, the dialog shown below will appear. You can get the same dialog at any time by selecting **Save Scheme As** from the **File** menu.

Enter the scheme name in the **File Name** field. There is a maximum length of eight characters.

The **New Group** button allows you to create sub-folders of schemes. Groups may be created inside groups, too.



6.2 Channel Characteristics Affecting the Signal

6.2.1 The Nature and Location of the "Reflectors" in the Water

The Starflow QSD measures echoed Doppler shifts from anything that is acoustically reflective and in the signal beam. It cannot discriminate where the echo is coming from and the bigger, closer reflectors will generate a stronger signal than smaller or more distant reflectors.

Reflectors can include:

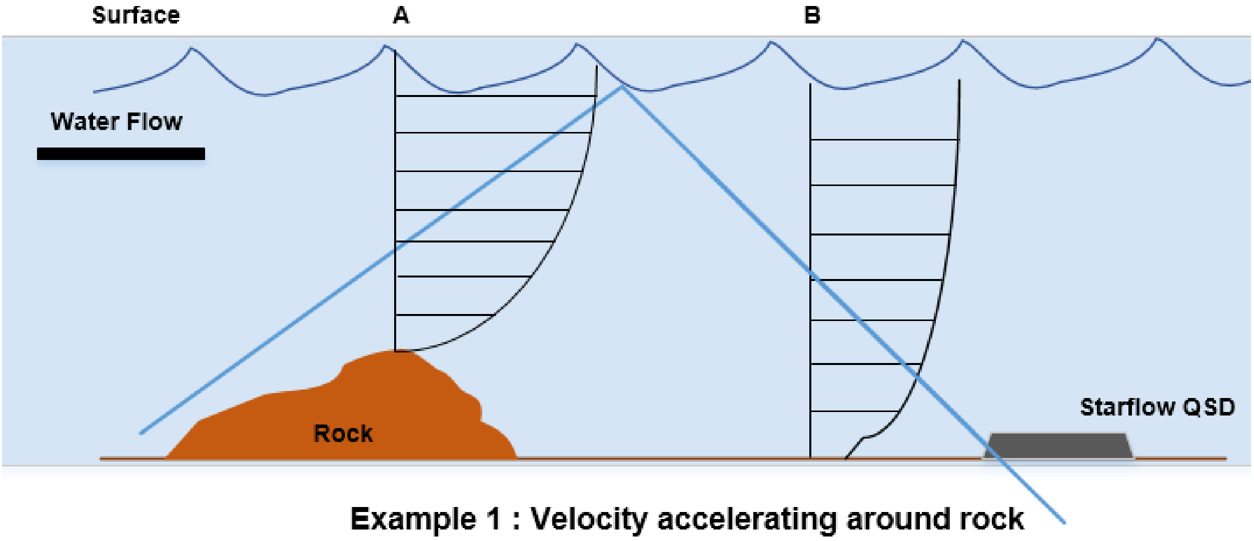
- All types of particles in suspension.
- Alluvial saltation load such as sand, pebbles and rocks moving at or near the bed.
- Leaves, sticks, and organic material.
- Surface waves from wind or velocity.
- Bubbles and entrapped air pockets.

During the time it takes to traverse the signal beam a particularly good reflector can be measured 100 or more times. The velocity of this reflector may bias or dominate one velocity measurement. This will tend to be averaged out during the logging period if it only happens occasionally.

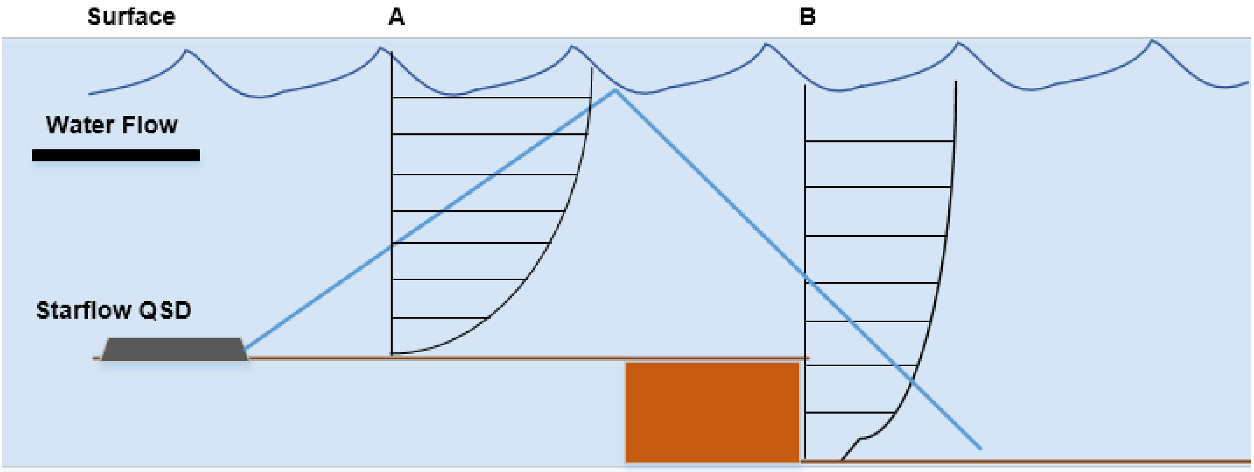
If it happens consistently it is a site characteristic. The relevance of this to the mean channel velocity will need to be understood and compensated for in processing.

6.2.2 Velocity Variations Due to Cross-Section Changes

At low flows in clean streams, the beam can be reflected for some distance and “see” unexpected velocities from some distance away.



