VALEPORT LIMITED

MIDAS DWR & WTR Wave Recorders

Operation Manual

Document Ref: 0730890B

Date: September 2008

Valeport Limited,
St. Peter's Quay,
Totnes,
Devon, TQ9 5EW,
UK

Tel: +44 (0)1803 869292
Fax: +44 (0)1803 869293
e-mail: sales@valeport.co.uk
Web: www.valeport.co.uk

CHAPTER	DESCRIPTION	PAGE

1 INTRODUCTION 4
2 SPECIFICATIONS 5
2.1 Standard Sensors 5
2.2 Optional Sensors 5
2.3 Physical 6
2.4 Electronic 6
3 PREPARING FOR DEPLOYMENT 7
3.1 Battery Pack 7
3.1.1 Battery Status Check 8
3.2 Installing the USB adaptor 9
3.3 Installing WaveLog Express 12
3.4 Setting Up 14
3.4.1 Connecting to the Instrument 14
3.4.2 Advice and Hints on Deployment Settings 16
3.4.3 Choosing your sampling regime 19
3.4.4 Save & Output SeTTINGS 21
3.4.5 Battery & Memory Life 22
3.4.6 Local Settings 22
3.4.7 Time Setup 23
3.4.8 Delay Start 23
3.4.9 Units Setup 23
3.4.10 Apply Settings 23
3.5 Priming Silt Trap 24
3.6 Running the Instrument 25
4 DEPLOYMENT & RECOVERY 26
4.1 Choosing Your Deployment Site 26
4.2 Valeport Deployment Frame 27
4.3 Deployment In Self Recording Mode 28
4.4 Deployment in Direct Reading Mode 28
5 DATA EXTRACTION 29
5.1 File Table 29
5.2 Upload Parameters 29
5.3 Memory Management 30
5.4 Upload Files 30
5.5 Data Translation 31
5.5.1 Logged Data Storage Structure 31
5.6 Post Processing 32
5.6.1 Processed Data Storage Structure 32
5.7 Real Time Data 33
5.7.1 Real Time data format 33
5.7.1.1 Tidestats output string: 33
5.7.1.2 Wavestats output string: 33
5.7.2 Real Time Data Storage Structure 34
6 DATA DISPLAY 35
6.1 Numerical Displays 36
6.1.1 Single Parameter Display 36
6.1.2 Last Data Display 36
6.2 Tabular Displays 37
6.2.1 Scroll Display 37
6.2.2 Directional Spectra Scroll 37
6.2.3 Frequency Scroll 39
6.2.4 Surface Wave Recreation Scroll 39
6.3 Graphical Displays 41
6.3.1 Directional Spectra Graph 41
6.3.2 Frequency Graph 41
6.3.3 Surface Wave Recreation Graph 42
6.4 Window 43
7 SUMMARY OF DATA ANALYSIS PROCESS 44
7.1 Non –Directional Data Analysis 44
7.2 Directional Data Analysis 45
8 DERIVATION OF WAVE STATISTICS 46
8.1 Mean level, h 46
8.2 Tidal slope, h_{ts} 46
8.3 Significant Wave Height, H_s 46
8.4 Maximum elevation above detrended mean, η_{max} (Eta$_{max}$) 46
8.5 Minimum elevation below detrended mean, η_{min} 46
8.6 Mean Period, T_1 46
8.7 Mean zero upcrossing period, T_z 46
8.8 Peak Period, T_p 47
8.9 Significant wave period, $T_{1/3}$ 47
9 DATA FILTER & ATTENUATION FUNCTIONS 49
9.1 Data Sampling Trigger 49
9.2 Attenuation and Filter Function Curves 50
10 FREQUENCY DATA RESOLUTION 52

11 DEPLOYMENT DURATION 53
11.1 Memory Life..53
11.2 Battery Life 54
12 WIRING INFORMATION 55
12.1 3m Y Lead (RS232)..55
12.2 3m Switched Y Lead (RS485 & RS422)..55

1 INTRODUCTION

This manual describes the operation, data handling and theoretical background of the Valeport MIDAS DWR Directional Wave Recorder, and the MIDAS WTR Wave & Tide Recorder. The name "MIDAS" is used to describe all of Valeport's premium products, utilising common system components and advanced sensor technology to provide a range of the highest quality oceanographic and hydrographic instrumentation.

Both devices use the long-established principle of Linear Wave Theory, measuring the pressure variations caused by waves and converting them into actual wave data. In addition, as a "PUV" type Directional Wave Recorder, the MIDAS DWR calculates the direction from which the waves are coming by measuring the current oscillations caused by wave motion.

The basic principles of wave measurement rely on the understanding that a wave is not a single defined entity, but the result of a series of individual waveforms superimposed on top of each other, all with different wavelengths, frequencies and amplitudes. Measurement of the wave activity therefore requires measurement of the pressure (and current) variations for a period of time, then "decomposing" the pattern into the constituent waveforms before analysing them and interpreting the data as a set. The key stages in these complex calculations are described in Section 8. The basic instrument functionality is therefore to measure a burst of data for a period of time (typically several minutes), then to perform the calculations; all raw and calculated data is available for on board storage or real time transmission using a variety of standard methods.

The MIDAS DWR & WTR are fitted with a pressure sensor (resonant quartz or strain gauge) to measure the pressure variations; the MIDAS DWR is also fitted with a Valeport electromagnetic current sensor to measure the current oscillations, with the direction referenced to an internal flux gate compass. In addition both instruments are fitted with a PRT temperature sensor as standard, and optional conductivity and turbidity sensors may also be fitted to the standard package. If the deployment situation allows, atmospheric pressure, wind speed and wind direction sensors may also be added to the package.

The instruments are supplied with Valeport's own WaveLog Express PC software for instrument setup, data extraction, and display of all data (real time or logged).

A brief look at the first few sections of this manual will enable both novices and experts to rapidly set the instrument up to measure wave data. However, it is recommended that time is taken to study the remainder of the manual in more depth, to more fully understand the complex principles behind Linear wave Theory and the PUV method of wave measurement, and the wide versatility and functionality of the MIDAS Wave Recorder instruments.

2 SPECIFICATIONS

2.1 STANDARD SENSORS

Pressure (Strain Gauge Type)

Range:	50 dBar standard (approx 40m water depth), other ranges on request
Accuracy:	±0.04% range (±2cm on a 50dBar sensor)
Resolution:	0.0025% range (1.25mm on a 50dBar sensor)

Pressure (Resonant Quartz Type)

Range:	65psi standard (approx 35m water depth), other ranges on request
Accuracy:	±0.01% range (±0.5cm on a 65psi sensor)
Resolution:	Dependent on sample rate, 0.001% range @ 1Hz (0.5mm on a 65 psi sensor))

Temperature

Type:	PRT
Range:	-5℃ to + 35℃
Accuracy:	±0.005℃
Resolution:	0.002℃

Current (DWR only)

Type:	Valeport 11cm discus electromagnetic current sensor
Range:	±5m/s in each axis
Accuracy:	±(1% reading + 5mm/s)
Resolution:	0.001m/s

Compass (DWR only)

Type:	Flux gate
Range:	0 – 360°
Accuracy:	±1°
Resolution:	0.1°

2.2 OPTIONAL SENSORS

Conductivity

Type:	Valeport Inductive Cell
Range:	0 – 80mS/cm
Accuracy:	±0.01mS/cm
Resolution:	0.002mS/cm

Turbidity

Type:	Seapoint STM (bulkhead)
Range:	0 – 2000 FTU (max), 0 – 20FTU (min). Software gain control
Accuracy:	±2%
Resolution:	1:40,000 (0.05FTU at max range)

Wind Speed

Type	Rotating Cup	Ultrasonic
Range	0 – 150kts (0 - 75m/s)	0 – 116kts (0 – 60m/s)
Resolution	0.2kts (0.1m/s)	0.02kts (0.01m/s)
Accuracy	±1% reading	±2% reading

Wind Direction

Type	Vane Potentiometer	Ultrasonic
Range	0 – 360°	0 – 359° (no dead band)
Resolution	0.1°	1°
Accuracy	±1°	±3°

Air Pressure

Type	Sealed strain gauge sensor.
Range	600 – 1100 mBar
Resolution	0.01mBar
Accuracy	±0.5mBar

2.3 PHYSICAL

Materials

Housing	Acetal
EM Current sensor (DWR)	Titanium & Polyurethane
Deployment frame	316 grade stainless steel

Dimensions

MIDAS WTR	30cmØ x 28cm high (excl. Optional Sensors), 12kg
MIDAS DWR	30cmØ x 40cm high, 13kg
Deployment Frame	94cm x 94cm x 42cm, 35kg

2.4 ELECTRONIC

Memory	64Mbyte onboard FLASH
Batteries	32 x D cells in removable carousel (accepts either 1.5v alkaline or 3.6v Lithium cells)
External Power	12 – 30vDC
Power Drain	WTR 0.4W max when running DWR 2W max when running
Communications	RS232, RS485 and RS422 fitted as standard, 2 wire FSK optional. RS232 / USB converter supplied as standard.
Baud Rate	2400 – 460800 (user selectable)

3 PREPARING FOR DEPLOYMENT

3.1 BATTERY PACK

The MIDAS Wave Recorders contain an internal battery pack of 32 x D cells. These are arranged in 4 parallel banks of 8 cells each, within a removable cylindrical carousel. The battery pack is designed to accept either 1.5v alkaline cells, or 3.6v Lithium cells (but NOT a mixture of both types). The battery carousel has been designed to allow simple field replacement of the battery pack – the straightforward procedure is described below:

1. Access the battery pack by inverting the instrument and removing the eight M6 x 40 socket cap screws from the base of the instrument. Take not to damage any protruding sensors. Note that the M6 x 40 screws are held in place by stainless steel barrel nuts, visible in the side of the housing. Take care not to lose the barrel nuts as the screws are removed.

2. Lift the bottom plate from the housing, exposing the battery carousel. The status of the battery pack may be assessed by using the small button in the centre of the carousel – please see Section 3.1.1.

3. To remove the battery carousel, simply lift the stainless steel handle to a vertical position, and pull; the carousel will lift out of the instrument. If a spare preloaded carousel is available, please proceed to step 7.

4. To open the battery carousel, remove the five M5 screws as indicated. The carousel will then separate into upper and lower halves, exposing the batteries themselves.

5. Note that the lower half of the carousel is marked with white lines. These indicate the boundaries of each of the 4 banks of 8 cells. Since these banks of cells are all connected in parallel, it is possible to fill 1, 2, 3 or all 4 banks – obviously a partially filled carousel will offer decreased operational time, but may be financially beneficial for short term deployments. Insert the cells into the required holes, taking care to observe the correct polarity.

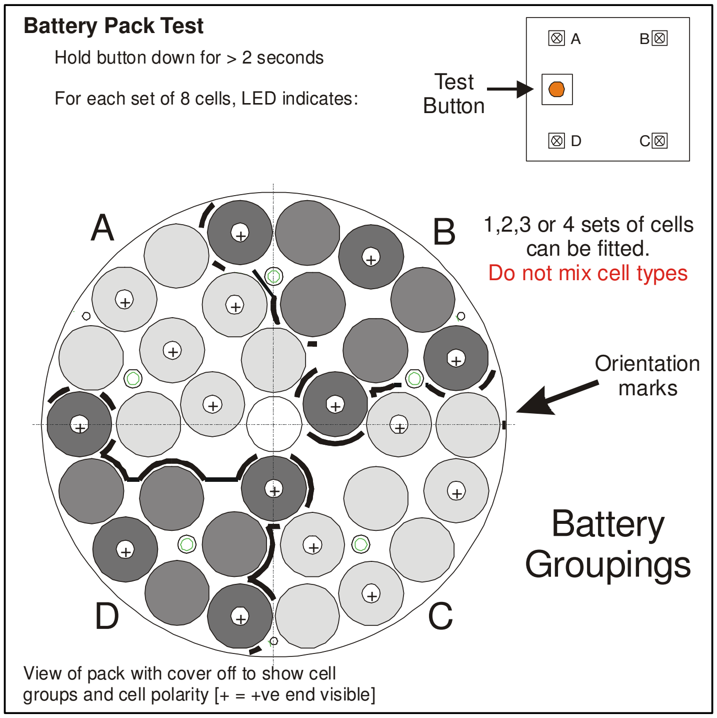
6. Place the upper half of the carousel over the lower half, taking care to match the red orientation marks. No permanent damage can be caused by misalignment, but only correct orientation will allow both the cell pattern and the fixing screw holes to align. Replace and tighten the 5 x M5 fixing screws.

7. Lower the carousel back into the instrument housing, rotating it to ensure that the three location lugs fit into place.
8. Check the o-ring for damage and debris, apply a light coating of silicon grease, and ensure that it sits completely in its groove. Replace the bottom plate, and secure with the eight M6 screws.

3.1.1 BATTERY STATUS CHECK

The battery carousel features a built-in status check circuit. This is activated by pressing the small button in the centre of the carousel – the status is indicated by a series of four LED's, one for each bank of eight cells. Note that the nature of Lithium cells is to maintain a fairly constant voltage level throughout their life, until shortly before they go flat, when they decline very quickly. For this reason the status check LED's should not be used as a definitive indication of remaining battery life, but simply as a verification of correct installation, and that "some" life remains:

Green	Voltage > 28.8v	Lithium cells correctly fitted.
Red/Green	28.8v > Voltage > 12v	Lithium cells incorrectly fitted or flat. Alkaline cells correctly fitted.
Red	12v > Voltage	Cells incorrectly fitted or flat.



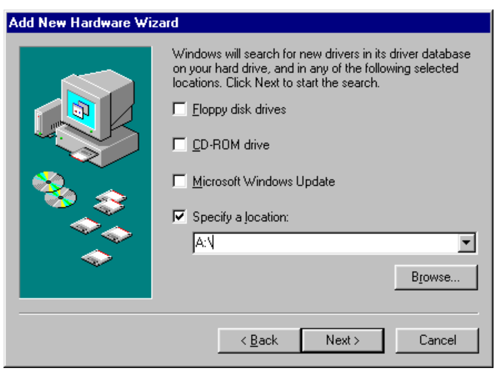
3.2 INSTALLING THE USB ADAPTOR

The MIDAS Wave Recorders have a 64Mbyte solid state memory, integral to the instrument. To facilitate rapid upload of this memory, the instrument is able to communicate using RS232 at speeds of up to 460,800 baud. This baud rate is above that possible with most standard PCs, but is approaching the data rates possible with USB communications. To take advantage of this capability, and also recognising the fact that many modern laptops and PC's are not fitted with traditional serial ports as standard, the instrument is supplied with a RS232 to USB adaptor. This adaptor should be installed as described below, resulting in a high speed comm port becoming available on the PC. Using this port, data rates of approaching 0.5Mbps are possible. Note that communications direct to standard PC serial comm ports are possible at lower baud rates, (typically 2400 to 115200, depending on PC serial port capability).

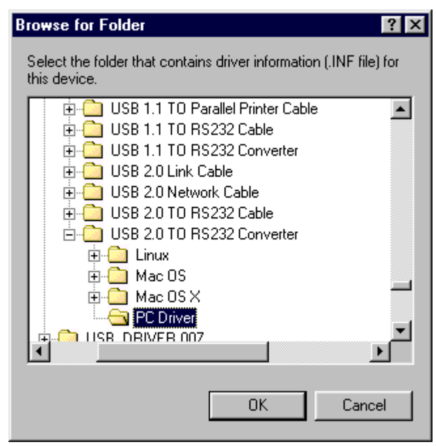
Connect the USB to RS232 adaptor to the PC USB port. The PC should quickly recognise that a new device has been connected, and will open a New Hardware wizard to assist with the installation:

Click Next.

Select the "Search for…" option, and click Next.



Check the "Specify a location" box and click Browse.



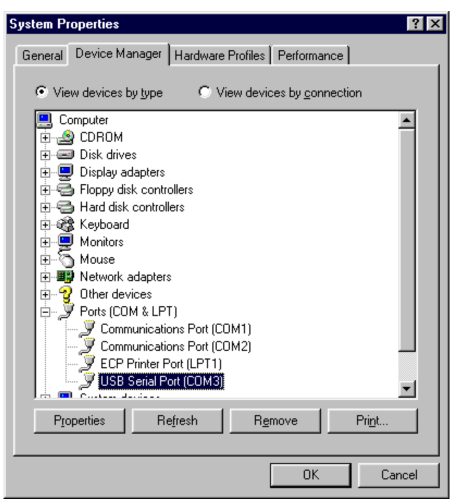
Locate the folder that contains the driver and click OK. Note that the driver may be supplied on a separate disk to the main WaveLog Express program, but nevertheless will be under the USB 2.0 to RS232 Converter \ PC Driver directory as indicated above.

Click Next.