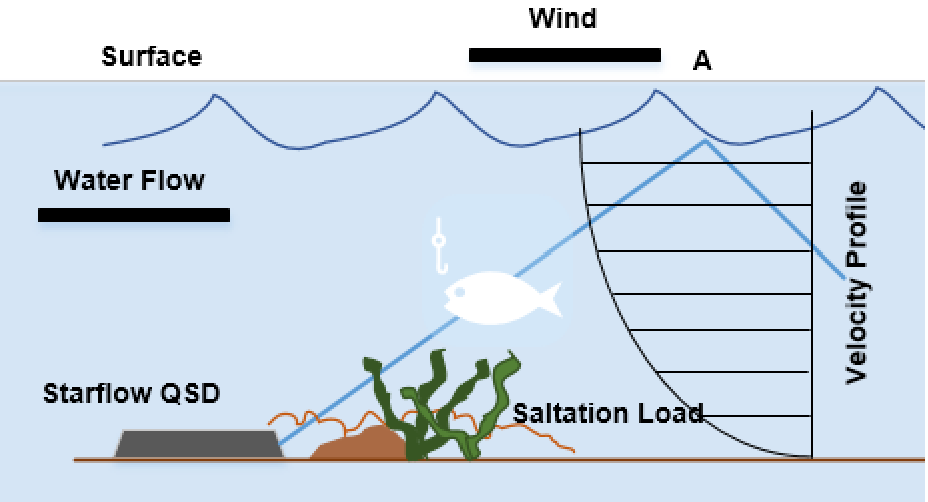
Example 1 : Velocity accelerating around rock



Example 2 : Velocity variations at culvert exit

6.2.3 Measuring Unexpected Velocities

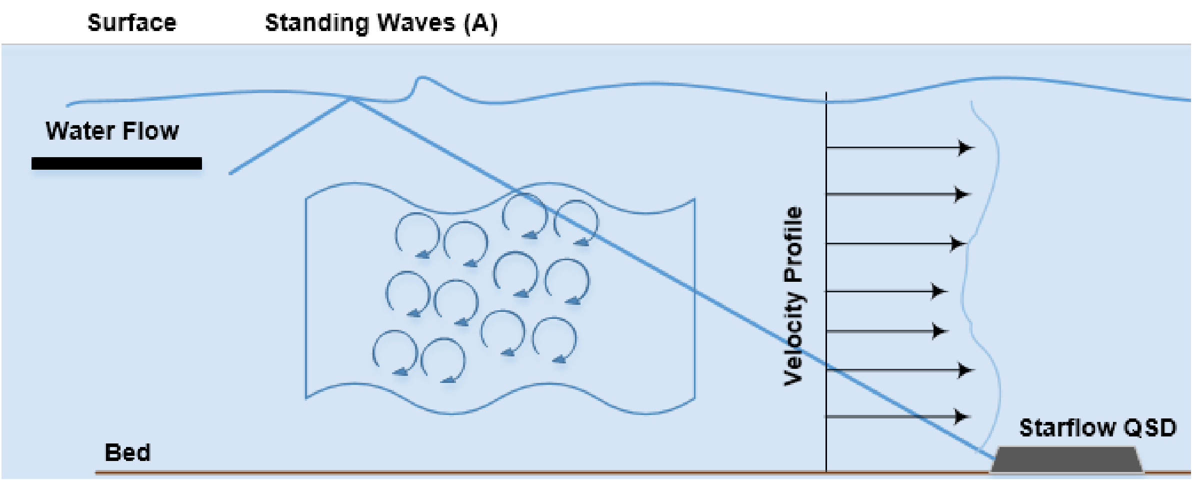
In some cases signals are from the wrong targets. A waving weed, aquatic animals, a strong stationary reflector in the bed, slow moving saltation targets or ripples on the surface can all produce Doppler shifts that are not directly related to the water velocity.



The beam can reflect from the surface underside and can detect different velocities to those expected.

6.2.4 Measuring Turbulent Velocities

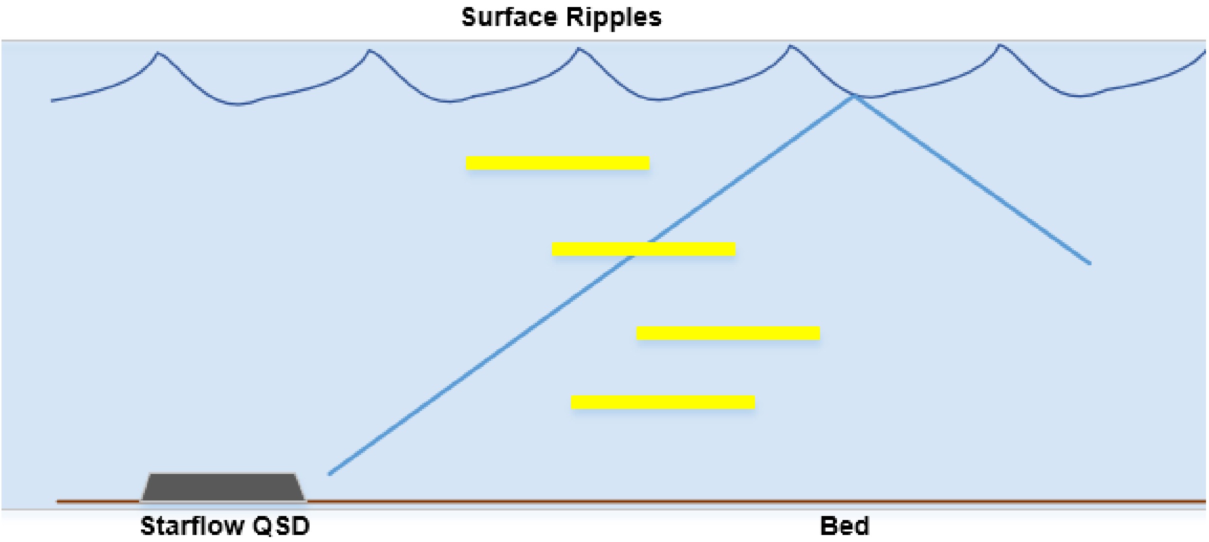
In higher bedslope streams a wide and multiple peaks may be displayed because of the complex moving landscape presented to the Starflow QSD.



6.2.5 Effects of Surface Ripples

In shallow water the presence of ripples or small waves on the surface can cause complications. The ripples may be caused by wind, or be a feature of the channel caused by obstructions in the channel or by irregularities on the bank. Ripples will be moving and at a different velocity to the water.

In shallow and clean water the Starflow QSD can clearly see the surface. As the ripples move they present a varying effect on the Doppler signal. At times the ripples will be positioned so that the carrier reflects away from the Starflow QSD. A minor signal is detected but many more signals are detected from the water and a correct velocity is measured.



When the ripples move slightly one can become positioned such that it becomes an "acoustic mirror" reflecting back a powerful signal and dominating the signals from the channel. The median velocity will be biased toward the ripple velocity and will be incorrect.

6.2.6 Measuring Flows in Very Small Channels

The Starflow QSD can be installed in channels as narrow as 75mm. It can measure minimum velocities to 20mm/second in depths as low as 25mm. This flow rate is well below the measuring ability of most instruments, flumes or weirs. However the Starflow QSD may struggle to operate correctly in these extreme conditions. The following conditions may be seen.

- The number of samples will be reduced. As velocities slow it takes the Starflow QSD longer to measure each Doppler shift. At shallow depths the volume of water from which to acquire signals is reduced. These factors combine to mean the Starflow QSD will generally not be able to acquire the full number of samples within the time allowed in a cycle. However, unless the water is extremely clean it will normally acquire enough signals for a sensible result.
- There will be an increase in the "signal noise". Because of the difficult environment there will be an increase in very high velocity signals. This can bias most data beyond the ability of the signal analysis process to extract meaningful velocities

6.2.7 Measuring Velocities in Very Shallow Water

Poor quality velocity data will result if the water becomes so shallow that the top of the eyes of the transducer come out of the water. A SDI-12 setting can be used to switch off the velocity operation of the Starflow QSD when measured depth is so shallow that the eyes are exposed.

6.2.8 Interference to the Transducers

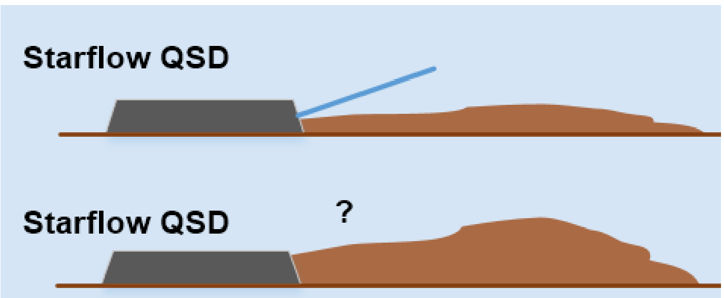
It is inevitable that bed mounted instruments will become layered with silt or algae. They may sometimes be affected by siltation or debris. The following effects have been noticed.

Silt, Algae and Other Soft, Saturated Materials

When covering the transducers with a 1-2mm thick layer, appear to have little effect on the signals logged. Provided the material is flexible and saturated the ultrasonic signals can be transmitted and received through it.

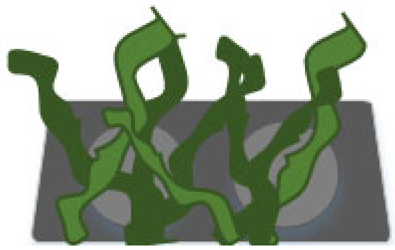
Burying the Transducer in Sand

Part buried sensors continue to operate. Provided some part of both velocity sensors are above the sand level the velocity recorded is the same as if the sensor was clear. Completely buried sensors result in the signal collapsing. The signal does not appear to escape from beneath the sand to interrogate the water above.



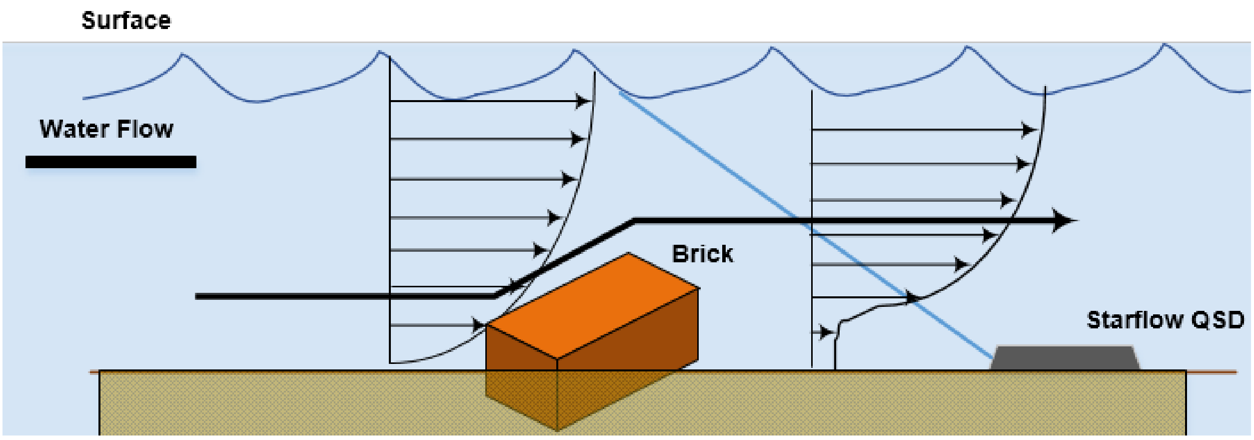
Debris on the Sensors

A similar effect to saltation can result from leaves and fine debris covering the sensors.
If the sensors are partly clear the recording is not affected. However one leaf lying across the two velocity sensors is enough to corrupt the signals and produce the type of histogram produced from a buried sensor.



Disruption of the Flow Pattern by Debris

Larger debris in the vicinity may affect the logged values by changing the velocity distribution in the field of view of the sensor.