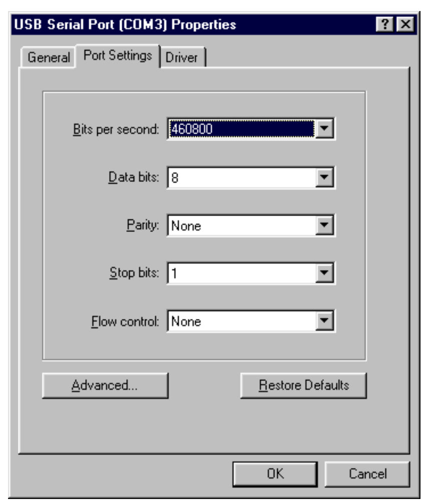
Click Next again.

Click Finish to complete the installation. Windows will now find the comm port and give 2 messages indicating that it is adding a comm port to your system. Do nothing – the messages will disappear after a few seconds.

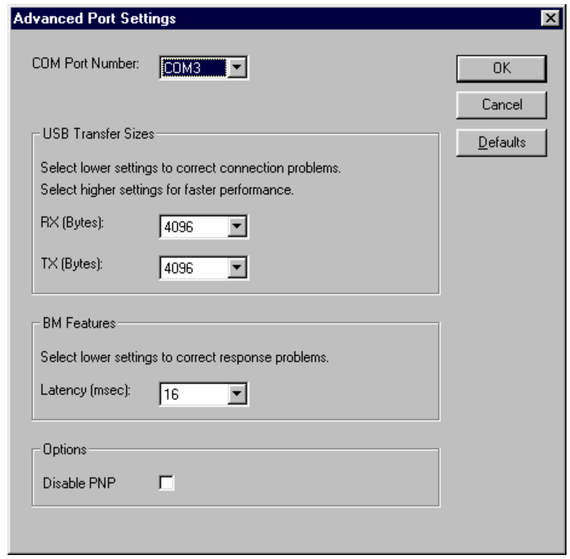
It is now necessary to finalise the setup of the new comm port. Under the Windows Control Panel, select System, and then the Device type tab. Highlight the new comm port:



Click Properties, followed by the Port Settings tab.



Ensure that the settings are as shown above; this will optimise the port for use with the Wave Recorder. Finally click the Advanced button.



Use the drop down list to set the comm port to your preferred number. Leave the other settings unchanged unless you are fully confident of the implications of changing them.

Click OK 3 times to finish the setup. The new high speed comm port will now be available for use within the Windows environment, but specifically under the WaveLog Express program.

3.3 INSTALLING WAVELOG EXPRESS

The MIDAS Wave Recorders are supplied with Valeport's WaveLog Express operating software, which is written in Delphi and is suitable for use on PC's running Windows 95 or above. The software is supplied on a CD-ROM, which should Autorun when inserted into the PC CD-ROM drive. If it fails to do so, the installation wizard may be started by running the setup.exe program via Windows Explorer.

WaveLog Express is distributed free of charge and unlicensed with Valeport Wave Recording products. As such it may be freely copied and installed within your organisation, although we should point out that the software is designed for use solely with these products, and will only present and process data measured with these products.

Note that in order to successfully install WaveLog Express on later version of Windows (2000, ME, NT, XP, Vista), the user must have logged in to Windows with full administrator rights. Not doing so may prevent some necessary files being installed.

For users of Windows Vista;

Windows Vista does not allow programs to modify the contents of the C:\Program Files directory, but has a built in work around for applications that require this. A Virtual Store directory is created under

C:\Users*username*\AppData\Local\VirtualStore\Program Files\WaveLog Express\Data\

WaveLog Express will work seamlessly and the user will not be aware that the data is in fact stored in the Virtual Store as within the application the user will be able to browse to C:\Program Files\WaveLog Express\Data\ and the data will be visible and can be opened etc.

If the user wants to copy the data elsewhere (onto a network or USB stick for instance) then it will need to be copied from the Virtual Store directory as this is where it is physically saved.

The following screens are taken from a PC running Windows XP. Simply follow the on screen instructions to complete installation:

1)

2)

3)

WaveLog Express will automatically be installed in the following directory:

c:\Program Files\WaveLog Express

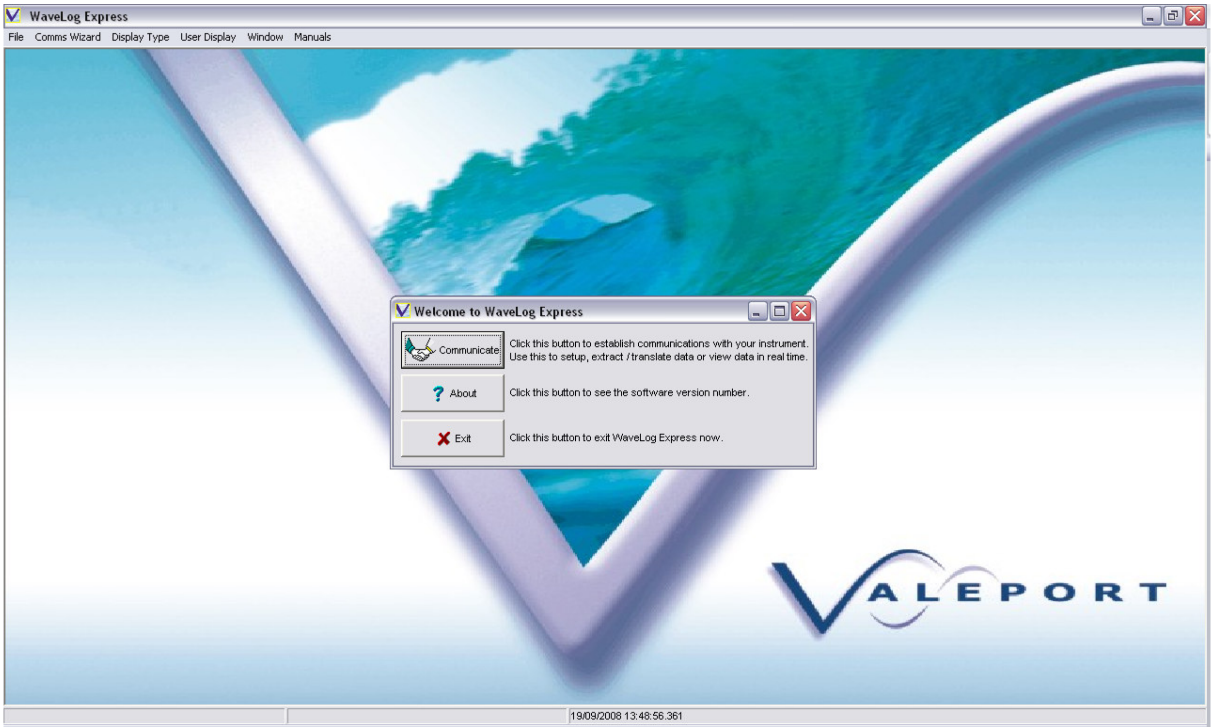
and an icon will be placed on the desktop.

The WaveLog Express program may be run by double clicking the icon:

3.4 SETTING UP

3.4.1 CONNECTING TO THE INSTRUMENT

Run the software by double clicking the WaveLog Express icon on the desktop. The following screen will appear after a few seconds:



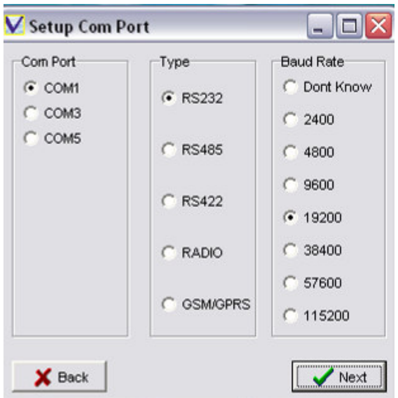
This page is the main operating environment for the WaveLog Express software – all command and data display windows are opened within this area, as described in subsequent sections. Key features are the menu bar at the top, and the status bar at the bottom. There are three sections to the status bar:

Left Software Status
Centre Last response from instrument
Right PC date & time

This section of the manual describes how to communicate with and setup the Wave Recorder. For details of data extraction, processing and display, please refer to Sections 5 & 6.

Connect the instrument to the PC serial port using the lead provided; the 10 way Subconn connector plugs directly into the connector on the top of the instrument, and the 9 way D type connector into the PC serial port (or USB / serial adaptor – see Section 3.2). Inserting the cable into the instrument connector will turn the instrument on if internal batteries are fitted. To conserve battery power during system setup, it may be advantageous to use an external DC power source, connected to the red (+ve) and black (-ve / ground) 4mm pins. A supply of at least 12v is required, with a current limit not less than 0.8A. Any external source will take precedence over the internal battery pack.

To establish communications with the instrument, click on the communicate button. (or click on Comms Wizard on the menu bar if the Communicate window is not visible)
The following screen will appear:

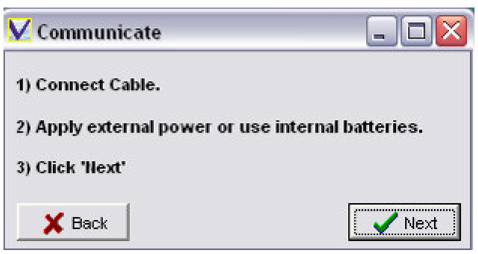


Begin by selecting the correct comm port, communication type and required baud rate.

On first use, please communicate at 19200 baud even if the USB to RS232 adaptor is being used.

Under most circumstances, communications will be direct to PC via RS232 (or RS232 / USB). However, all Valeport MIDAS products are also fitted with RS422 and RS485 communications methods as standard, selected by pin choice on the output connector. These communications protocols allow data transfer over long lengths of cable (1000m for RS485, 1500m for RS422), which is useful in certain applications. In each of these cases an additional adaptor unit will be required at the top end to convert the data in to RS232, so that it may be taken into a PC.

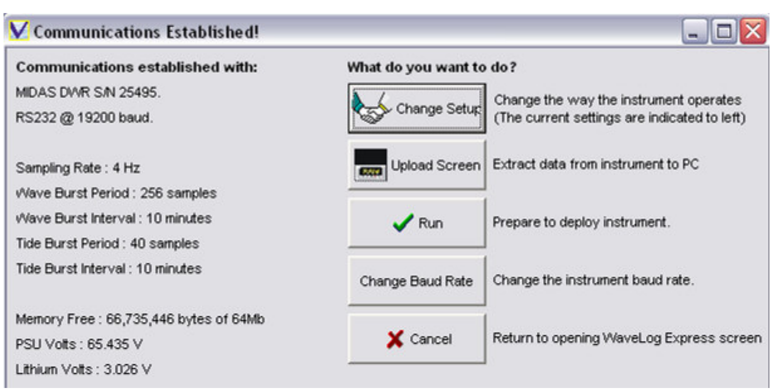
Click the next button, the following screen will appear:



Finally click the next button to attempt communication with the instrument.

Note that the vast majority of communication failures are due to using an incorrect baud rate; this may typically happen if the instrument is used with different PCs. The instrument therefore has an auto-baud feature on switch on, where for the first 15 seconds it will allow communications at baud rates other than that set. If communications cannot be established, set the software to 19200 baud, remove the connector from the instrument for 15 seconds, and then reconnect and try interrupting again.

Note also that the instrument will not allow interruption whilst it is performing data processing routines, immediately after sampling has finished. While the instrument is being interrupted, various messages will be displayed at the bottom of the screen indicating the commands that are being processed. In the unlikely event that a communications problem occurs, please make a note of the command that appears to be causing the problem – this information may help Valeport technicians to solve any problems more quickly.



Once communications are successfully estabilished you will see the following screen. This allows you to change setup, upload data, run the instrument or change the baud rate.

3.4.2 ADVICE AND HINTS ON DEPLOYMENT SETTINGS

The following advice is aimed at the non-expert user. It is designed to provide an initial understanding of how the MIDAS Wave Recorders measure wave action, and things that should be considered when trying to get the best results.

- The nature of wave recorders is to sample data for a fixed period of time; this data is then broken down into its constituent waveforms and analysed to produce a descriptive report of the wave climate. The data analysis process requires a number of samples that is a power of 2, i.e. 128 (2^7), 256 (2^8), 512 (2^9), 1024 (2^{10}), 2048 (2^{11}) or 4096 (2^{12}). To keep things simple, and ensure that this number of samples always equals a whole number of seconds, the sampling rate is limited to 1, 2, 4 or 8Hz. Effectively, this gives a minimum sampling period of 16 seconds, and a maximum of 4096 seconds (1hr, 8mins, 16 seconds). The instrument will do all this analysis on board and output the results, but it takes some time (longer with more data). What this means is that you cannot get an instant answer (i.e. how big was that last wave?). What you do get is a summary report that effectively tells you the size and frequency of the biggest wave, the mean size and frequency of the biggest 33% of the waves (significant wave height, which is the size referred to in sea state reports), and with the MIDAS DWR, the direction from which most of the wave energy is coming.

- When setting up your sampling regime, bear in mind the following two conflicting principles of wave recording:
  - Generally speaking, the more data that is sampled, the more accurate the analysis of the wave climate.
  - The more data sampling you do the quicker you will use up the available battery life and memory.

  Your chosen deployment scenario will often involve a compromise between these two principles, depending on how often you are able to recover the instrument to empty the memory and change the batteries.

- Faster (higher frequency) sampling allows higher frequency waves to be measured. Most wave energy is typically found in waves of period around 7 – 15 seconds. Waves of higher frequency than this do not normally contain much energy (although they may be more numerous). Waves of lower frequency would contain proportionally more energy, but are usually small or rare.

- The deeper you go the weaker the wave signal becomes; high frequency waves penetrate the water column less than low frequency waves. The extent of this effect obviously depends on the magnitude of the waves, but it is realistic to say that in order to accurately measure waves of period less than 4 seconds, you should deploy in less than 10m water. By the time you get to 20m depth, only the signal from waves of period 7 seconds or longer will penetrate. Please refer to Section 9 for more detailed guidelines.

- How often do you want an update of the wave climate?
  It is worth noting that wave climate in general does not change rapidly – an increase in wave height due to an impending storm may be measured in hours rather than minutes. If a long deployment is required, for example to carry out a seasonal study of the local wave climate, then there is little benefit in taking measurements more than once per hour, and even once every 2 or 3 hours will provide a good overview. It is unlikely that a significant storm event would build up and die down within a 2 or 3 hour period where no measurements were being taken. Note that the devices do feature a Trigger Sampling function where waves will only be recorded if they exceed a pre-set height, determined by a brief sampling period using an approximate analysis. This will allow power and memory to be conserved during quiet periods, with more data collected during more active events. This function is described in more detail in Section 9.1.
- What type of waves are you looking for?

Most applications require measurement of wind waves, i.e. waves caused by meteorological events, of period 7 – 15 seconds. These are the dominant wave type in a coastal or offshore environment, and have the greatest implications in terms of civil engineering or environmental monitoring. The key feature of such waves is that they are generally consistent, at least over a time scale of a few minutes to an hour. In such scenarios, it is advisable to measure as much data as possible, taking into consideration the required deployment time, battery life and memory capacity.

Some typical deployment situations and recommended scenarios are discussed below. Note that tables and graphs giving greater detail on data resolution & quality, and battery & memory life, are given in Section 11.

Situation 1: Long term deployment for wave climate analysis in advance of a coastal defence scheme, 15m deployment depth.

In coastal waters the typical recommendation is to sample data for 1024 seconds (just over 17 minutes), at a frequency of 1, 2 or 4Hz. Sampling at 4Hz will allow higher frequencies up to around 1.2Hz to be detected, but will use twice as much memory as sampling at 2Hz (which will measure waves up to 0.6Hz frequency), or 4 times as much as 1Hz sampling (waves of 0.3Hz). In 15m water, it isn't possible to detect waves of period less than 5 seconds (0.2Hz) anyway, so choosing 1Hz sampling of 1024 samples over 4Hz, 4096 samples will give comparable results with a quarter of the memory usage. Doing this every 2 hours will give a battery life of around 60 days (MIDAS DWR), or 300 days (MIDAS WTR). This could be extended to around 85 days and 420 days respectively by sampling at 3 hourly intervals. Please refer to Section 11.2 for more details of the battery calculations.

Situation 2: Long term deployment for studying coastal erosion in an area of mud flats. Max 4m deployment depth, exposed at low tide.