The flow distribution in the channel may no longer be laminar and the relationship between the logged and mean channel velocity may be distorted.

7.0 FLOW MEASUREMENT EXTENSIONS

Starflow QSD is able to perform a wide range of flow calculations when connected to a Unidata Logger, like Neon Remote Terminal or Neon Remote Logger using SDI-12. This enables Starflow QSD to be used in partly filled circular pipes, regular open channels and natural streams.

Other closed shapes such as ovoid pipes, require a user-defined Area Rating Table.

Terms

Area (A): (cross section) Calculated by Starflow QSD from the Area Rating Table using the measured depth.

Units = cm2 or dm2 or m2.

Area Rating Table: Look-up table of depth versus cross-sectional area of the channel being measured.

Depth (D): Water depth above the Starflow QSD unit.

Units = mm.

Velocity (V): Average (median) velocity of water in the channel measured by Starflow QSD.

Units = mm/s.

Scan Rate (SR): Frequency of Starflow QSD measurement cycle (Default = 60 secs).

Units = second.

Log Interval: Frequency of Starflow QSD recordings. (Default = 15 minute).

Units = scans

Flow Rate (FR): Instantaneous Flow Rate, calculated by Starflow QSD as the product of Velocity and Area.

Units = l/s or kl/s or Ml/s.

FR V A

Flow (F): Flow volume each scan interval calculated by Starflow QSD as the product of the Flow Rate and the measurement interval (Scan Rate).

Units = l or kl or Ml

F FR SR

Total Flow (TF): Totalised Flow Volume.

Units = l or kl or Ml

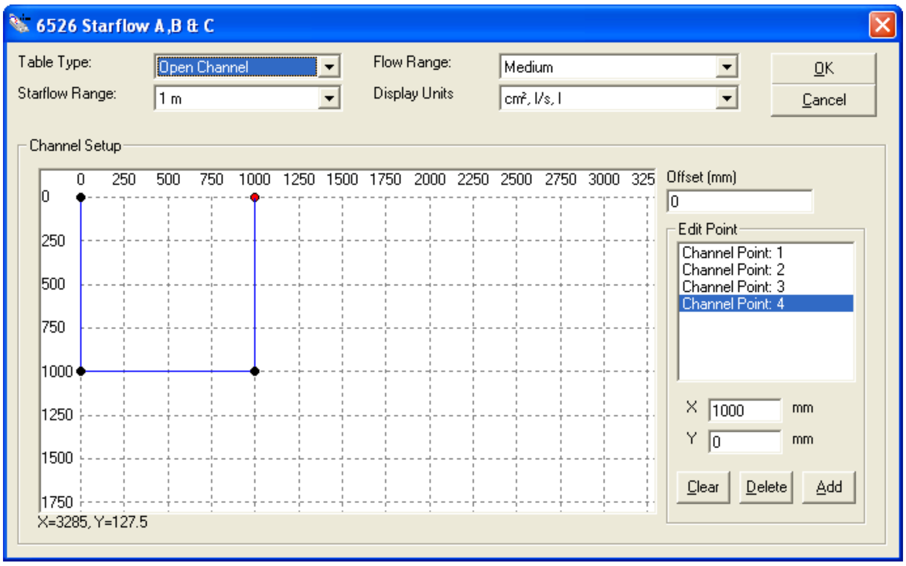
TF F

7.1 Overview of Creating a Flow Scheme

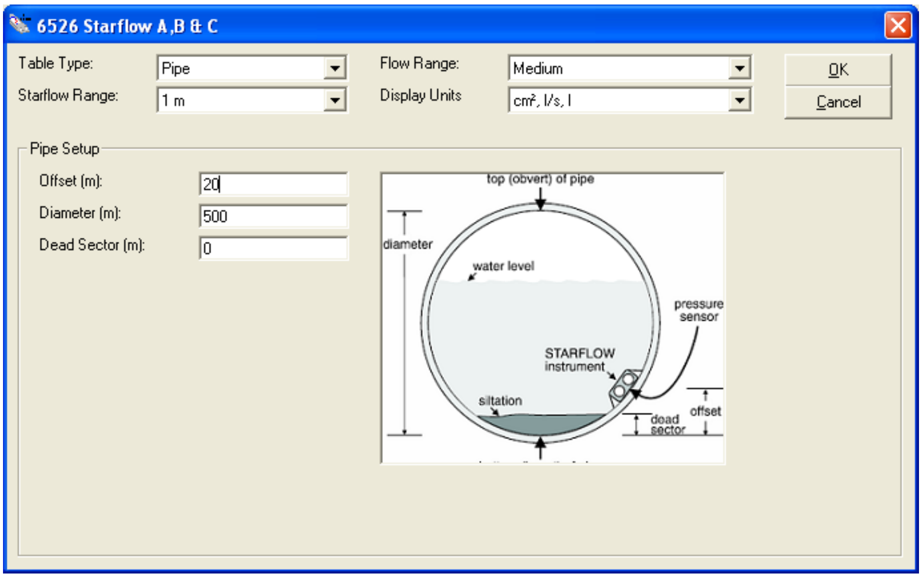
Creating a Starflow QSD Scheme for flow measurement is a five-step process:

1. Determine the dimensions of the channel.
2. For open channels create a Cross-Sectional Area in the Flow extension instrument which has already been added in the scheme editor and enter the parameters of your channel. Points can be added and deleted, also note that the Starflow QSD range should be selected, this will be written on the front of the Starflow QSD.

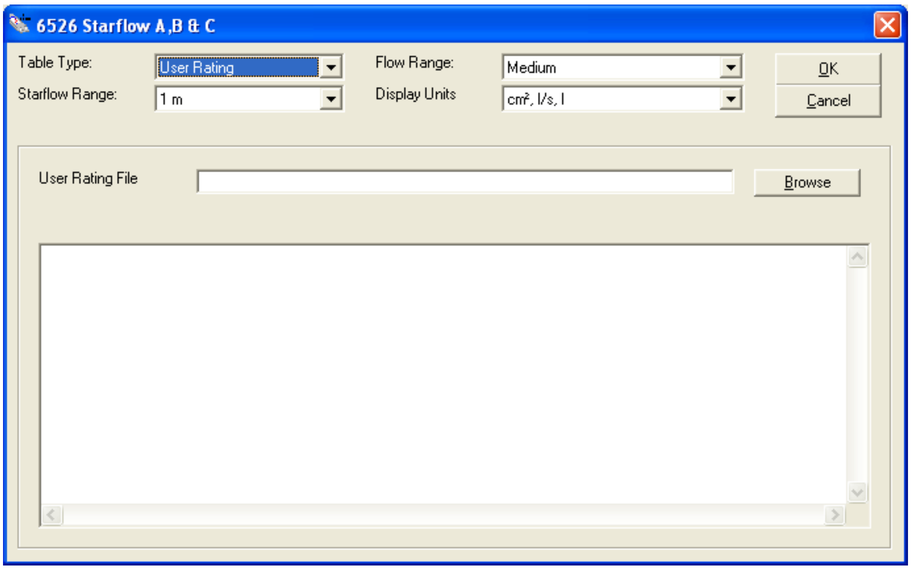
   If your water depth will always be below 1m it is advisable to choose the 1m range.



3. The table type can also be a pipe; in this situation the pipe dimensions should be entered.



4. In the case of a User Defined Area Rating Table, select the text file to be used.



5. Once this has been completed then Save the Scheme.

Creating an Area Rating Table

To calculate Flow, Starflow QSD uses a lookup table called the Area Rating Table. The Area Rating Table is automatically generated when the scheme is saved from information provided in the Flow extension instrument.

An Area Rating Table is created for each scheme. This table is generated by one of three methods depending on the Starflow QSD site.

Type	Starflow QSD Site	How Created
Pipe	Partially filled circular pipe	Enter offset, diameter and dead sector in Area Rating Table window.
Open Channel	Open channel and natural stream	Entering the correct dimensions in the flow extension instrument
User Defined	Other closed-in shapes, like an ovoid pipe	Create a text file listing measurements. Nominate this file in the scheme's User Rating file.

Partially Filled Pipe

There are four parameters needed to define a pipe installation.

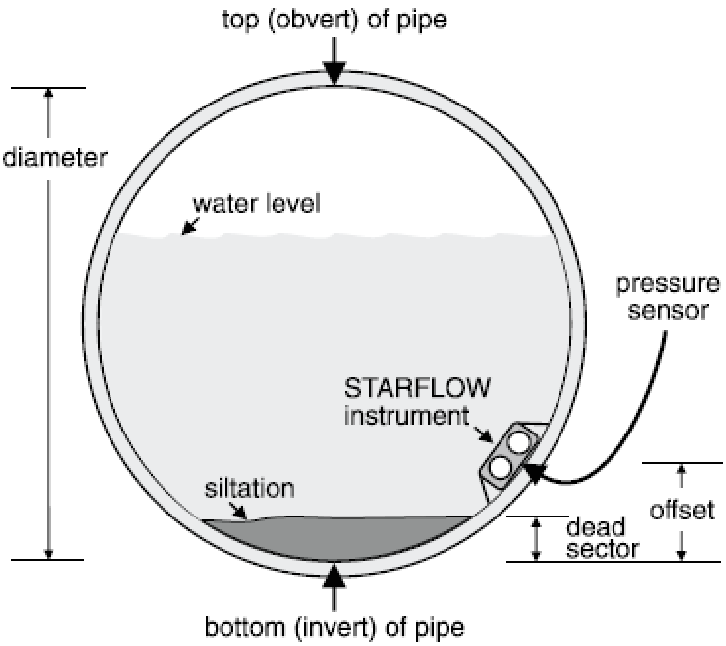
Range (m) Depth range of Starflow QSD. This defines the depth range able to be measured by the Starflow QSD. There are two ranges: 2m and 5m although if the depth will never be above the 1m range this should be selected for greater precision.

Define the smallest maximum depth for the channel that is compatible with your Starflow QSD as this will give best results. For example - For a 2m depth range Starflow QSD in a 900mm diameter pipe choose 1 to improve accuracy.

Offset (m) Offset defines the offset from the bottom of the pipe to the position of the Starflow QSD depth sensor. This is usually zero; however, in some installations the Starflow QSD may be located away from the bottom (to avoid silt and rubbish).

Pipe Diameter (m) Defines the pipe diameter.

Dead Sector (m) The deadband due to siltation (if any).