In these circumstances, the shallow water depths will allow higher frequency waves to be detected – indeed, at very shallow (<1m) depths, these high frequency waves are likely to be more significant, since larger, higher energy, lower frequency waves are likely to have broken further offshore. Sampling at a high rate is therefore advisable, and either 4Hz or 8Hz sampling would be recommended. However, it is still desirable to sample for as long as possible, and at these sample rates memory may be used quickly. The maximum 4096 samples at 8Hz is 8 minutes 32 seconds, which is acceptable, but actually results in lower data resolution than 4096 samples at 4Hz (17 minutes 4 seconds). Either scenario is justifiable, as is a further compromise of 2048 samples at 4Hz, which would effectively double the memory life with an acceptable drop in data quality. Two other points to consider with this scenario are:

- The instrument dries out at low tide, which may present opportunities for more regular service visits, allowing a more liberal attitude towards memory and battery usage.
- Since the instrument may be uncovered for hours at a time, it might be possible to take advantage of the Trigger Sampling feature. This will monitor the pressure data during the tide burst, and calculate the standard deviation. If the instrument is in the air, the readings will be almost constant. If it is covered with water, the readings will be noisier because of the wave action. This will be reflected in a higher standard deviation value. The instrument has a pre-set trigger value and once the standard deviation exceeds this, the wave sampling pattern will begin. In this way, the instrument can be set up to only sample waves when it is submerged, allowing a more intense sampling scenario, without wasting battery and memory life during the low tide phases.

Situation 3: Short term deployment monitoring waves caused by boat wash in a river, 2m deployment.

Linear Wave Theory (and therefore a Valeport Wave Recorder) was not designed to account for boat wash, but in shallow waters it can give good results if used with care. There are two key points to make:

- Boat wash consists of a high speed, high frequency (usually single frequency) wave; as such its signal does not penetrate the water column to the same extent that a wind wave of lower frequency but similar magnitude might.
- Boat wash events are both unpredictable and transient. A boat may pass at any time, and the wash from it may only last for 30 seconds or so.

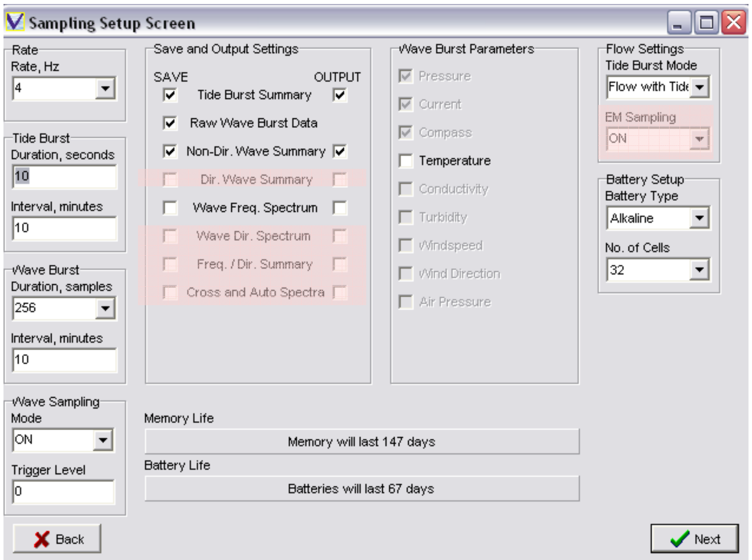
For these reasons it is important to sample at a high frequency but to keep the sampling period as short as possible. The energy from a 30 second event in a 17 minute burst of data would be mathematically spread out over that burst in the processing algorithms, and as such may become insignificant against the continuous background wave activity. At the same time, shorter data bursts give lower resolution and decreased accuracy. Using the shortest possible burst of 8Hz, 128 samples would give a data set of only 16 seconds' duration, and a severely limited data resolution. We would recommend aiming for a burst duration of 32 or 64 seconds, which is 256 or 512 samples at 8Hz. This would give data of limited resolution, but would allow the transient event to be "significant" within the measured burst.

The above method would allow a reasonably continuous data set of wave activity over a period of time, but it is important to remember that after each burst of data, the instrument will take a short period of time to process that data before it can begin sampling again. Even with the short data bursts described, there will be a 30 second – 1 minute period of no data collection before the instrument can begin sampling again. In cases where a specific transient event is being sought, for example a single particularly large vessel passing, we would recommend taking a much longer data sample, encompassing the scheduled time of the vessel passing. This single large data file may then be broken down into several smaller files that may be analysed in post-processing to isolate the transient event.

3.4.3 CHOOSING YOUR SAMPLING REGIME

Once communications have been established, select “Change Setup” and choose the deployment mode. Choosing Tide Only or Wave Only will restrict the options available on the next screen. Tide and Wave is discussed in the next section as this encompasses all options.

Note that certain features, indicated on the illustration with a red box, are only enabled on the MIDAS DWR directional wave recorder. They will not be visible or available for use with a MIDAS WTR non-directional device.



The MIDAS Wave Recorders offer a wide choice of sampling regimes, giving the experienced user the opportunity to precisely tailor their deployment scenario to suit the data requirement. However, for the less experienced user we offer some advice and points for consideration in Section 3.4.3 below.

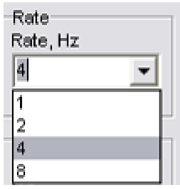
In all cases it is important to understand the instrument’s basic operating pattern:

The instrument should be thought of as running two separate sampling patterns at the same time. Firstly, it runs a “Tidal Cycle”, which is a brief burst of measurement at frequent intervals, designed to measure background parameters such as tide height, mean current direction (DWR only), and data from additional sensors such as conductivity or temperature. The purpose of this burst is twofold; obviously it enables the instrument to maintain a record of these background parameters, but it also allows a coarse estimation of the wave activity (based on standard deviation of pressure readings), which may be used to trigger the wave cycle. The tide cycle requires a duration and interval value to be set, where Duration is the time in seconds for which the sensors should be sampled, and the Interval is the time in minutes between these bursts. In the typical example screen shown above, the Tide Cycle is sampling for 30 seconds every 10 minutes. Note that the sampling frequency is the same as for the wave cycle, 2Hz in the above example.

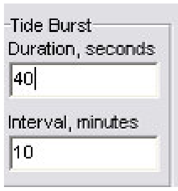
Secondly, the instrument runs a wave cycle. This is a longer burst of measurement activity, during which the pressure and current (DWR) sensors are sampled continuously for a specified number of samples at a specified rate. This data is then analysed to produce information on the wave activity. As with the tide cycle, the Duration (in samples) and Interval (in minutes) must be set, and the sampling frequency chosen. Note that the Wave Cycle Interval must be a multiple of the Tide Cycle Interval (minimum 1, but 3 in the above example).

Note also that after a wave cycle has finished, the instrument must spend a certain amount of time processing and outputting the data. During this period, which varies according to the number of samples collected, it is not possible to begin another cycle (wave or tide). You will therefore find that WaveLog Express will not allow certain sampling regimes to be set, if they result in a conflict between sampling time and processing time.

In summary, use the boxes on the left hand side of this page to set the sampling pattern as follows:

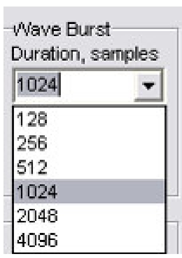


Instrument Sampling Rate. 1, 2, 4 or 8Hz, selected from drop down menu

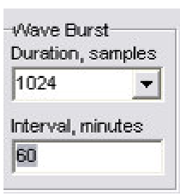


Time in seconds for a basic Tide Cycle. 20 seconds minimum, 40 or 60 seconds recommended

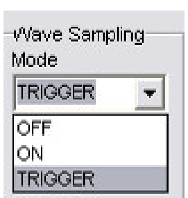
Regularity of Tide Cycle in minutes; 10 minute interval is normal



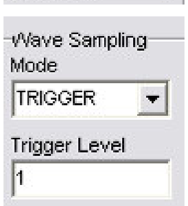
No. of samples in the wave burst. This must be a power of 2 from 128 to 4096, selected from the drop down menu. The time taken is no. of samples divided by the sampling rate



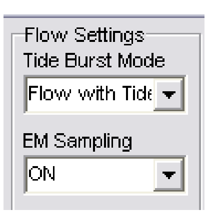
Regularity of Wave Cycle in minutes. Enter a time that is a multiple of the Tide Burst Interval.



Wave sampling may be ON, OFF or TRIGGER. When ON , wave sampling occurs as programmed. When OFF, only the Tide Cycle occurs. In TRIGGER mode, wave sampling only occurs if pressure variations during tide burst exceed defined level.



Trigger level at which wave sampling will be initiated. The value to be entered is 4 x Standard Deviation of the pressure readings taken during a tide cycle. This can be used to approximate Significant Wave Height, but does not account for any depth attenuation – please refer to Section 9 for further advice.



(DWR only)

Measurement of current in the MIDAS DWR uses considerably more power than the non-directional sampling of the MIDAS WTR. In applications where wave direction analysis is not required, it is possible to turn off most of the additional system components that are required for directional measurement. Whilst this does not quite improve the performance to the very low power levels of the MIDAS WTR, it does represent a significant saving over the normal directional mode. Simply select EM Sampling "ON" for directional or "OFF" for non-directional modes.

Note that mean current measurement during a tide burst will also be disabled if "OFF" is selected.

3.4.4 SAVE & OUTPUT SETTINGS

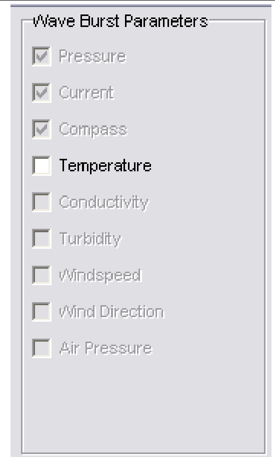
At a basic level, a wave recorder should just record the sensor readings according to the sampling setup; these may be uploaded when the instrument is recovered and processed to generate the wave data. However, the Valeport MIDAS Wave Recorders are fitted with a powerful processor that is able to perform all the data processing on board, in real time. The wave data thus generated may be saved within the instrument alongside (or instead of) the raw sensor readings, and also output in real time. A suitable cable or data telemetry system (such as the Valeport Model 750 Data Telemetry Buoy) may then be used to transmit the data to a PC, where data on the current wave climate may be displayed.

The various options are set on the Sampling Setup page. There are 8 different types of data that can be recorded or output in real time - simply check the box to the left to indicate that the data should be saved, and the box to the right to indicate that it should be output.

Note that all 8 data types are available for the MIDAS DWR, but only Tide Burst Summary, Raw Wave Burst Data, Non-Directional Wave Summary, and Wave Frequency Spectrum are available on the MIDAS WTR.

Tide Burst Summary	The mean and standard deviation of each fitted parameter during the tide burst cycle. The mean current direction during the burst is also included.
Raw Wave Burst Data	The raw sensor readings from pressure and current sensor during the wave burst. This may also include data from additional fitted sensors, as specified in the Wave Burst Parameters box. Note that this data type is NOT available for real time output.
Non-Directional Wave Summary	The traditional wave statistics data, comprising the following parameters: Mean Water Height, Tidal Slope, Significant Wave Height, Maximum Elevation, Minimum Elevation, Maximum Wave Height, Mean Wave Period, Mean Zero Up-crossing Period, Significant Wave Period, Total Energy. Derivation of each of these calculated parameters is given in Section 8.
Directional Wave Summary	Mean & Peak Wave Direction during the burst
Wave Frequency Spectrum	Analysis of the amount of energy at each wave frequency in the burst
Wave Directional Spectrum	Analysis of the amount of energy at each wave frequency in each direction
Frequency Direction Summary	The frequency in each direction that contains the most wave energy
Cross & Autospectra	Number array allowing expert users to calculate spreading angles of the waves. Unnecessary under normal circumstances, so do not check it unless you know you want it.

The device is also able to save high frequency data from other fitted sensors within the wave burst, as well as the basic pressure (and current) readings. This may be of particular benefit in certain applications, such as using high frequency turbidity measurement to correlate sediment transportation with wave motion. Check the box next to each sensor for which data should be sampled during the wave burst. Data from all these sensors is included in summary with the tide burst data by default.

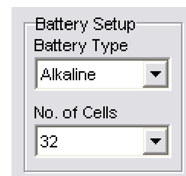


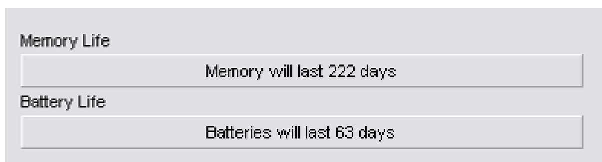
In this example, the device (a MIDAS DWR) is only fitted with the standard temperature sensor in addition to the pressure, current and compass sensors, so only that sensor is shown as available.

.

3.4.5 BATTERY & MEMORY LIFE

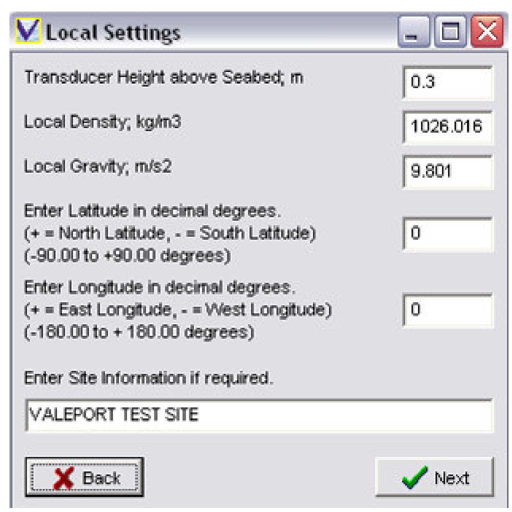
At the bottom of the setup page, the software will indicate the expected battery and memory life with the save settings and sampling regime as indicated. Note that the calculations used assume that the battery pack is new, and that the memory is completely empty. Select the battery type (Alkaline or Lithium) and the number of cells fitted (8, 16, 24 or 32).





3.4.6 LOCAL SETTINGS

Use this page to setup certain constant values for the instrument deployment. Under most circumstances, acceptable data will be gathered with no adjustment to this page.



Transducer Height — A key part of Linear Wave Theory and the relative attenuation of the wave signal, is the distance of the pressure sensor above the seabed. This is set as 30cm by default, which assumes that the device is placed directly on the bed. This number should be set correctly for the proposed deployment, particularly if it is intended to fix the device to a platform or base that is raised from the bed.

Local Density	This value is used in the conversion of pressure data into depth data.
Local Gravity	Local Gravity is also used in the Pressure Depth Conversion. If local gravity is known, then simply type the number in. If not, then use the default value of 9.80665.
Latitude / Longitude	The fluxgate compass fitted to the MIDAS DWR has been calibrated at Valeport's premises to provide optimum performance (better than ±1° accuracy) at any point on the earth's surface. This requires the user to input the local latitude and longitude, to enable the compass to adjust its calibration to suit. Values should be input as decimal degrees, so 50°30'00" should be entered as 50.5
Site Information	A small text string may be incorporated into the header of each data file, containing relevant information for the planned deployment. Enter the required data string (max 64 characters) in the box. This text will be added to each data file until the string is changed.

3.4.7 TIME SETUP

The instrument has its own internal clock, which will be set to UK time when the instrument leaves the factory. To set the time to local time, make sure that your PC clock is correct, and click the Set Time button. The program will read the time from the PC, and reset the instrument clock to this time.

Please note that the clock used in Valeport MIDAS instruments is a 20ppm clock, which may drift by up to 1 minute per month (approximately). This is significantly more accurate than the clocks used by most PC's, so there may be a discrepancy between PC and instrument at the end of the deployment.

3.4.8 DELAY START

Like all Valeport MIDAS instruments, the Wave Recorders have a Delay Start function. This allows the device to be setup in the laboratory in advance of deployment, and the instrument will not begin its sampling regime until this alarm time is reached. To enter an alarm time, select Delay Start YES, and type in the required start time in the following format:

dd/mm/yyyy hh:mm:ss

This time will be sent to the instrument when the APPLY button is pressed.
Note that in order for the delay start function to operate, the instrument must still be "Run" with the switch cap or signal cable as described in Section 3.6.

3.4.9 UNITS SETUP

Data can be output in metric (M) or imperial units (ft)

3.4.10 APPLY SETTINGS

Click the finish button on the Units setup screen and the settings from the previous four screens will be applied to the instrument.

3.5 PRIMING SILT TRAP

Valeport Wave Recorders are fitted with a silt trap device to help prevent the pressure port of the instrument becoming blocked with sediment and thus damping the wave signal.

It is critical that the silt trap is checked, and cleaned and primed if necessary, before each deployment. A build up of sediment in the path from the open water to the transducer face may eliminate wave signals altogether, or the very least dampen them to a sufficient extent to cause incorrect readings. Note that the presence of air in the tube may also dampen the wave signal.

The silt trap device consists of a coil of clear plastic tubing within a protective acetal cap. The coil should be filled with oil before each deployment, following the instructions given below:

- Unscrew the acetal cap, exposing the clear tube. Check for sediment and air bubbles within the tube – if it is clear, but still full of oil, then replace the acetal cap and continue with the deployment.