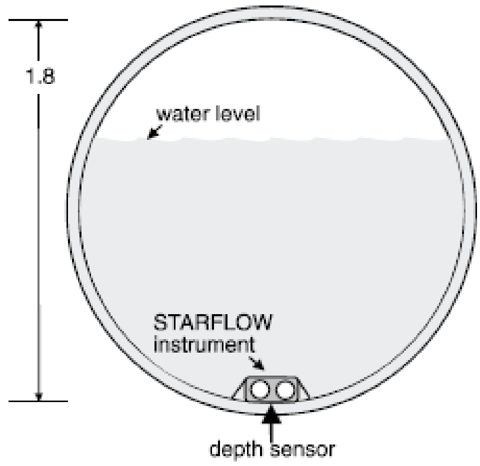


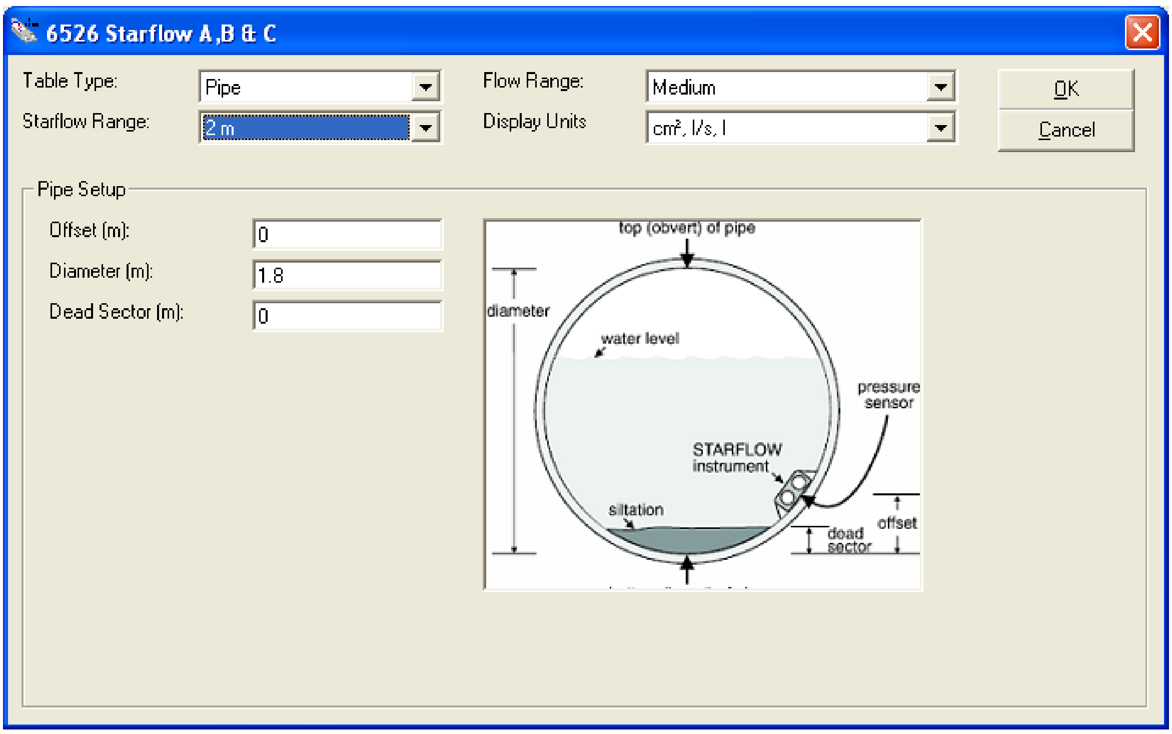
Pipe Example 1

The pipe is 1.8m in diameter.

A Starflow QSD unit is mounted at the bottom.

No silt (dead sector) in pipe.



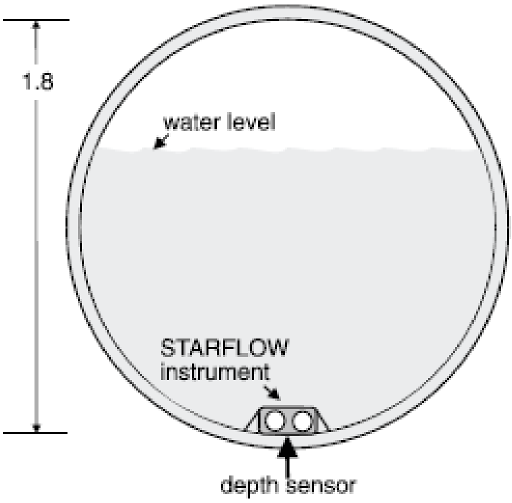


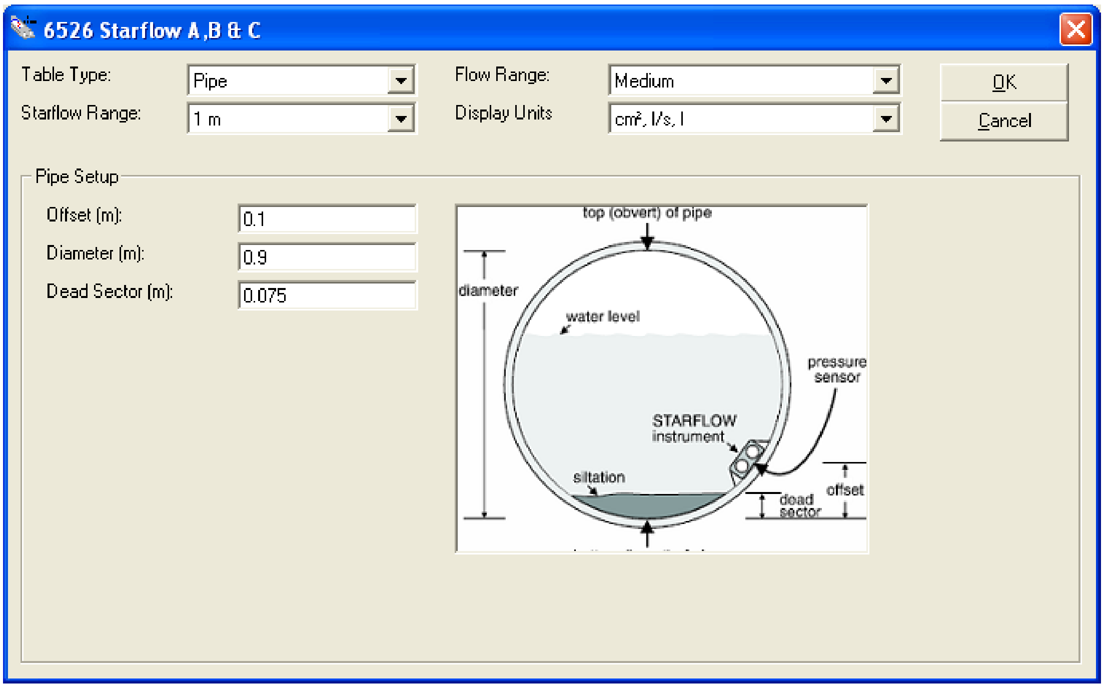
Pipe Example 2

The pipe is 900mm in diameter.