- To clean and prime the silt trap, use an 18mm spanner to remove the inner acetal core from the main instrument, complete with the coiled plastic tube.
- Carefully clean around the pressure port on the instrument, taking care not to insert any sharp objects down the internal pressure port hole.

- Fill the pressure port with the oil provided, using the syringe. This is Dow Corning 704 Diffusion Pump Oil, selected because it has similar viscosity properties to water. For correct results, use only this type of oil, available from Valeport or other Dow Corning outlets worldwide.
  Take care not to push the syringe needle into the small hole at the bottom of the pressure port. This could result in permanent damage to the transducer.

- Again using the syringe provided, squirt oil through the acetal inner core and coiled tube assembly, until clear, bubble free oil comes out of the end of the coiled tube.
- Screw the inner core and coil tube back into the pressure port – excess oil will be ejected through the coiled tube. Tighten using an 18mm spanner.
- Finally replace the protective outer cap. The instrument is now ready for deployment.

Note that this procedure should be carried out as close as possible to the actual deployment time. Once submerged, the water pressure will prevent the oil from leaking out of the silt trap assembly. Whilst it is held in place by capillary action, the oil is more likely to leak out of the silt trap if the instrument is in the air.

3.6 RUNNING THE INSTRUMENT

The instrument sampling regime may be initiated by one of two methods:

- In self-recording only deployments, by inserting the switch plug into the instrument connector. This plug contains a link between two of the pins that acts as a switch. It is NOT a dummy plug – if it is lost, it must be replaced with a linked switch plug supplied by Valeport.

- In real time deployments, by inserting the signal cable into the instrument connector, establishing communications as described in Section 3.4.1, and clicking the Run instrument button.

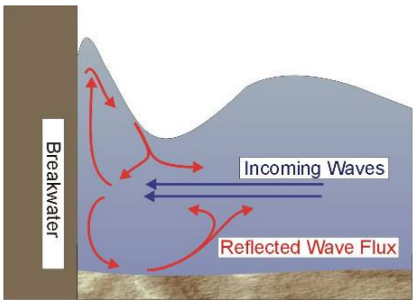
  Alternatively, if the signal cable is inserted and no “Interrupt” command is received, the instrument will spontaneously begin operating within 15 seconds (unless the Delay Start function is used).

4 DEPLOYMENT & RECOVERY

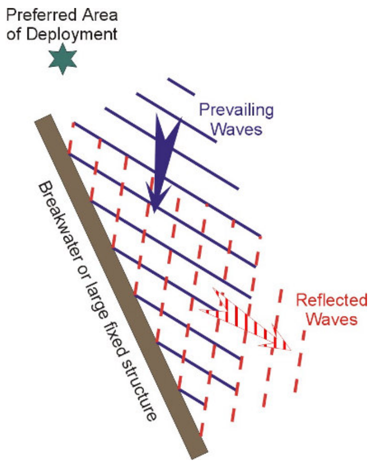
4.1 CHOOSING YOUR DEPLOYMENT SITE

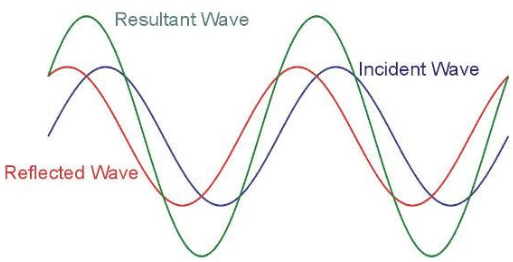
Selection of a good deployment site can be critical to obtaining good wave data. Some basic important points to consider are:

- Pressure based wave recorders are designed for use in water depths of less than 20m. Remember to include the maximum expected tide height when choosing a site.
- If it is possible to find a site shallower than 20m, then better data will be measured.
- It is possible to use the instrument in water depths greater than 20m, but only if the instrument is sited within 20m of the surface.
- The instrument should be either on the seabed or fixed to a solid structure. If on the seabed, a firmer bed is preferable to a very soft one, to prevent the device sinking into the sediment.
- The instrument measures what is going on directly above it, so deploying in a sheltered area will not indicate the levels of wave activity away from the shelter.
- Measuring wave activity close to solid structures is difficult – it may not give a true representation of the actual situation. You can see from the illustration that as a wave approaches a solid structure such as a breakwater, the motion is amplified, and the water is forced to flow in essentially random directions away from the structure. These effects will distort both pressure and current readings.



- Solid structures such as quays and breakwaters reflect the waves; the incident and reflected waveforms may interact, causing a resulting waveform that is different from both incident and reflected waves. Unless you specifically want to measure this effect, we recommended deploying in an area outside this reflection zone.





4.2 VALEPORT DEPLOYMENT FRAME

The MIDAS Wave Recorders are optionally supplied with a stainless steel pyramidal mooring frame, into which the instrument is bolted. This frame aids deployment and recovery, allows additional weight to be added for mooring purposes, and also serves to inhibit accidental trawling.

If the frame is not used, then the instrument may be fixed to a structure of the user's choice, using M5 bolts. Note that studding is not acceptable, since the thread in the instrument housing is fixed. The mounting holes are 4 equispaced holes on a 283mm pcd (effectively a square of 200mm side).

The frame is supplied flat packed, and will require assembly on site by the user. The frame components (illustrated) are as follows:

1 x base	0.94m square
1 x top	0.42m square
4 x corner pieces	0.54m long
4 x M6 x 30 countersunk socket screws	
8 x M6 nyloc nuts	
8 x M6 washers	
1 x 6mm allen key	
1 x 17mm spanner	
2 x stainless steel shackles	




- Place the bottom frame on the ground, with the flat surface of the spars uppermost.

- Fix the corner pieces to the bottom frame using the studded lugs. Use a nut and washer to secure these corner pieces in place, but do not tighten yet.

- Offer the top piece to the corner pieces from below, and secure in place using the M6 screws, nuts and washers.
- Tighten all nuts.
- Place the instrument centrally within the frame, with the mounting holes positioned over the holes in the frame spars. Use the 4 x M5 bolts and barrel nuts supplied in the instrument spares kit to secure the instrument to the frame.

The mooring frame also has holes in the top for shackles to aid deployment.

4.3 DEPLOYMENT IN SELF RECORDING MODE

The majority of deployment situations are in self-recording mode, where the device is simply deployed in a fixed location for a period of time, before it is recovered for data extraction and analysis. Before deploying the instrument, please take a few moments to confirm that the following points have all been checked:

- ❑ Sampling regime set
- ❑ Memory (sufficiently) empty
- ❑ Battery pack (sufficiently) full
- ❑ Delay Start set (if required)
- ❑ Silt trap primed
- ❑ Switch plug fitted (important – instrument will not run without this)

4.4 DEPLOYMENT IN DIRECT READING MODE

To take advantage of the real time data processing capabilities of the MIDAS Wave Recorder, it will be necessary to use either a signal cable, or a data telemetry link (radio or GSM). All MIDAS devices are fitted as standard with RS232 communications, which will work with up to 200m cable, RS485 communications for up to 1000m cable, and RS422 communications for up to 1500m cable. All these output protocols are selected by pin choice on the output connector. Valeport offer optional RS485 and RS422 adaptors for these long cable links.

In addition, an optional FSK communications method is available (factory fit), which will allow communications over 2 wire cables up to 3500m in length (with suitable quality cable).

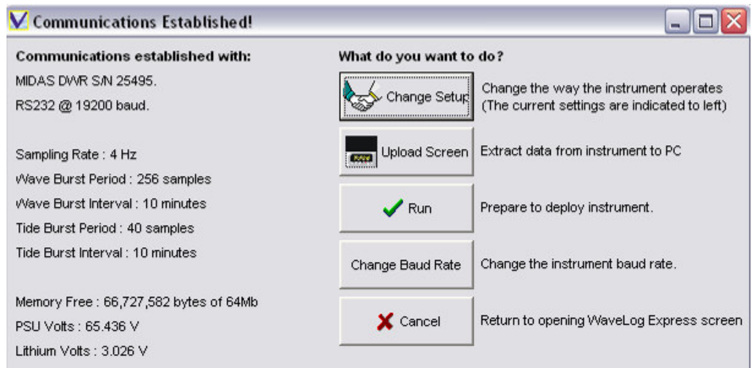
Valeport offer the Model 750 data telemetry in both UHF radio and GSM configurations. This device may be moored using an armoured signal cable to the Wave Recorder, allowing real time data links over greater distances (assuming line of sight / network coverage).

When using any of the above methods, please take a few moments to confirm that the following points have all been checked:

- ❑ Sampling regime set
- ❑ Silt trap primed
- ❑ Sufficient external power available, or battery pack full
- ❑ Cable communications tested
- ❑ Telemetry communications tested
- ❑ GSM account live and paid

5 DATA EXTRACTION

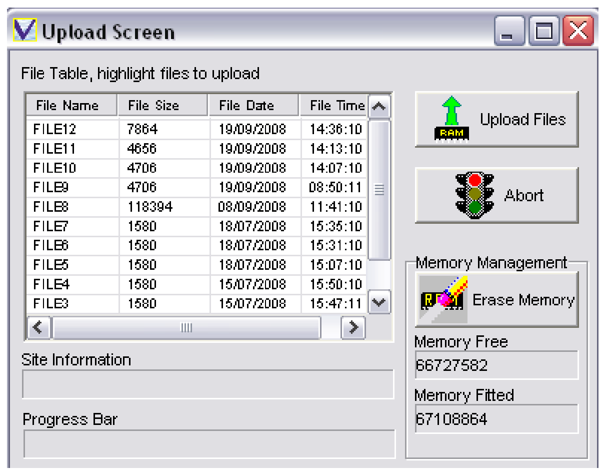
To extract data from the device, first communicate with the instrument as described in Section 3.4.1. Select "File Upload Screen" from the Screen / Instrument menu:



5.1 FILE TABLE

This section lists all the files stored in the instrument memory. Note that each time the instrument is set into Run mode, a new file will be created. This will therefore happen at the following points during operation:

- Each time power is applied, unless the instrument is interrupted during the first 15 seconds after switch on.
- Each time the switch plug is plugged in.
- Each time the Run button is pressed.



The file table lists all the stored files, with the most recent file displayed at the top of the screen. The table includes the following information about each file:

File Name This is automatically generated by the instrument, in the form FILE#, where # is the next number in sequence. There is no limit to the maximum number of files that can be stored, apart from the physical capacity of the memory.

File Size This shows the size of each file in bytes. Note that each file contains a certain amount of header information, such as calibration coefficients, date, time and sampling regime. The size of the header information will vary slightly, but is usually in the region of 500 bytes.

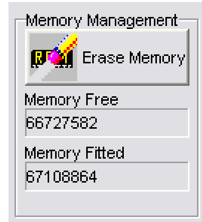
File Date/Time These two columns give the date and time at which the file was created.

Highlight files to upload, selecting multiple files by using the Ctrl & Shift keys in standard Windows fashion.

5.2 UPLOAD PARAMETERS

WaveLog Express uses an advanced Zmodem protocol for data upload, which features error checking capabilities to ensure that data is not corrupted during upload. Even with this feature, the protocol is reasonably fast. The time taken to upload data can be improved by selecting a higher baud rate (in the Communicate screen), which necessitates use of a short cable (ideally the 3m Y lead).

5.3 MEMORY MANAGEMENT



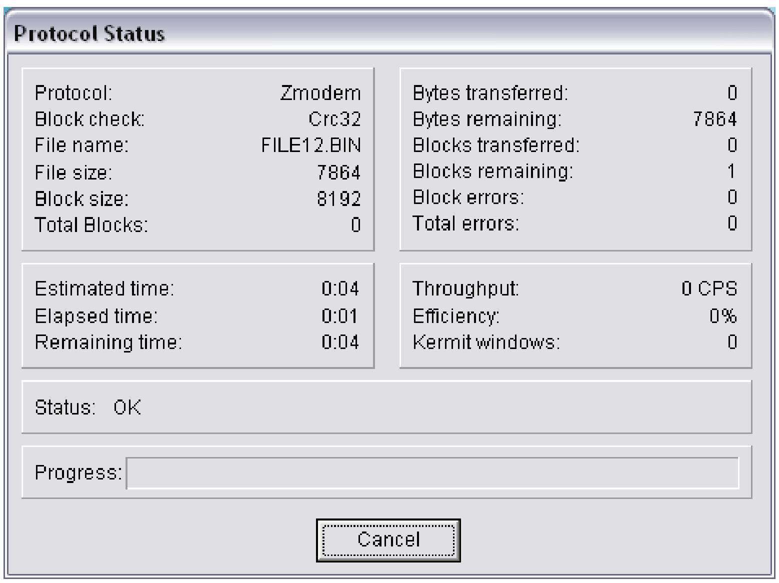
This section indicates the total amount of memory fitted to the instrument, in bytes, and the amount, which remains unused (again in bytes). It also contains the most dangerous button in the software – the Erase Memory button.

Take care when erasing memory. Although the user is asked twice for confirmation, they should ensure that all required data has been uploaded prior to erasing the memory. FLASH memory is non-volatile; one of its features is that each byte cannot be overwritten, only reset to "Empty". The Erase process therefore requires each used byte of memory to be actively reset. This takes some time (approx 1 minute per 10Mb), as indicated on the Erase Status bar at the bottom of the page. It also means:

Once memory has been erased, it cannot be recovered.

5.4 UPLOAD FILES

Once the desired files have been selected, simply click on the Upload Files button to initiate the data upload procedure.

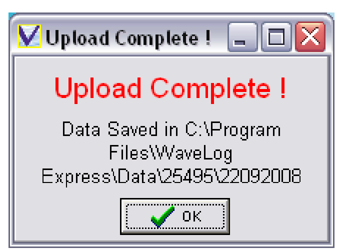


Data will be automatically uploaded into a subdirectory of the WaveLog Express directory, labelled according to the serial number of the instrument and the date of upload (Please see Section 5.6). This subdirectory will be created if necessary. The following screen will be shown:

The screen gives an indication of the progress of the upload of the current file – note that this screen will automatically disappear when the current file has uploaded. It will then reappear for each file that is uploaded.

At any stage, upload can be stopped by using the Cancel button on the above screen, or the Abort button in WaveLog Express

When data has been uploaded the following message will appear:

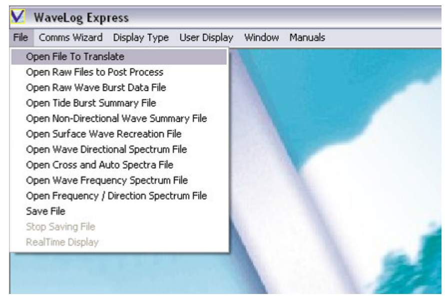


5.5 DATA TRANSLATION

All data is stored in the instrument in binary format, to maximise the use of the available memory. In order for the data to be viewed and processed it must be converted into ASCII text, in a process called Translation. Once the required data files have been uploaded from the instrument, select “Open File to Translate” from the File menu;

The uploaded file (File1.bin in this case) will have been placed in the following subdirectory:

C:\Program Files\WaveLog Express\Program\nnnnn\ddmmyyyy



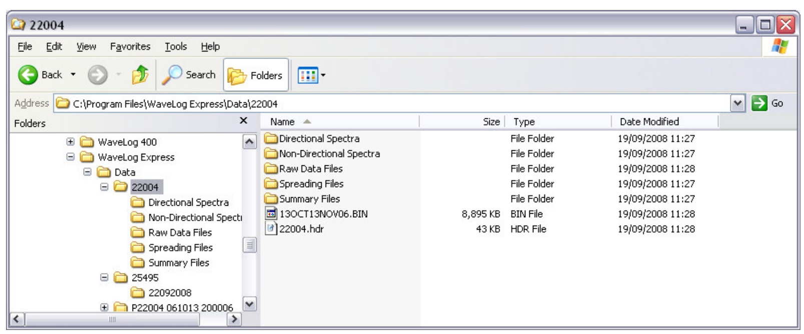
Where “nnnnn” is the instrument serial number (12345 in this example), and ddmmyyyy is the date of the upload (10082004 in this example).

Locate this file using the standard Windows “Open File” dialog box” and click “Open”. The program will create a series of new folders into which all the translated data will be placed (see below), and will then perform the translation. Depending on the file size, this may take a few minutes.

5.5.1 LOGGED DATA STORAGE STRUCTURE

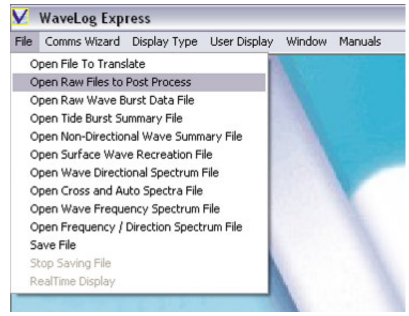
In the same directory that the binary file was located, the software will create a folder with a unique name, defining the deployment from which the data came.
This folder is named “nnnnn ddmmyy hhmmss” where nnnnn is the instrument serial number, and ddmmyy hhmmss is the time at which the data was recorded.

Within this folder, the data is stored in 5 subdirectories according to the data type, within these folders, the data files are named in exactly the same fashion, so that the origin of any individual data file can be determined simply from its name. The file extension varies according to each file type.



Directional Spectra	*.dsp	A separate file is created for each burst of wave data, showing the full directional spectrum of data over the burst, including the peak wave frequency in each direction.
Non-Directional Spectra	*.spc	A separate file is created for each burst of wave data, showing the frequency spectrum of data over the burst.
Raw Data Files	*.raw	A separate file is created for each burst of wave data, containing the actual data measured by the sensors during the burst
Spreading Files	*.spd	A separate file is created for each burst of wave data, giving the cross and auto-spectra data during the burst. This data may be used to calculate spreading angles, but should be ignored in the majority of cases.
Summary Files	Tide *.txt	A single file detailing the mean sensor values recorded during each tide burst.
	Wave *.txt	A single file detailing the wave statistics calculated during each wave burst. This is includes all wave height and period statistics, as well as mean and peak wave direction values.

5.6 POST PROCESSING



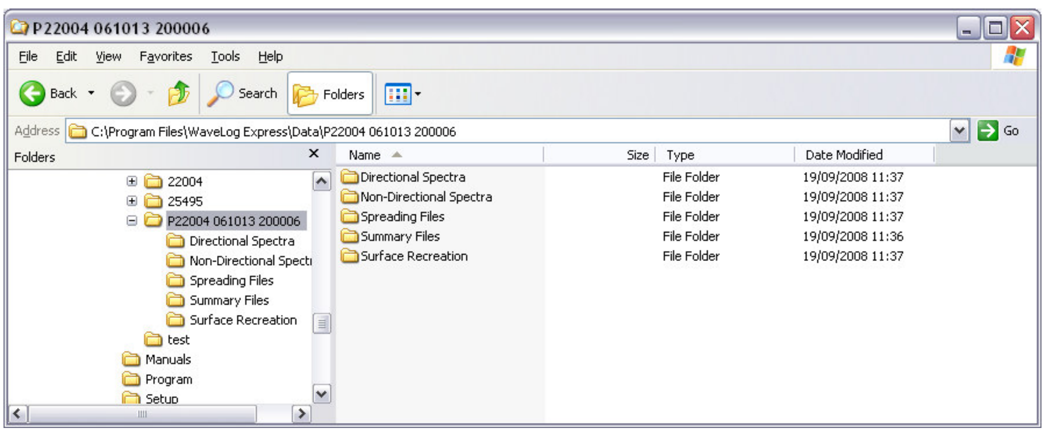
WaveLog Express is also able to post-process raw wave burst data logged by the instrument. The algorithms used are identical to those in the instrument itself. To perform the post process procedure, select "Post Process" from the File menu. The software will ask you where the files to be process are; they will be situated in the Raw Data Files folder as described above.

Select as many files as are required using standard Windows Ctrl and Shift keys, and click Open. The post processing procedure takes a few seconds only.

5.6.1 PROCESSED DATA STORAGE STRUCTURE

In the same directory that the binary file was located, the software will create a folder with a unique name, defining the deployment from which the data came.

This folder is named "Pnnnnn ddmmyy hhmmss" where P signifies that the data is post processed data, nnnnn is the instrument serial number, and ddmmyy hhmmss is the time at which the data was recorded.



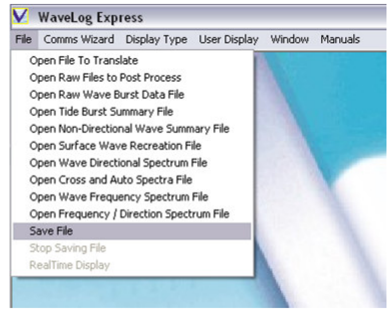
Within this folder, the data is stored in 5 subdirectories according to the data type:

Within these folders, the data files are named in exactly the same fashion (including the preceding P), so that the origin of any individual data file can be determined simply from its name. The file extension varies according to each file type.

Directional Spectra	*.dsp	A separate file is created for each burst of wave data, showing the full directional spectrum of data over the burst, including the peak wave frequency in each direction.
Non-Directional Spectra	*.spc	A separate file is created for each burst of wave data, showing the frequency spectrum of data over the burst.
Spreading Files	*.spd	A separate file is created for each burst of wave data, giving the cross and auto-spectra data during the burst. This data may be used to calculate spreading angles, but should be ignored in the majority of cases.
Summary Files	Tide *.txt	A single file detailing the mean sensor values recorded during each tide burst.
	Wave *.txt	A single file detailing the wave statistics calculated during each wave burst. This is includes all wave height and period statistics, as well as mean and peak wave direction values.
Surface Recreation	*.swe	A separate file is created for each burst of wave data, showing the calculated surface elevation during the burst as a time series.

5.7 REAL TIME DATA

If the Wave Recorder is configured to output data in real time over a cable or telemetry link, WaveLog Express is able to display and store the incoming data on PC. Details of the display functions are given in Section 6, but the data storage function is described here. To begin saving data on the PC, simply select "Save Data" from the File menu. The program will automatically begin to store all data as it comes in, according to the data structure as defined below.



To stop recording incoming data, select "Stop Saving Data" from the File menu.

5.7.1 REAL TIME DATA FORMAT

At the end of the tide or wave burst, by default the underwater unit outputs the tide and Non-directional wave statistical data.(Section 3.4.4)

5.7.1.1 Tidestats output string:

T[tab]p=x.xxx[tab]pd=x.xxx[tab]T=x.xxx[tab]Td=x.xxx*[tab]C=x.xxx[tab]Cd=x.xxxxxx*[tab]D=x.x[tab]U=x.xxx[tab]V=x.xxx[cr][lf]

Note that values in italics are only present if a Conductivity cell is fitted. A sample without conductivity is below:

T p=10.260 pd=0.000 T=21.492 Td=0.002 D=309.5 U=-0.123 V=0.023

5.7.1.2 Wavestats output string:

Th[tab]hts[tab]Hs[tab]ETAMAX[tab]ETAMIN[tab]T1[tab]Tz[tab]Tp[tab]T1/3[tab]Hmax E[tab][cr]
[lf]
dBar abs[tab]dBar[tab]dBar [tab]dBar[tab]dBar[tab]Secs[tab]Secs[tab]Secs[tab]Secs[tab]dBar[tab]dBar^2.secs[cr]
[lf]
x.xxxxxx[tab]x.xxxxxx[tab]x.xxxxxx[tab]x.xxxxxx[tab]x.xxxxxx[tab]x.xxxxxx[tab]x.xxxxxx[tab]x.xxxxxx[tab]x.xxxxxx[tab]x.xxxxxx[tab]x.xxxx xx[cr]
[lf]

A sample is shown below:

Th hts Hs ETAMAX ETAMIN T1 Tz Tp T1/3 Hmax E

dBar abs dBar dBar dBar dBar Secs Secs Secs Secs dBar dBar^2.secs

10.260473 0.000003 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000

5.7.2 REAL TIME DATA STORAGE STRUCTURE

In the same directory that the binary file was located, the software will create a folder with a unique name, defining the deployment from which the data came. In order to ensure that data files of all types (logged data, processed data and real time data) are located in a similar place, the software first creates a directory as described below, if it does not already exist:

C:\Program Files\WaveLog Express\Program\nnnnn\ddmmyyyy

Where “nnnnn” is the instrument serial number and ddmmyyyy is the current date.

Within this directory, the software creates a folder for the real time data, named “Rnnnnn ddmmyy hhmmss” where R signifies that the data is post processed data, nnnnn is the instrument serial number, and ddmmyy hhmmss is the time at which the data was recorded.

Within this folder, the data is stored in 4 subdirectories according to the data type:

Within these folders, the data files are named in exactly the same fashion (including the preceding R), so that the origin of any individual data file can be determined simply from its name. The file extension varies according to each file type.

Directional Spectra	*.dsp	A separate file is created for each burst of wave data, showing the full directional spectrum of data over the burst, including the peak wave frequency in each direction.
Non-Directional Spectra	*.spc	A separate file is created for each burst of wave data, showing the frequency spectrum of data over the burst.
Spreading Files	*.spd	A separate file is created for each burst of wave data, giving the cross and auto-spectra data during the burst. This data may be used to calculate spreading angles, but should be ignored in the majority of cases.
Summary Files	Tide *.txt	A single file detailing the mean sensor values recorded during each tide burst.
	Wave *.txt	A single file detailing the wave statistics calculated during each wave burst. This is includes all wave height and period statistics, as well as mean and peak wave direction values.

6 DATA DISPLAY

It is possible to display data within WaveLog Express in a variety of formats. However, all data is in ASCII text format, so may be opened within a spreadsheet package such as MS Excel is the user prefers.

The following table indicates the various data displays that are currently available within the WaveLog Express package.

- "Num" indicates a numerical display of the last data value
- "Scr" indicates a tabular scroll of all data values
- "Gr" indicates a graphical display of all data values
- N/A indicates that the data is not available for display (e.g. Raw Wave Burst Data is not output in real time).

	Real Time			Uploaded			Post Processed			PC Saved		
	Num	Scr	Gr	Num	Scr	Gr	Num	Scr	Gr	Num	Scr	Gr
Tide Burst Summary	✓	✓	✓	N/A	✓	✓	N/A	N/A	N/A	N/A	✓	✓
Raw Wave Burst Data	N/A	N/A	N/A	N/A	✓	✓	N/A	N/A	N/A	N/A	N/A	N/A
Non-Directional Wave Summary	✓	✓	✓	N/A	✓	✓	N/A	✓	✓	N/A	✓	✓
Directional Wave Summary	✓	✓	✓	N/A	✓	✓	N/A	✓	✓	N/A	✓	✓
Wave Frequency Spectrum	N/A	✓	✓	N/A	✓	✓	N/A	✓	✓	N/A	✓	✓
Wave Directional Spectrum	N/A	✓	✓	N/A	✓	✓	N/A	✓	✓	N/A	✓	✓
Frequency / Direction Spectrum	N/A	✓	✓	N/A	✓	✓	N/A	✓	✓	N/A	✓	✓
Cross & Auto Spectra	✓	✓	✓	N/A	✓	✓	N/A	✓	✓	N/A	✓	✓
Surface Wave Recreation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	✓	✓	N/A	N/A	N/A

The general display concept is that the user may open multiple windows within the WaveLog Express environment; each window may be moved and sized within WaveLog Express, so that the user is able to create their own data display screen, optimised to show the parameters of interest in the most appropriate manner.

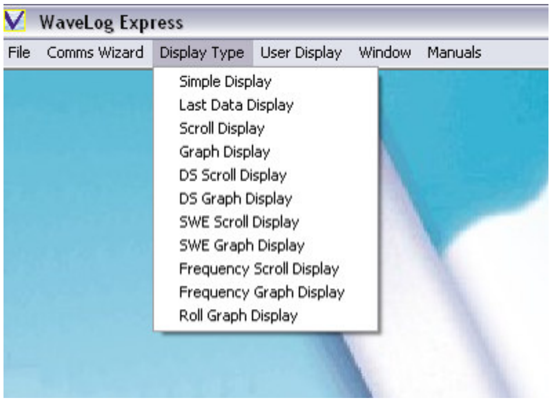
There are a total of 10 different display types, 4 of which are for use with basic single value parameters, as given in the tide and wave burst summary data strings. The remaining 6 display types are reserved for use with the complex processed data files representing the energy and directional spectra, and the recreated surface wave patterns. In each, case, both a tabular and graphical format is available.

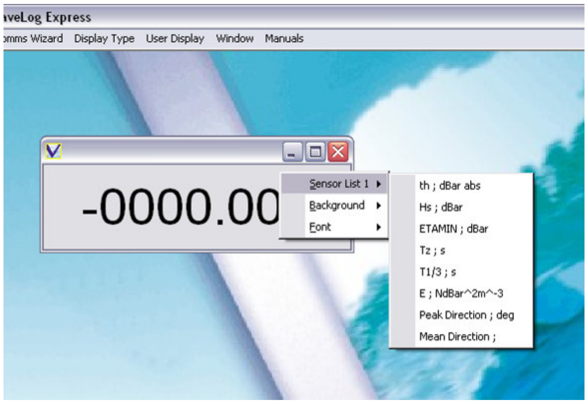
6.1 NUMERICAL DISPLAYS

6.1.1 SINGLE PARAMETER DISPLAY

This display type is designed to give a large clear indication of the last data value of a specified parameter. It is only available for real time data input; a typical application would be for use in a port operations environment where the current Significant Wave Height must be displayed. Note that more than one of these windows can be opened, all indicating different parameters.

To open this type of display, select Simple Display from the Display Type menu:



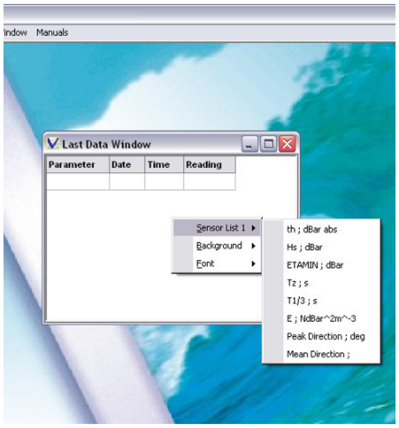


To change the displayed parameter, right click inside the window and context menu will appear. Select the required parameter from the list. Note that the large number of data parameters available may be split alphabetically into up to three separate lists. The screen will be updated the next time that data is received.

6.1.2 LAST DATA DISPLAY

This display type is designed to give a ready reference of the last received data value from a list of parameters. It is a more compact display method than opening multiple single parameter displays. This display type is only available for real time data.

Select Last Data Display from the Display Type menu. A window will appear as indicated – just repeatedly select the required parameters using the context menu. Note that the large number of data parameters available may be split alphabetically into up to three separate lists. The screen will be updated the next time that data is received.



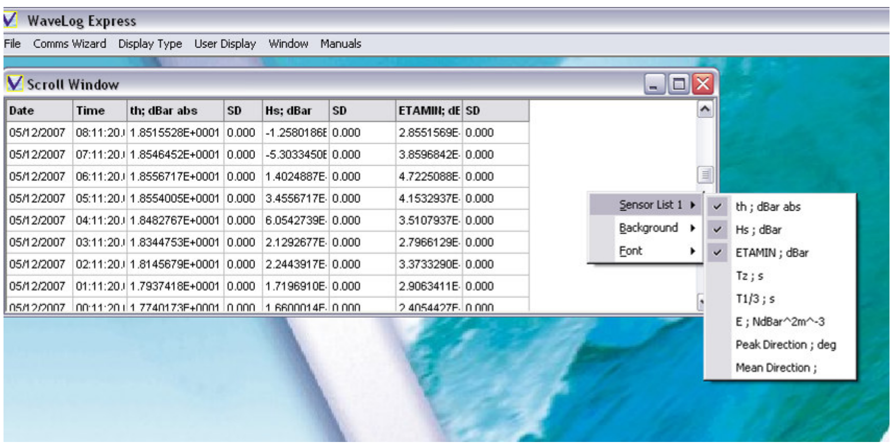
6.2 TABULAR DISPLAYS

The Tabular Display functions present a tabular history of data values for the selected parameters. They may be used for both real time and historical data.

6.2.1 SCROLL DISPLAY

Scroll Display is for use with single value parameters, as found in the wave and tide summary files, or in a raw wave burst date file. Simply select Scroll Display from the Display Type menu.

To display data in real time, repeatedly select the required parameters from the drop down list. Note that the large number of data parameters available may be split alphabetically into up to three separate lists. The screen will be updated the next time that data is received, alternatively the screen will display any compatible historical data currently loaded.