A Starflow QSD unit is mounted 100mm up from the bottom and there is 75mm of silt in the pipe.

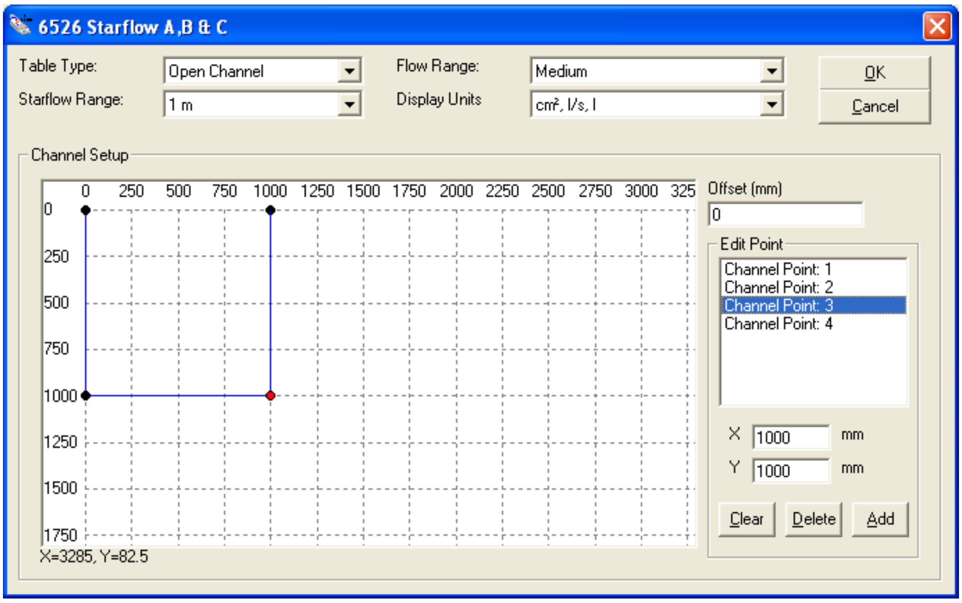
Note that the Table Range was set to 1 to give improved accuracy. Even though using a 2m depth Starflow QSD, maximum depth in this application is 800mm (less than 1m).





7.1.1 Open Channel and Natural Stream

The dimensional definition of any open channel (or stream) consists of pairs of “distance” and “reduced level” measurement which define the profile of the channel or stream. These pairs comprise the Channel Cross-Sectional Area.



For constructed channels, this information is easily determined from known construction dimensions. For natural streams, you will need to make actual measurements of the stream bed.

In addition, you require two parameters, the depth range and offset.

Range (m) Depth range of the channel. This defines the maximum depth of the channel. There are two ranges: 2m and 5m.

Define the smallest maximum depth for the channel that is compatible with your Starflow QSD as this will give best results. For example - for a 2m depth range Starflow QSD in a 900mm maximum depth channel, choose 1 to improve accuracy.

Offset (m) This defines the offset (reduced level) of the Starflow QSD instrument from the reference to the depth sensor.

Determining Distance/Reduced Level Information

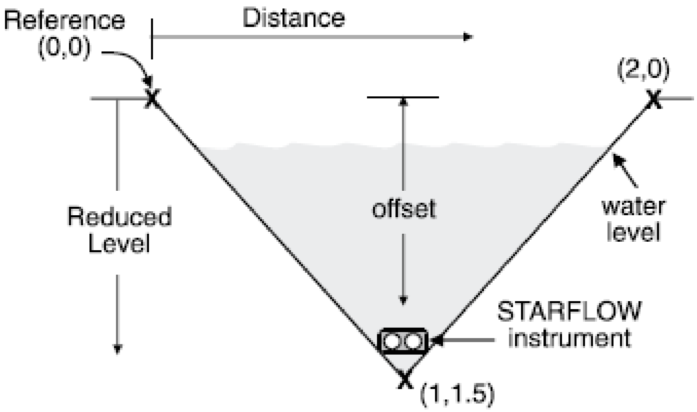
Select an arbitrary reference point above the highest water level expected. This is (0,0) pair.

Measure across the channel and down to the channel bed at sufficient number of points to define the bed profile. Adjacent points are connected by straight lines. There may be as many Distance/RL pairs as you need.

The reference point (0,0) may be any datum standard which must be above the highest water level.

Open Channel Example 1:

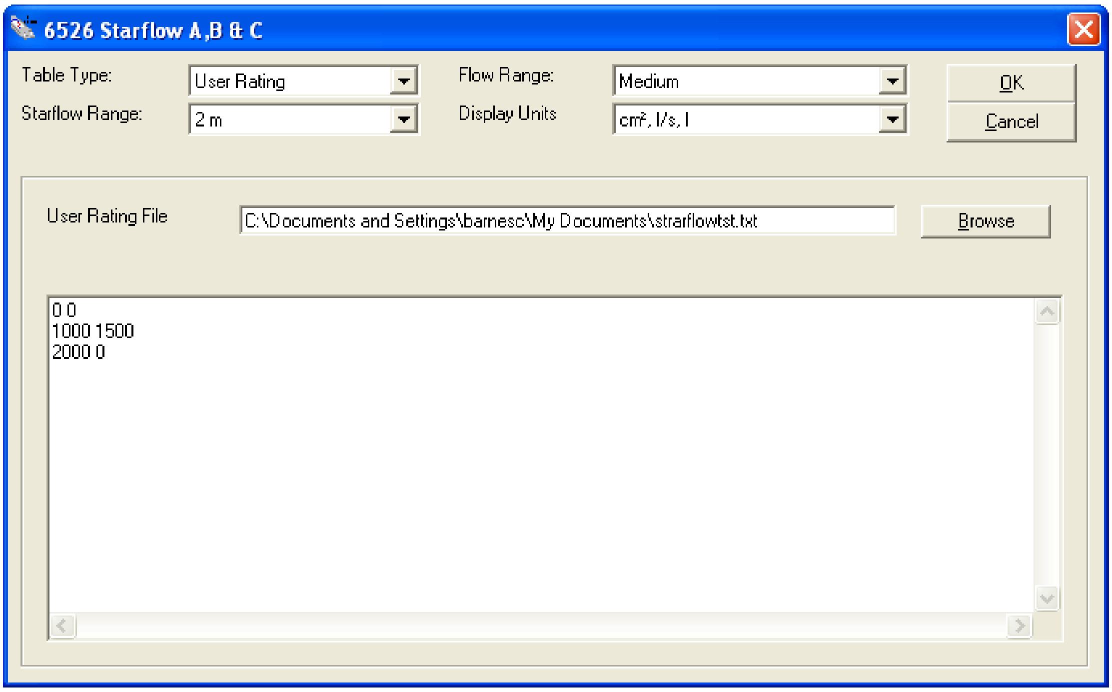
This Open Channel is a V-Notch shape which is 2m wide and 1.5m deep. A 2 metre depth range Starflow QSD unit is mounted in the lowest point of the notch.