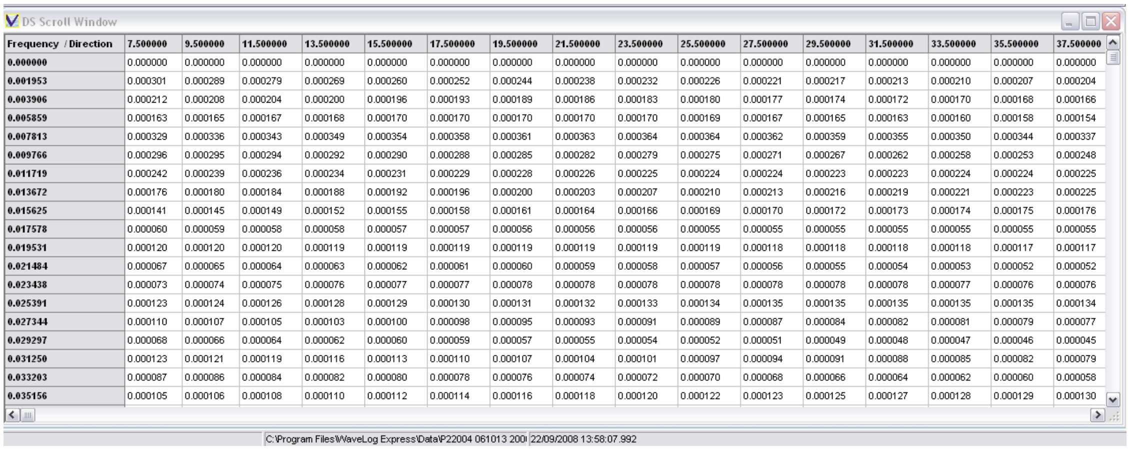
6.2.2 DIRECTIONAL SPECTRA SCROLL

The Directional Spectra Scroll display gives a tabular display of the directional spectrum matrix, where an energy value is given for each wave frequency (vertical array) at each point of the compass, at 2° intervals (horizontal array). The energy value given is actually an Energy Density figure, the derivation of which is given in Section 8. Note that the first directional point given in the table is actually the compass orientation of the instrument, with subsequent directional values increasing by 2°, through 360° / 0°, back towards the start value. This display is available for use with both real time and archive data.

To view the Directional Spectra Scroll single value parameters, simply select "Directional Spectra Scroll" from the Display Type menu.

To display data in real time, ensure that the device is set to output "Wave Directional Spectrum", as described under Section 3.4.4. The display will update automatically as data is received.

To view historical data, select File on the menu, and click “Open Wave Directional Spectrum File”. Navigate to the desired file, remembering the file naming convention where each file is named according to the device serial number and the date/time to which it refers.



Frequency / Direction	7.500000	9.500000	11.500000	13.500000	15.500000	17.500000	19.500000	21.500000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.001953	0.000301	0.000289	0.000279	0.000269	0.000260	0.000252	0.000244	0.000238
0.003906	0.000212	0.000208	0.000204	0.000200	0.000196	0.000193	0.000189	0.000186
0.005859	0.000163	0.000165	0.000167	0.000168	0.000170	0.000170	0.000170	0.000170
0.007813	0.000329	0.000336	0.000343	0.000349	0.000354	0.000358	0.000361	0.000363
0.009766	0.000296	0.000295	0.000294	0.000292	0.000290	0.000288	0.000285	0.000282
0.011719	0.000242	0.000239	0.000236	0.000234	0.000231	0.000229	0.000228	0.000226
0.013672	0.000176	0.000180	0.000184	0.000188	0.000192	0.000196	0.000200	0.000203
0.015625	0.000141	0.000145	0.000149	0.000152	0.000155	0.000158	0.000161	0.000164
0.017578	0.000060	0.000059	0.000058	0.000058	0.000057	0.000057	0.000056	0.000056
0.019531	0.000120	0.000120	0.000120	0.000119	0.000119	0.000119	0.000119	0.000119
0.021484	0.000067	0.000065	0.000064	0.000063	0.000062	0.000061	0.000060	0.000059
0.023438	0.000073	0.000074	0.000075	0.000076	0.000077	0.000077	0.000078	0.000078
0.025391	0.000123	0.000124	0.000126	0.000128	0.000129	0.000130	0.000131	0.000132
0.027344	0.000110	0.000107	0.000105	0.000103	0.000100	0.000098	0.000095	0.000093
0.029297	0.000068	0.000066	0.000064	0.000062	0.000060	0.000059	0.000057	0.000055
0.031250	0.000123	0.000121	0.000119	0.000116	0.000113	0.000110	0.000107	0.000104
0.033203	0.000087	0.000086	0.000084	0.000082	0.000080	0.000078	0.000076	0.000074
0.035156	0.000105	0.000106	0.000108	0.000110	0.000112	0.000114	0.000116	0.000118

Frequency / Direction	23.500000	25.500000	27.500000	29.500000	31.500000	33.500000	35.500000	37.500000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.001953	0.000232	0.000226	0.000221	0.000217	0.000213	0.000210	0.000207	0.000204
0.003906	0.000183	0.000180	0.000177	0.000174	0.000172	0.000170	0.000168	0.000166
0.005859	0.000170	0.000169	0.000167	0.000165	0.000163	0.000160	0.000158	0.000154
0.007813	0.000364	0.000364	0.000362	0.000359	0.000355	0.000350	0.000344	0.000337
0.009766	0.000279	0.000275	0.000271	0.000267	0.000262	0.000258	0.000253	0.000248
0.011719	0.000225	0.000224	0.000224	0.000223	0.000223	0.000224	0.000224	0.000225
0.013672	0.000207	0.000210	0.000213	0.000216	0.000219	0.000221	0.000223	0.000225
0.015625	0.000166	0.000169	0.000170	0.000172	0.000173	0.000174	0.000175	0.000176
0.017578	0.000056	0.000055	0.000055	0.000055	0.000055	0.000055	0.000055	0.000055
0.019531	0.000119	0.000119	0.000118	0.000118	0.000118	0.000118	0.000117	0.000117
0.021484	0.000058	0.000057	0.000056	0.000055	0.000054	0.000053	0.000052	0.000052
0.023438	0.000078	0.000078	0.000078	0.000078	0.000078	0.000077	0.000076	0.000076
0.025391	0.000133	0.000134	0.000135	0.000135	0.000135	0.000135	0.000135	0.000134
0.027344	0.000091	0.000089	0.000087	0.000084	0.000082	0.000081	0.000079	0.000077
0.029297	0.000054	0.000052	0.000051	0.000049	0.000048	0.000047	0.000046	0.000045
0.031250	0.000101	0.000097	0.000094	0.000091	0.000088	0.000085	0.000082	0.000079
0.033203	0.000072	0.000070	0.000068	0.000066	0.000064	0.000062	0.000060	0.000058
0.035156	0.000120	0.000122	0.000123	0.000125	0.000127	0.000128	0.000129	0.000130

6.2.3 FREQUENCY SCROLL

The Frequency Scroll display gives a tabular display of three different file types, where the data value is a function of the frequency. These are the Cross & Auto Spectra data files, the non-directional Wave Spectrum files, and the Frequency / Direction files.

Cross & Auto Spectra data allow expert users to calculate additional wave parameters such as spreading angles. Whilst WaveLog Express includes no features for these advanced calculations, the Cross & Auto Spectra data are available if required; as a general rule, if you don't know what these are, you don't need to know! The values are essentially multiples of vertical (pressure) and horizontal (current) variations at each frequency in the spectrum, and are designated as pee, puu, pvv, puv, pue & pve.

Non-directional spectrum files give the amount of Energy at each frequency in the spectrum, for the given data burst.

Frequency / Direction data are included as part of the .dsp Directional Spectrum file, and give the peak direction (i.e. direction containing most energy) for each frequency in the burst.

To view any of these files in a tabular form, select "Frequency Scroll" from the Display Type menu.

To display data in real time, ensure that the device is set to output the appropriate file type as described under Section 3.4.4. The display will update automatically as data is received.

To view historical data, select File on the menu, and choose the required file type. Navigate to the desired file, remembering the file naming convention where each file is named according to the device serial number and the date/time to which it refers. Note that Cross & Auto Spectra are found under the "Spreading Files" directory, Wave Frequency Spectra under the Non-directional Spectra directory, and Frequency / Direction Spectra under the Directional Spectra directory. The illustration shows this display type open with the Wave Frequency file type.

Frequency Scroll Window

Frequency, Hz	pee	puu	pvv	puv	pue	pve	Spectral	Peak Dir
0.000977	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	1.018876	0.000000
0.002930	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.097577	0.000000
0.004883	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.008285	0.000000
0.006836	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.017170	0.000000
0.008789	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.039667	0.000000
0.010742	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.046684	0.000000
0.012695	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.018681	0.000000
0.014648	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007869	0.000000
0.016602	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.021601	0.000000
0.018555	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.013900	0.000000
0.020508	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.029131	0.000000
0.022461	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005760	0.000000
0.024414	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.010148	0.000000
0.026367	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.011643	0.000000
0.028320	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.011930	0.000000
0.030273	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.020945	0.000000
0.032227	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.010010	0.000000
0.034180	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.009181	0.000000
0.036133	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.019917	0.000000
0.038086	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007307	0.000000

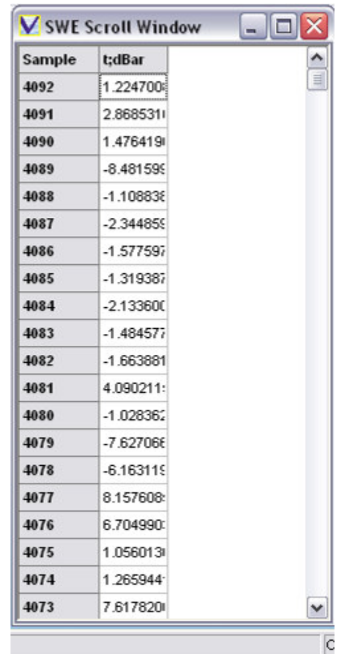
ight Click for sensor list. C:\Program Files\WaveLog Express\Data\P22004 061013 200 22/09/

6.2.4 SURFACE WAVE RECREATION SCROLL

An important feature of the WaveLog Express software is its ability to recreate the actual surface patterns that cause the measured pressure and current oscillations. This process is carried out in post-processing only, so data cannot be displayed in real time. Data is presented as values above and below the mean water level during the data burst. Note that the units of the data are the same as the pressure data, i.e. dBar, but this can be converted into metres using the first level approximation of 1m = 1dBar.

Select “Surface Wave Recreation Scroll” from the Display Type menu.

To open a historical data file, select File on the menu, and click “Open Surface Wave Recreation File”. Navigate to the desired file, remembering the file naming convention where each file is named according to the device serial number and the date/time to which it refers.



6.3 GRAPHICAL DISPLAYS

WaveLog Express features a variety of graphical display modes, designed to give a visual representation of data from all the different file types available within the software. Graphical displays are available for both real time and archive data.

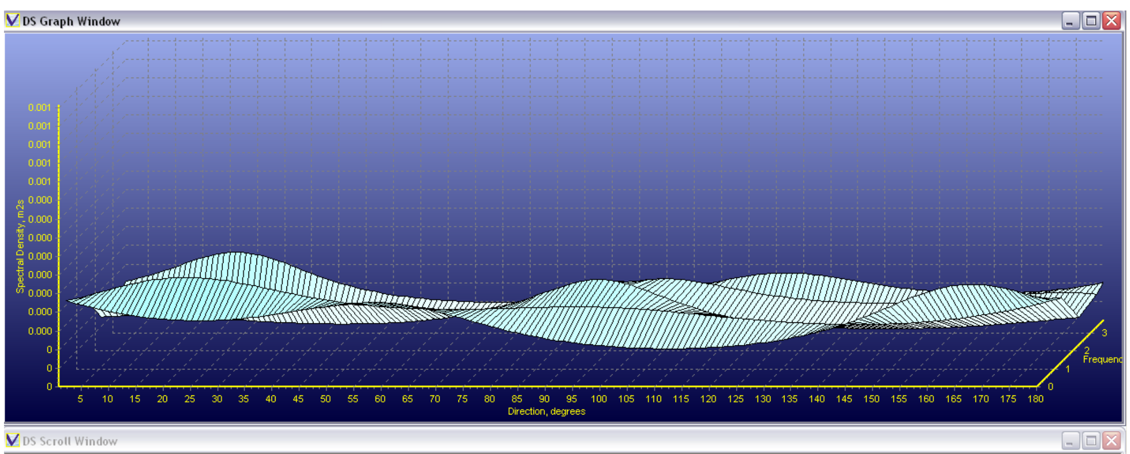
Note that all Graphical displays feature a right click context menu, which allows the user access to a variety of functions related to the Graph appearance and manipulation. .

- The Copy and Save functions will convert the graph to a Windows bitmap, for easy import into other packages for preparation of reports etc.

6.3.1 DIRECTIONAL SPECTRA GRAPH

This function gives a 3D display of the directional energy spectrum from a single wave burst, which may have been generated in real time or, from an uploaded or post-processed data file.

Select Directional Spectra Graph from the Screen menu. A window will appear as indicated; click File, Open New Directional Spectra Graph, and browse to the *.dsp file for the wave burst of interest. Note that the "Open Old Directional Spectra Graph" function is included to allow data collected from older Valeport Model 730D Wave Recorders to be displayed.



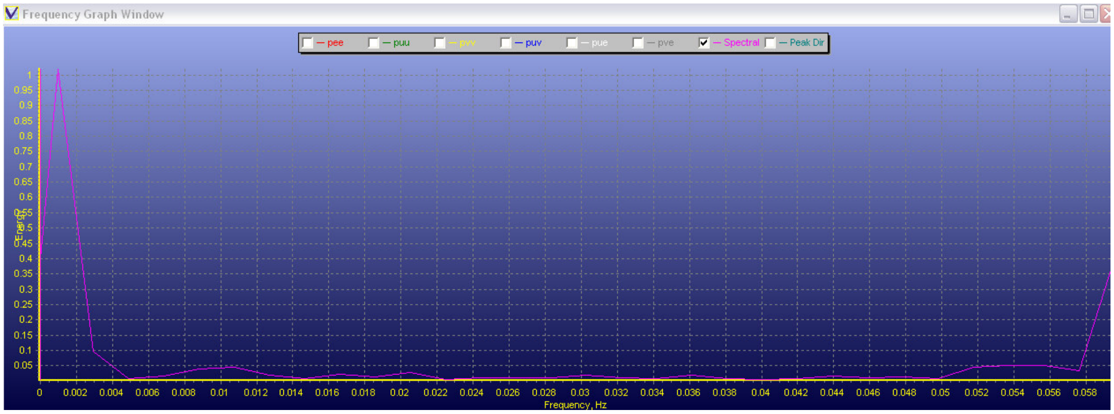
6.3.2 FREQUENCY GRAPH

This function gives a display various parameters against the wave frequency in individual data bursts. This display type may be used to show data from Cross & Auto Spectra (Spreading) Files, Wave Frequency Spectrum (Non-directional) Files, and Frequency / Direction data from Directional Spectrum (*.dsp) Files. The display will work with both real time and archive data.

Select "Frequency Graph" from the Display Type menu as indicated.

To view real time data, simply ensure that the graph is open, and that the instrument is set to output the required data type in real time.

To view archive data, select the required data file type from the File Menu.. The file will be loaded and the data display accordingly:

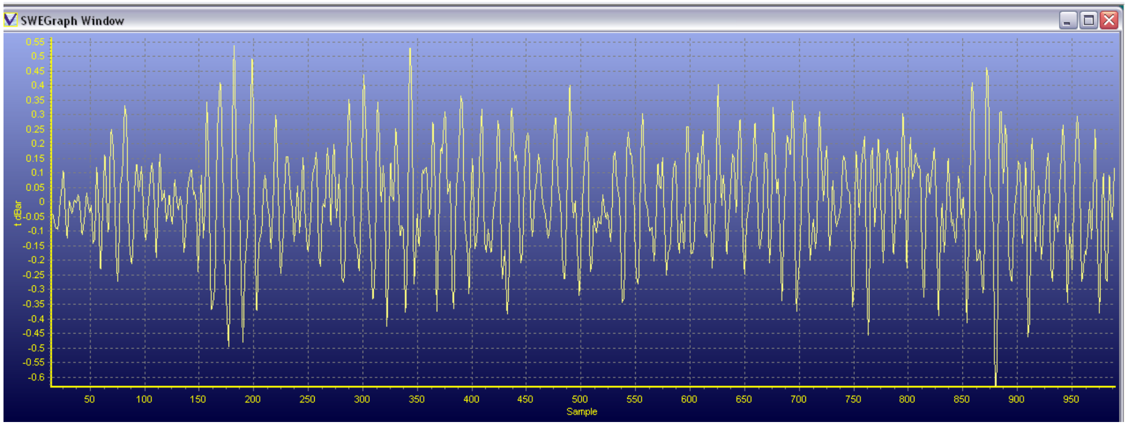


6.3.3 SURFACE WAVE RECREATION GRAPH

The Surface Wave Recreation Graph gives a time series display of the surface elevation with respect to the mean water level for the duration of each wave burst. Since Surface Wave data is only recreated during post-processing, this display is only available for post-processed data files, and not in real time, or directly uploaded from the instrument. Note that raw wave data must be saved on the instrument to allow post-processing.

Select "Surface Wave Recreation Graph" from the Display Type menu.

Click File, "Open Surface Wave Recreation File", and navigate to the desired *.swe file. The file will be loaded and the data display accordingly:



6.4 WINDOW

Once the required display screens have been selected, their size and position may be manipulated to create a unique overall display environment. However, several standard Windows type display arrangement functions are included under the Window menu:

Tile All open windows are given equal size.
Close Closes active window
Minimize All Minimizes all open windows

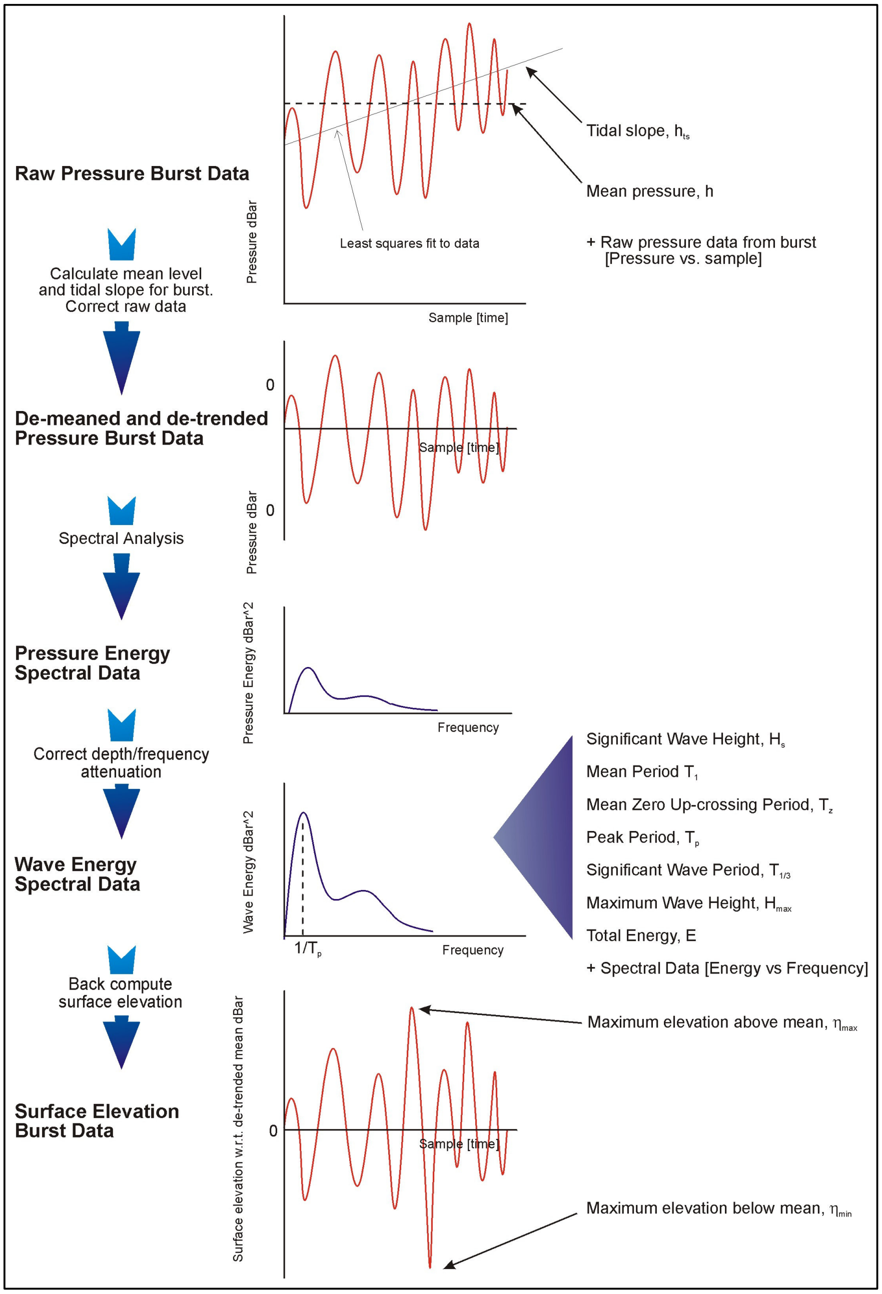
Note also that when WaveLog Express can save two screen configurations and reload at any point.

7 SUMMARY OF DATA ANALYSIS PROCESS

7.1 NON –DIRECTIONAL DATA ANALYSIS

The following diagram illustrates the wave data processing that is carried out in the MIDAS DWR. The main stages in the computation are:

- Pressure readings are logged during the Wave Burst
- Tidal slope calculated by linear regression.
- Pressure data "de-trended" to take out the tidal variation during burst, so that all wave calculations are referred to the same level.
- Fourier Transform carried out to provide pressure spectral analysis.
- Using the frequency analysis and mean pressure, all raw data is passed through a reverse Fourier Transform to back calculate the surface elevation for every sample in the burst. This is carried out in post processing only, NOT on board the instrument



Level and height units are all logged and calculated in pressure dBar, which may be converted to depth using the following relationships:

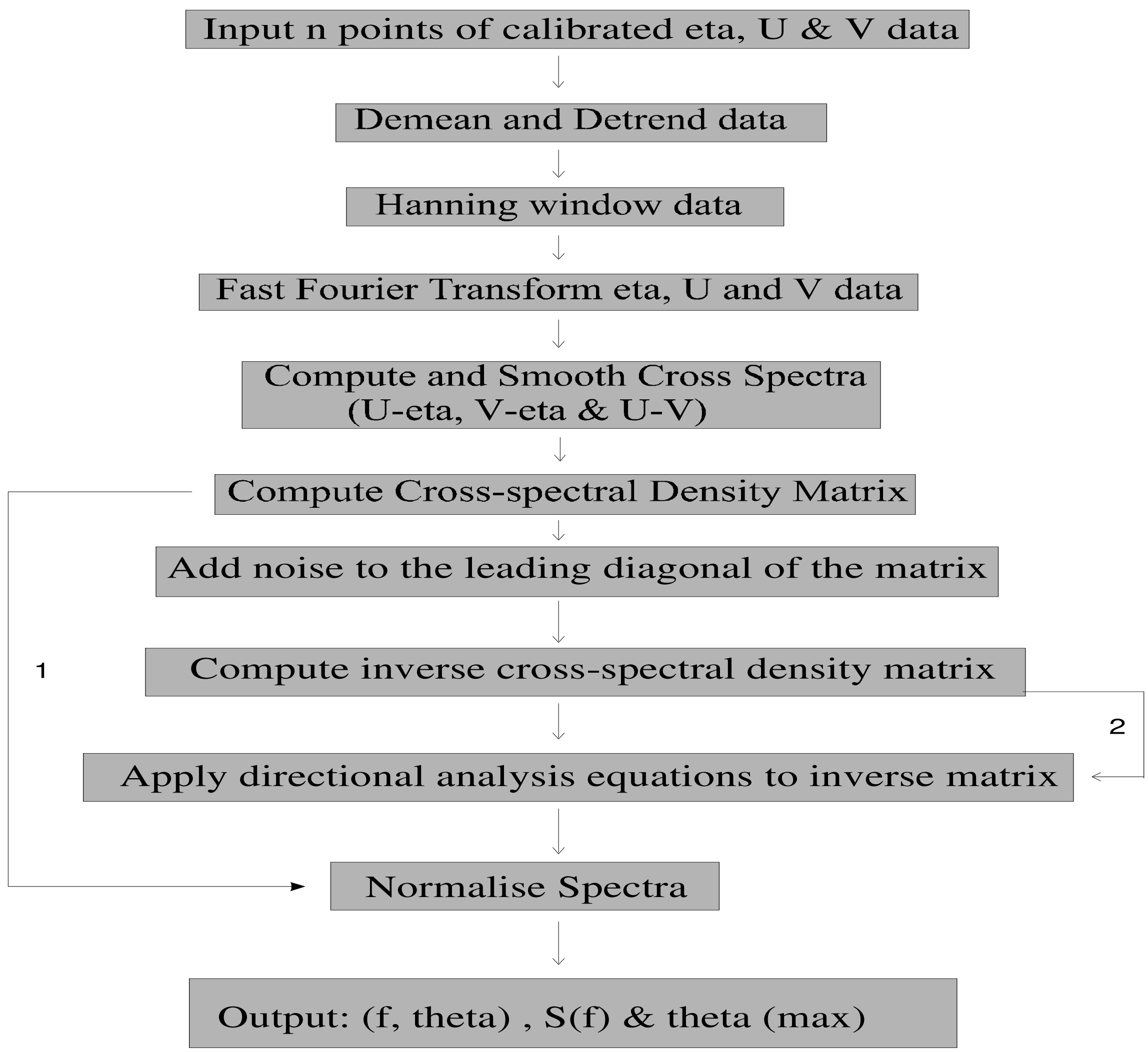
1dBar = 1m (to a first approximation)

1dBar = 0.995m (standard seawater)

1dBar = 1.02m (fresh water)

7.2 DIRECTIONAL DATA ANALYSIS

Directional Analysis Procedure



8 DERIVATION OF WAVE STATISTICS

The Wave Statistics are calculated as follows:

8.1 MEAN LEVEL, H

Mean of all the raw pressure readings in the wave burst. Pressure readings are absolute and therefore include air and water pressure.

8.2 TIDAL SLOPE, H_{TS}

Calculated by linear regression of pressure values during a wave burst, and expressed in dBar per sample period. To convert this to tidal slope per minute, multiply by the number of samples per minute (e.g. for 2 Hz sampling multiply the figure by 120).

8.3 SIGNIFICANT WAVE HEIGHT, H_S

Calculated from spectral moments of the time series of surface elevation.

H_s is defined as $H_s = 4m_0^{½}$

m_0 is the variance and $m_0^{½}$ the standard deviation, so H_s is in fact 4 times Standard Deviation. Note that this is standard deviation of the surface elevation, not just standard deviation of the pressure readings.

8.4 MAXIMUM ELEVATION ABOVE DETRENDED MEAN, η_{MAX} (ETA_{MAX})

Taken from the time series of surface elevation

8.5 MINIMUM ELEVATION BELOW DETRENDED MEAN, η_{MIN}

Taken from the time series of surface elevation

8.6 MEAN PERIOD, T_1

Calculated from spectral moments of the time series of surface elevation.

T_1 is defined as $T_1 = m_0 / m_1$

8.7 MEAN ZERO UPCROSSING PERIOD, T_Z

Calculated from spectral moments of the time series of surface elevation.

T_z is defined as $T_z = (m_0 / m_2)^{½}$

8.8 PEAK PERIOD, T_P

From spectral analysis, this is the period [i.e. 1/frequency] of the peak of the spectrum.

8.9 SIGNIFICANT WAVE PERIOD, $T_{1/3}$

Calculated from the Peak Period [ref: Goda 1974]

$T_{1/3}$ is defined as $T_{1/3} = 1.02 * T_p$

Maximum wave height, H_{max}

Calculated from the Significant Wave Height

H_{max} is defined as $H_{max} = 1.57 * H_s$ [ref: Goodnight and Russell (1963)]
Note that other multiplier values have been proposed by other researchers, for example 1.87 [ref: Putz (1952)]. If an alternative is preferred, then a simple mathematical adjustment may be made to the data.

Total energy, E

Calculated from Significant Wave Height, density and gravity. Energy Density is expressed as J/m^2, which is derived as follows:
Integrating both potential and kinetic energy along the full length of the wave yields the total energy density E as:
$E = \rho g H_s^2/16$ [units of $(kg\ m^{-3}) . (m\ s^{-2}) . (m^2)$, simplifying to $kg\ m\ s^{-2}\ m^{-1}$]

Since a Newton (F=ma) has units of $kg.ms^{-2}$

$E = Nm^{-1}$

The usual units of energy are:
E=Nm or Joules (J)

Thus the equation used gives an energy density. That is energy integrated over one wavelength and per unit length of wave crest. Therefore this is equivalent to:

$E = Jm^{-2}$

Peak Wave Direction

Calculated as the wave direction at which the Peak Frequency is most dominant

Mean Wave Direction

The arithmetic mean direction of wave activity, based on energy distribution. The exact calculations involved are highly detailed and are not included here.

9 DATA FILTER & ATTENUATION FUNCTIONS

The fundamental methodology of wave measurement used by the Valeport range of Wave Recorders is to record the pressure variations in the water column caused by wave motion. These pressure variations attenuate with depth, as a function of the wave frequency; generally speaking, the pressure signal from higher frequency waves attenuates more quickly than that from lower frequency waves. In order to use these attenuated pressure variations to accurately recreate the surface activity, it is necessary to use a series of algorithms to amplify the wave signals in the correct proportions as a function of their frequency. The algorithms employed by the Valeport instruments to correct the data for this attenuation are proprietary, and their exact form is not reproduced here.

The attenuation of the wave signals is significant, meaning that the raw data may need to be multiplied several times to generate the correct values. Unfortunately, as depth and wave frequency increase, this scale factor reaches a level where background signal noise is also being significantly amplified, and producing erroneous results. The scale function is therefore "capped" to ensure that such background noise is not amplified to significant levels. This also results in a loss of high frequency wave data at greater depths, but this must be accepted since at these levels of attenuation, the wave data is effectively indistinguishable from background noise anyway.

9.1 DATA SAMPLING TRIGGER

Understanding this principle of attenuation and scaling is not just important for the expert user. Whilst it will allow a more detailed assessment of the quality of data from the instrument, perhaps the most significant use of this knowledge is in the setting of an appropriate trigger level for the measurement of wave data (see Section 3.4.2). The instrument may be set to run a rapid tide cycle, and on the basis of the standard deviation of the pressure signal may decide to begin a full wave sampling burst. Whilst it is a well documented fact that significant wave height equates to 4 x standard deviation of surface elevation, our understanding of the principles of attenuation mean that measuring the standard deviation of the pressure readings alone is not sufficient to accurately gauge the surface activity. The user must therefore set a trigger level for wave activity during the tide cycle, based on the expected attenuation. The following table gives an indication of the attenuation that may be expected in different water depths for different wave frequencies.

If for example it is believed that the significant wave frequency is in the region of 0.15Hz (6.67 second period), and the device is deployed at 10m depth, the wave signal from that significant wave will attenuated by a factor of 0.596. If we only wish to record data when the significant wave height is above 0.5m, we must consider that at 10m depth, a 0.5m wave will only cause a pressure change of 0.298dBar (using the approximation of 1m = 1dBar). The wave trigger level should therefore be set to 0.298.

Frequency [Hz]	Attenuation Factor			
	At 5m depth	At 10m depth	At 15m depth	At 20m depth
0.05	0.969	0.948	0.923	0.899
0.10	0.878	0.800	0.707	0.619
0.15	0.747	0.596	0.434	0.303
0.20	0.568	0.351	0.174	0.080
0.25	0.377	0.155		
0.30	0.211	0.052		

Note that this value is obtained by a method that uses at least three approximations:

- The frequency of the significant wave
- The overall water depth
- That 1m = 1dBar

It is therefore suggested that unless memory conservation is of absolute priority, the trigger level is set slightly lower to account for any approximation errors, and to ensure that no data of value is missed - it is generally better to have too much data than too little. In the above example, perhaps a trigger level of 0.2 or 0.25 would be more appropriate than the exact figure of 0.298.

9.2 ATTENUATION AND FILTER FUNCTION CURVES

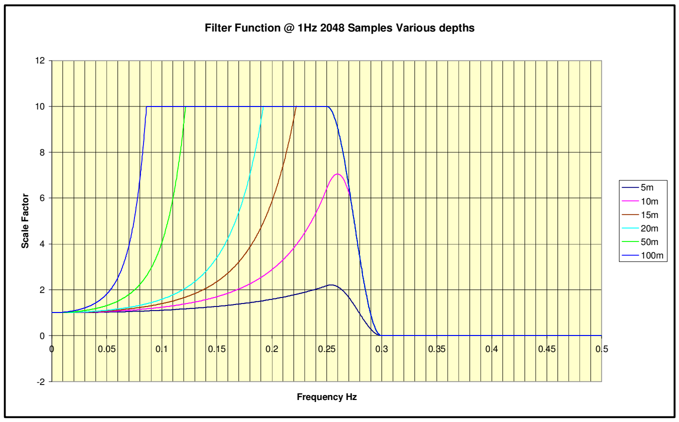
The following graphs illustrate the attenuation factors and filter functions of varying wave frequencies at selected depths. They indicate the amount by each wave frequency is attenuated, and therefore must be scaled up, for a series of different depths. The algorithms describing these functions are embedded in the software. Note that the algorithms vary depending on the instrument sampling frequency.

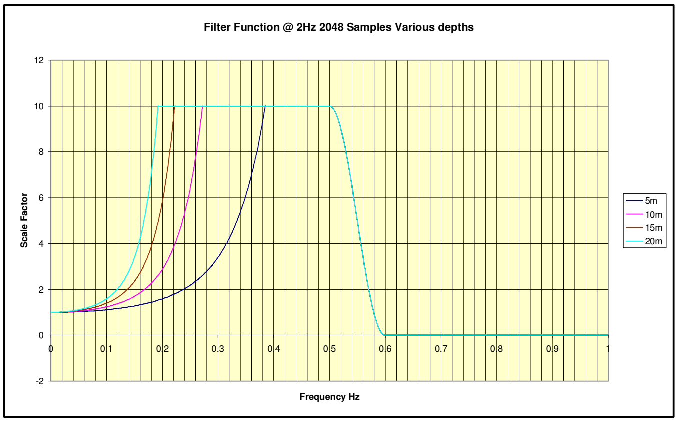
To read these graphs, note that each curve has three sections:

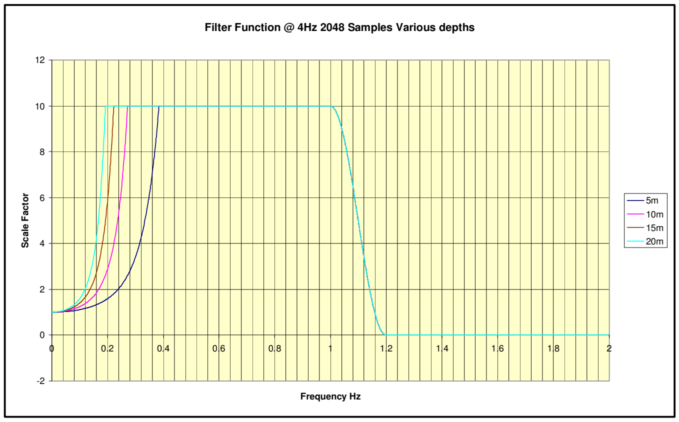
- Rising Part: The left side of each curve. This shows the increase in attenuation with wave frequency, at the given depth, and is the part of most interest. Looking at the pink line on the 1Hz graph for example, this tells us that in 10m water, a wave of frequency 0.2Hz (5 second period) would be attenuated (and therefore must be scaled) by a factor of around 3.

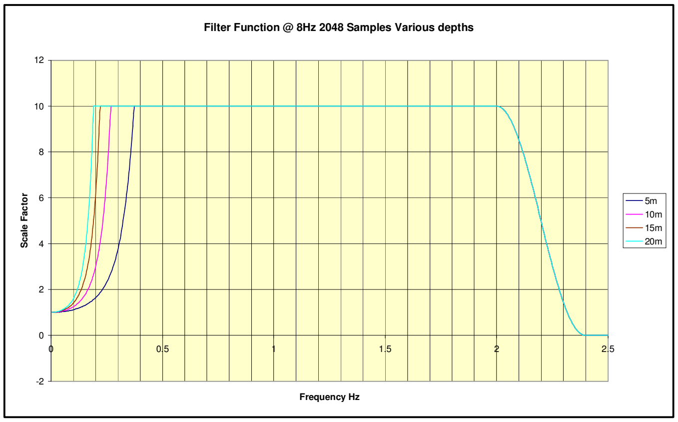
- Top Part: For most of the curves, this is capped at a Scale Factor of 10. It can be seen that the rise of the curve up to this part is very steep, and it can easily be imagined that the attenuation factor would quickly become very large indeed. At this point, we therefore say that the waves of this frequency and above are effectively “lost” in the background noise.

- Falling part: The right hand side of the curve. This is simply the decline in the filter function. Waves of this frequency cannot be measured, and the attenuation factor is effectively falling to zero.

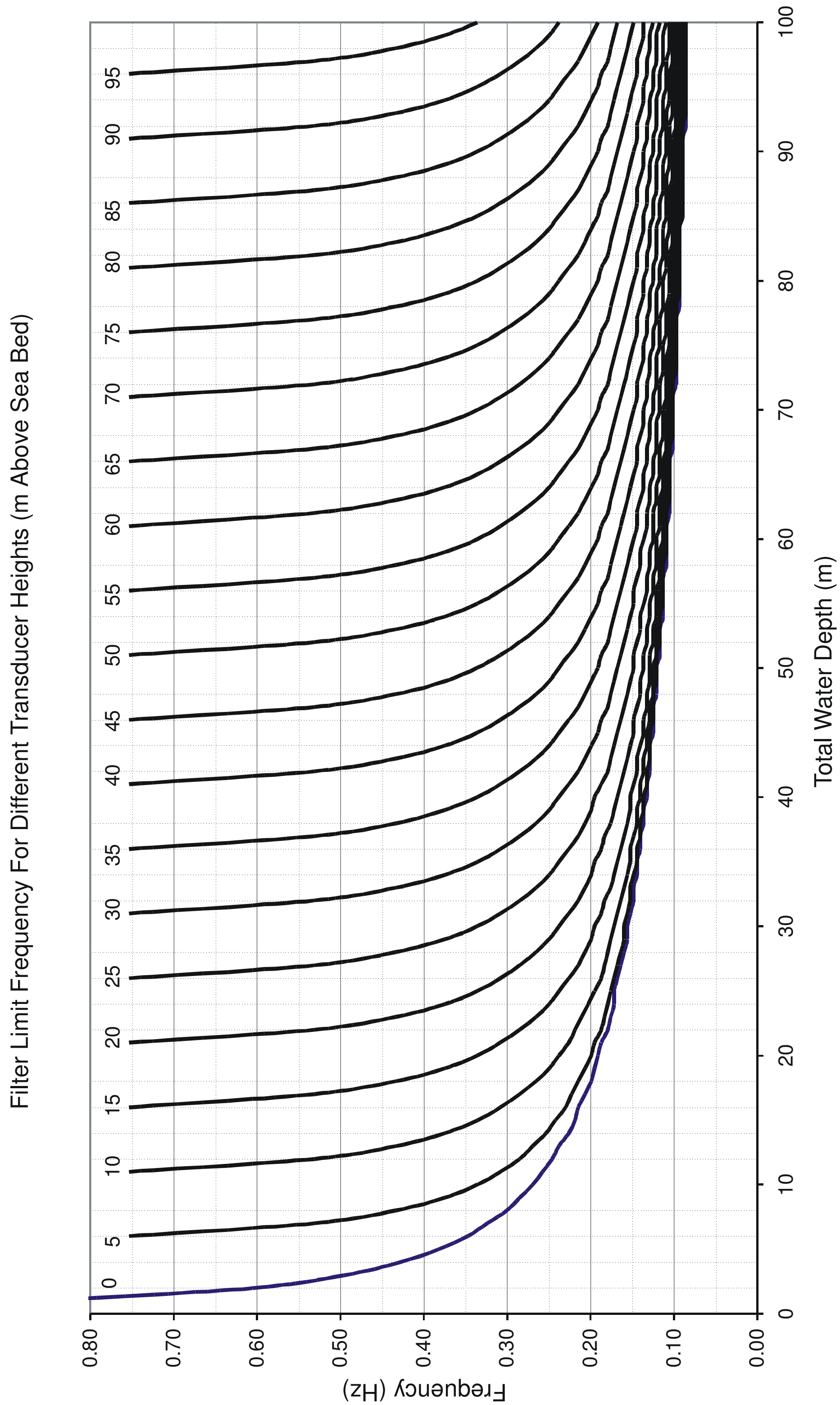








Below is a plot showing the wave frequency at which the scale factor is capped (i.e. reaches a value of 10), at different deployment depths.



For example, it can be seen that for an instrument deployed on the seabed in 10m depth, the frequency limit is approximately 0.27Hz, which is a wave period of 3.7 seconds.

10 FREQUENCY DATA RESOLUTION

Note that all data analysis is performed in terms of wave frequency, not wave period. Wave energy is assigned to discrete frequency "bins", or Spectral Points, the separation (i.e. resolution) of which is a function of the duration of sampling (in seconds). The number of Spectral Points is a function of the number of actual data samples, and the maximum frequency (i.e. shortest wave period measurable) is a function of the sampling rate.

Frequency resolution (A) may be calculated as:

$$A = 8 / T$$

where T is the duration of the wave burst measurement in seconds

The number of Spectral Points (B) is calculated as:

$$B = (5 \times (N / 128)) - 1$$

where N is the number of samples in the wave burst measurement

The lowest measurable frequency (i.e. longest wave period) (C) is:

$$C = 0.5 \times \text{Frequency Resolution}$$

The highest measurable frequency (i.e. shortest wave period) (D) is:

$$D = (A (B - 1)) + C$$

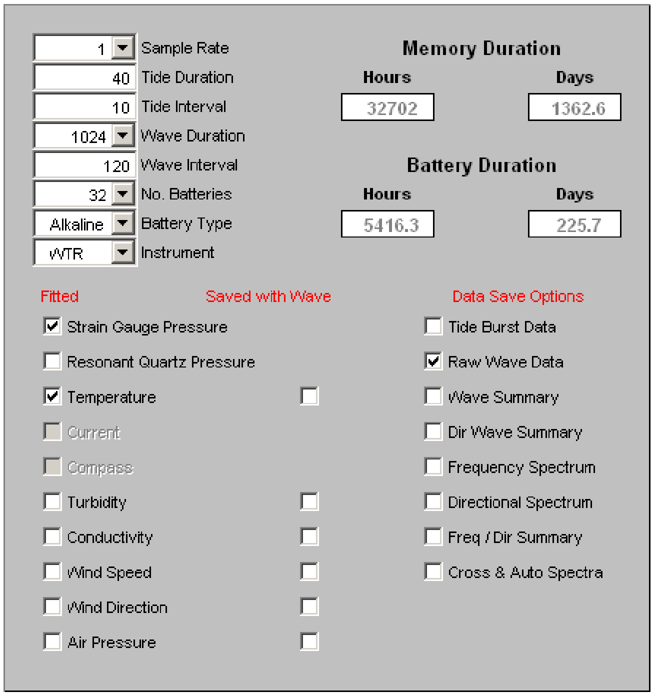
The following table gives details of the Spectral Range and Resolution for various sampling regimes:

Rate (Hz)	Number of Samples	Sample Duration (s)	Frequency Resolution (Hz)	Number of Points	Lowest Spectral Point		Highest Spectral Point	
					Frequency (Hz)	Period (s)	Frequency (Hz)	Period (s)
1	128	128	0.0625	4	0.03125	32	0.21875	4.571
1	256	256	0.03125	9	0.015625	64	0.265625	3.765
1	512	512	0.015625	19	0.0078125	128	0.2890625	3.459
1	1024	1024	0.0078125	39	0.00390625	256	0.30078125	3.325
1	2048	2048	0.00390625	79	0.001953125	512	0.306640625	3.261
1	4096	4096	0.001953125	159	0.000976563	1024	0.309570313	3.230
2	128	64	0.125	4	0.0625	16	0.4375	2.286
2	256	128	0.0625	9	0.03125	32	0.53125	1.882
2	512	256	0.03125	19	0.015625	64	0.578125	1.730
2	1024	512	0.015625	39	0.0078125	128	0.6015625	1.662
2	2048	1024	0.0078125	79	0.00390625	256	0.61328125	1.631
2	4096	2048	0.00390625	159	0.001953125	512	0.619140625	1.615
4	128	32	0.25	4	0.125	8	0.875	1.143
4	256	64	0.125	9	0.0625	16	1.0625	0.941
4	512	128	0.0625	19	0.03125	32	1.15625	0.865
4	1024	256	0.03125	39	0.015625	64	1.203125	0.831
4	2048	512	0.015625	79	0.0078125	128	1.2265625	0.815
4	4096	1024	0.0078125	159	0.00390625	256	1.23828125	0.808
8	128	16	0.5	4	0.25	4	1.75	0.571
8	256	32	0.25	9	0.125	8	2.125	0.471
8	512	64	0.125	19	0.0625	16	2.3125	0.432
8	1024	128	0.0625	39	0.03125	32	2.40625	0.416
8	2048	256	0.03125	79	0.015625	64	2.453125	0.408
8	4096	512	0.015625	159	0.0078125	128	2.4765625	0.404

The Spectral Points are separated linearly in terms of frequency, but of course when the frequency is inverted to give a wave period, the distribution becomes non-linear. This results in a greater wave period resolution at shorter wave periods (higher frequencies), and a much lower resolution at longer wave periods (lower frequencies).

11 DEPLOYMENT DURATION

The software is supplied with an MS Excel spreadsheet that allows offline calculation of the battery and memory duration for any given sampling setup. This utility uses exactly the same calculations as the similar feature in the Setup page of the WaveLog Express software. The utility is intuitive to use, and detailed instruction is not given here. A brief explanation of the rational behind the memory and battery usage figures is explained below.



11.1 MEMORY LIFE

The MIDAS Wave Recorders are fitted with a 64Mbyte FLASH memory, which is actually 67,108,864 bytes. The length of time for which this memory will last is a function of the parameters fitted to the device, the number of samples in the wave burst, the interval between data bursts, and the user's selection of which data types to store.

The following table indicates the amount of memory used per data burst, for each data type at all possible wave burst sizes. Values are given for both standard DWR (current, pressure, compass and temperature sensors) and WTR (pressure and temperature sensors) only *(DWR / WTR)*. If the device has optional additional sensors fitted, they will typically use an additional 8 bytes per parameter per tide burst, and 4 bytes per sample per parameter for each wave burst.

Data Type / Wave Burst Length	128	256	512	1024	2048	4096
Tide Burst Data	32 / 20	32 / 20	32 / 20	32 / 20	32 / 20	32 / 20
Raw Wave Burst Data	1544 / 516	3080 / 1028	6152 / 2052	12296 / 4100	24584 / 8196	49160 / 16388
Non-directional Wave Summary	44 / 44	44 / 44	44 / 44	44 / 44	44 / 44	44 / 44
Directional Wave Summary	14 / NA	14 / NA	14 / NA	14 / NA	14 / NA	14 / NA
Wave Frequency Spectrum	16 / 16	36 / 36	76 / 76	156 / 156	316 / 316	636 / 636
Directional Wave Spectrum	3626 / NA	7246 / NA	14486 / NA	28966 / NA	57926 / NA	115846 / NA
Frequency / Direction Summary	752 / NA	792 / NA	872 / NA	1032 / NA	1352 / NA	1992 / NA
Cross & Auto Spectra	168 / NA	360 / NA	744 / NA	1512 / NA	3048 / NA	6120 / NA

11.2 BATTERY LIFE

The Valeport Wave Recorders (with standard sensors) draw approximately the following power during the various stages of the operating cycle:

	WTR	DWR
Measuring	0.36W	1.92W
Calculating	0.30W	0.54W
Sleeping	0.0012W	0.0012W

The battery life is therefore very much dependent on the sampling regime, as well as the type (and number) of batteries fitted. In addition to the sampling regime, it is also necessary to consider the battery performance; the capacity of the cells is dependent on the current drain, and the cell type:

Battery Type	V	Nominal efficiency	Max Capacity (with 32 cells)		
			High Drain (Measuring)	Mid Drain (Calculating)	Low Drain (Sleeping)
Alkaline	1.5v	75%	40000mAh	56000mAh	56000mAh
Lithium	3.6v	90%	26600mAh	45600mAh	68400mAh

Both WaveLog Express and the MS Excel offline spreadsheet use the above coefficients in calculating the expected battery life from the chosen settings.

12 WIRING INFORMATION

12.1 3M Y LEAD (RS232)

10 Way Male Subconn	3m Blue Polyurethane Cable	1m White Cable	4mm Banana Plugs	1m Grey Cable	9 Way D Type	Function
1	WHITE	BLUE	BLACK			Power Ground
2	PINK	BROWN	RED			Power +V
3	N/C					
4	N/C					
5	N/C					
6	N/C					
7	GREY			YELLOW	2	RS232 Tx (To PC)
8	BLUE			BLUE	3	RS232 Rx (From PC)
9	GREEN			GREEN	5 (link to 1,6,8,9)	RS232 Ground
	SCREEN			SCREEN	SHELL	
10	YELLOW					Internal Battery Enable Link to RS232 Ground

12.2 3M SWITCHED Y LEAD (RS485 & RS422)

10 Way Male Subconn	3m Blue Polyurethane Cable		1m White Cable	4mm Banana Plugs	1m Grey Cable	15 Way D Type	0.2m Grey Cable	9 Way D Type	Function
1	WHITE	*SWITCH BOX*	BLUE	BLACK					Power Ground
2	PINK		BROWN	RED					Power +V
3	RED				RED	9			RS422 TxA
4	BLACK				BLACK	10			RS422 TxB
5	ORANGE				VIOLET	11			RS422 RxA
6	BROWN				BROWN	12			RS422 RxB
7	GREY				YELLOW		YELLOW	2	RS232 Tx (To PC)
8	BLUE				BLUE		BLUE	3	RS232 Rx (From PC)
9	GREEN				GREEN	5	GREEN	5 (link to 1,6,8,9)	RS232 Ground
	SCREEN				SCREEN	SHELL	SCREEN	SHELL	
10	YELLOW								Internal Battery Enable