The Cross-Sectional Area File is shown below:

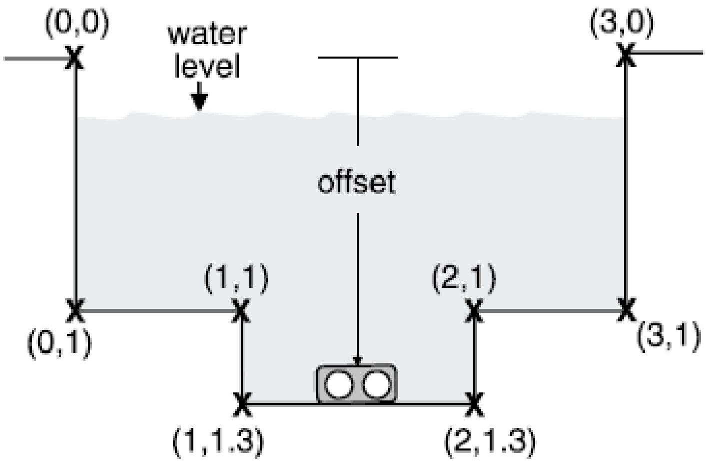
```
0 0
1000 1500
2000 0
```

The Area Rating Table window for this application looks like this:



Open Channel Example 2:

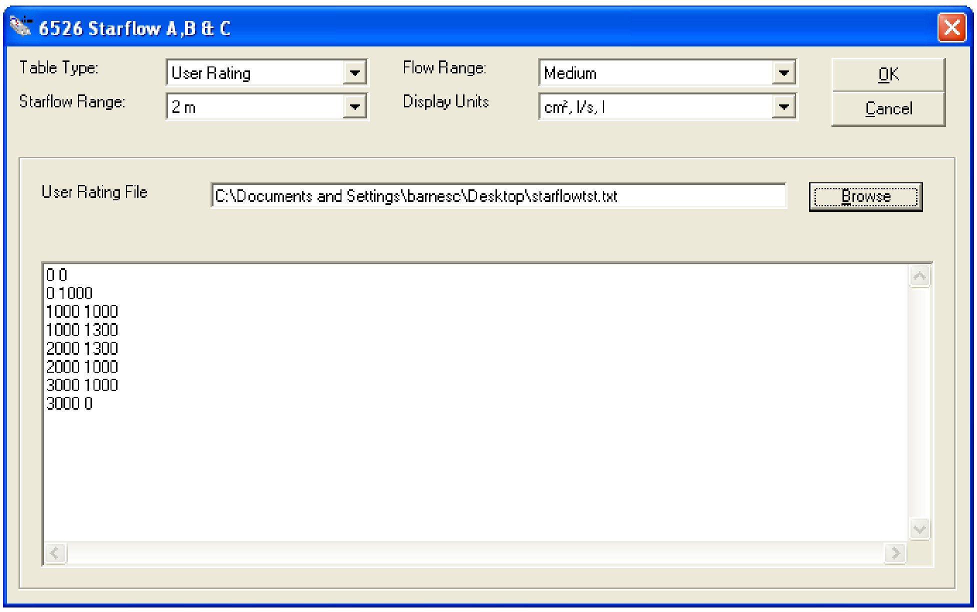
This Open Channel is a pre-formed two-stage Rectangular Channel which is 3 metres wide and 1m deep with a 1m x 300mm secondary channel in the centre.



The Cross-Sectional Area File (OCEX2.XAC) is shown below:

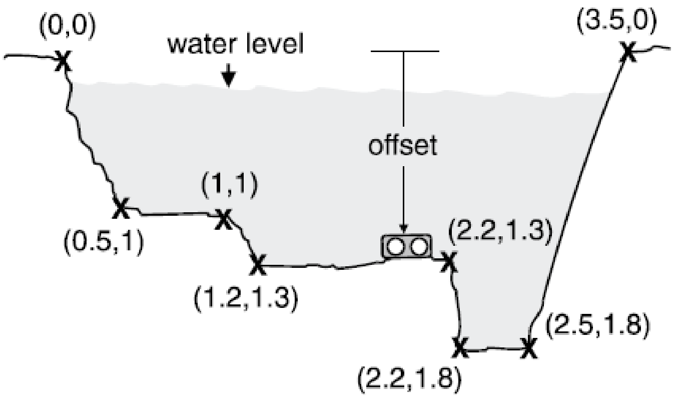
```
0 0
0 1000
1000 1000
1000 1300
2000 1300
2000 1000
3000 1000
3000 0
```

The Area Rating Table window for this application has these settings:



Open Channel/Natural Stream Example 3:

This Natural Stream is 3 metres wide with the shape illustrated below.



The Cross-Sectional Area File is shown below:

```
0 0
500 1000
1000 1000
1200 1300
2200 1300
2200 1800
2500 1800
3500 0
```

The Area Rating Table window for this application looks like this: