Cardno OceanSense Wave Data Quality Manual

Bureau of Meteorology Wave Buoy Support

59916051

Prepared for
Bureau of Meteorology

Contract 164-2013-14

27 February 2017

Cardno
Shaping the Future

Contact Information

Cardno (NSW/ACT) Pty Ltd
ABN 95 001 145 035

Level 9 – The Forum
203 Pacific Highway
St Leonards
NSW 2065

Telephone: 02 9496 7700
Facsimile: 02 9439 5170
International: +61 2 9496 7700

sydney@cardno.com.au
www.cardno.com

Author(s):

David Aubourg
Mathew Smith

Approved By:

Andrew Bradford
Senior Engineer

Document Information

Prepared for	Bureau of Meteorology
Project Name	Bureau of Meteorology Wave Buoy Support
File Reference	59916051 R002
Job Reference	59916051
Date	27 February 2017
Version Number	Rev A
Effective Date	27 February 2017
Date Approved:	27 February 2017

Document History

Version	Effective Date	Description of Revision	Prepared by:	Reviewed by:
Rev A	27/02/2017	Internal review released for client review	David Aubourg Matt Smith	Neil Lawson

Table of Contents

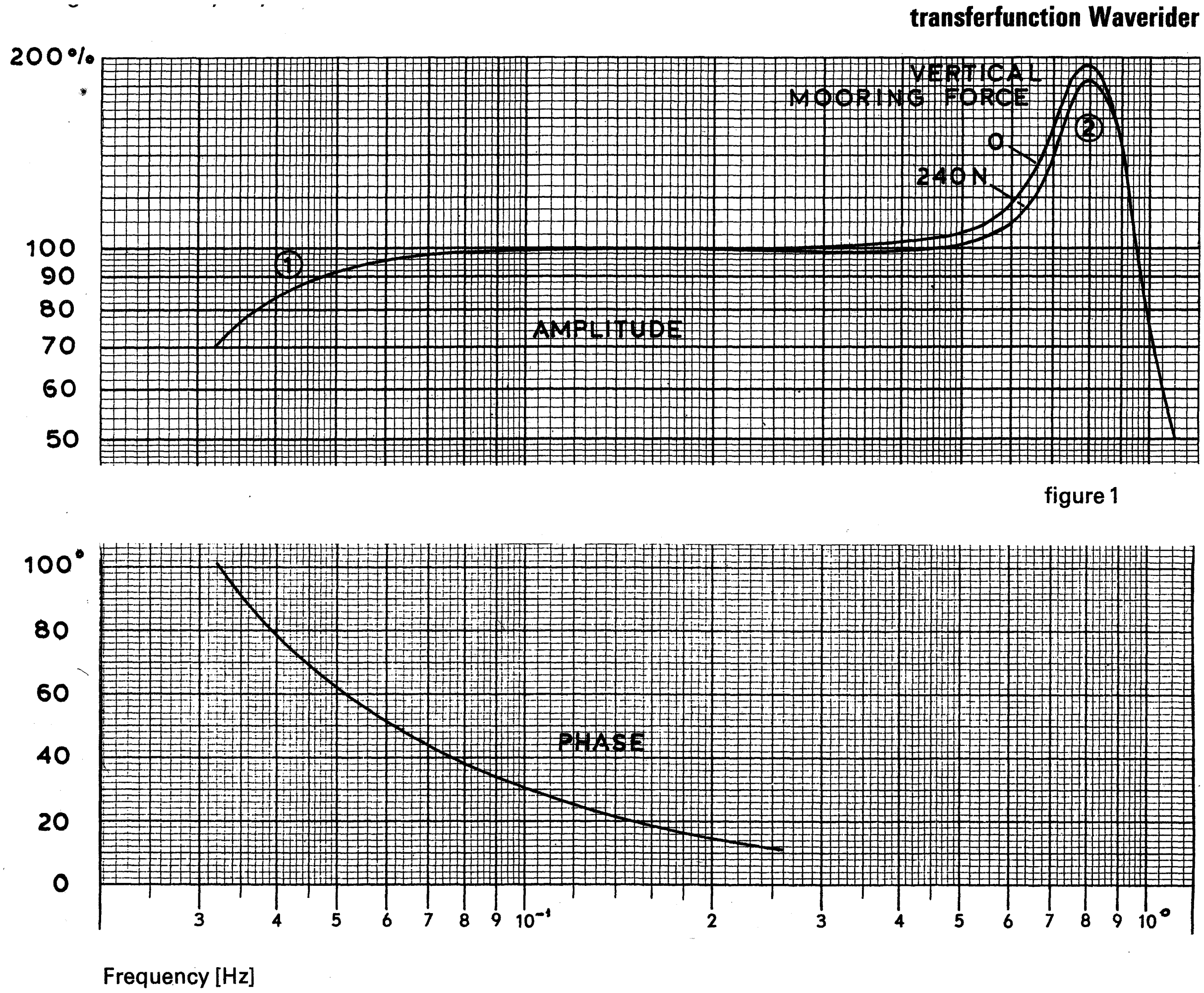
1 Wave Buoy Measurement

Waverider buoys contain an accelerometer to measure the vertical acceleration as the buoy moves up and down with the water surface. By integrating this acceleration with time received from an internal clock, the Waverider buoy provides an instantaneous reading of relative water level around a 2000cm mean. Similarly, in a Directional Waverider buoy, separate accelerometers are used to measure the horizontal accelerations as the buoy moves sideways with the waves.

As wave periods increase, the acceleration caused by a given wave height becomes lower. This decreased acceleration makes it more difficult for the accelerometer to accurately measure the acceleration, and therefore the instantaneous water level change caused by longer period waves. Due to this, there is a natural drop off in the response (accuracy) of a Waverider buoy as wave periods increase, particularly noticeable with periods greater than 20 seconds.

Conversely, the Waverider buoy in water has a natural frequency around 1 second, causing the buoy to overestimate the instantaneous wave caused accelerations around this period, and therefore the associated instantaneous water level changes. This is generally not a major problem as waves in coastal and estuarine areas usually quickly develop a period of at least 2 seconds.

These two effects can be seen in the transfer function figure provided by Datawell, shown below (Waverider f1 Information Sheet, Datawell, 1979).



Further details on the mechanical and electrical operation of Waverider buoys may be found in the Waverider buoy manual.

Waverider Buoy Performance Degradation

The Waverider buoy vertical accelerometer is mounted on a disk sitting in a high viscosity liquid. Readings from the accelerometer are transferred to the buoy electronics for conversion to a water level via three thin wires. These three wires also act as a suspension system for the disk, allowing it to move in the liquid relative to the container holding the liquid, while the liquid and disk damp the movement of the accelerometer so that it does not continue to move after the wave caused acceleration has changed (similar to shock absorbers in a car suspension system).

Over deployed time, the viscosity of the liquid starts to break down, causing the buoy's response to deteriorate as the damping decreases and the accelerometer continues to react to past wave accelerations. This generally manifests as the buoy reporting proportionally large amounts of low frequency wave energy (<0.05Hz) during times of low wave energy. At this stage, the buoys can still be used to provide accurate wave data in high energy conditions (eg offshore locations), however they cannot be used in low locations where low energy conditions are expected.

As degradation continued, the accelerometer eventually completely fails. The accelerometer cannot be repaired and the cost cutting up the buoy, removing the accelerometer and then installing a new sensor is usually close to or more than the price of a new buoy.

An alternative issue which can occur is that the buoy is spun too quickly so that the three thin suspension wires become entangled, introducing oscillations into the suspended platform. This occurs because the damping of the liquid does not allow the disk to rotate as fast as the buoy if the buoy is spun too quickly. This manifests in a similar way to degraded suspension liquid, with proportionally large amounts of low frequency wave energy at around 40 seconds.

It should be noted that the latest Waverider buoys have a new suspension which by its design has introduced a small amount of low frequency energy. As these buoys have not been deployed for an extended period, it is possible that evidence of performance degradation in these buoys will be different.

Acceptable Values for Waverider Performance

As can be seen from the figure above, it can be acceptable for a buoy to under report wave height by 30%, or over report wave height by 200%, depending on wave frequency. Due to this, a specific fixed accuracy value (eg 5% of actual wave height) cannot be set as the allowable limit before a buoy is determined to be "out of calibration".

Datawell claim that once wave heights have been corrected using the transfer function in the figure above, Waverider buoys have an accuracy of 3%. This may be used as the basis for deciding whether a Waverider buoy is within acceptable limits, however an additional allowance for the long term degradation of the buoy components, say 2%, should be included.

It is also important to note that while an older buoy may start to report incorrect long period wave energy during low energy wave conditions, this buoy will still provide accurate data in high energy wave conditions. Due to this, the particular nature of a any issues detected during a calibration should be considered when deciding on what should happen with a particular buoy.

In practice, while the response of a Waverider buoy does degrade over time, this is generally due to breaking down of the viscous fluid inside the accelerometer. The buoy usually maintains an acceptable response up until the accelerometer fails suddenly and completely. While the degradation of performance may be seen over time by comparing successive calibrations of a particular buoy, it is difficult to predict failure.

Wave Analysis

As ocean waves are comprised of a series of waves with slightly different periods and heights, rather than a set of uniform sinusoidal waves, no single value accurately describes the instantaneous wave height and period at a set location. Due to this, a number of different output parameters are generally calculated using some form of statistical analysis. A limitation of any statistical analysis is that confidence in the accuracy of the calculated parameters increases with the amount of collected data. Analysis of ocean waves is complicated by the fact that they can change relatively quickly depending on the local conditions, such as wind. This provides an upper limit on the length of time data is collected for to ensure that the waves within the data set are not changing. In addition, operations personnel usually prefer data being updated relatively frequently so they are sure they are seeing the “real time” data.

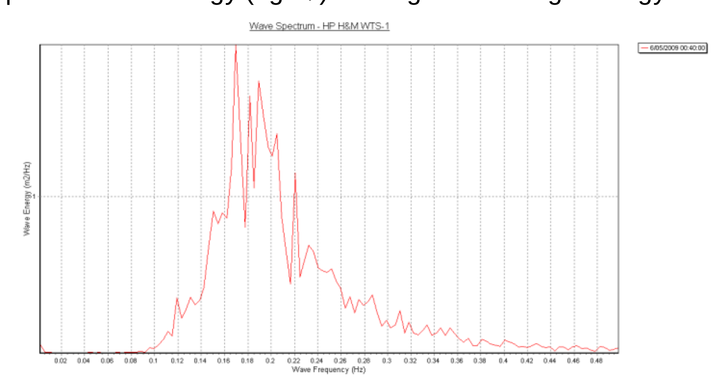
To address these competing issues, Cardno’s software conducts an “overlap” analysis. This process is most easily understood through an example.

- For the Bureau of Meteorology real time wave data, 4096 individual data points are collected at 1/2.56Hz (just over 26 minutes of data) before an analysis is conducted. This provides a large enough data sample to be confident in the results, while being short enough that the wave conditions being measured will generally not have changed an appreciable amount. In line with World Meteorological Organisation standards for most other parameters, the results of the analysis are reported at the next 10 minute time interval. This means that one data collection and analysis cycle, which starts at one 10 minute time interval, takes 30 minutes.
- Rather than waiting for one analysis to be completed before starting to collect data for the next analysis, (and therefore providing an updated analysis every 30 minutes), the last 7 minutes of data from the previous analysis is included in the next analysis. This means that only an additional 10 minutes of data needs to be collected before the next analysis can be conducted.

This overlap data collection scheme allows a larger amount of data to be collected, while maintaining the update frequency expected by the operators.

Statistical analysis techniques for ocean waves have been developed over many years for different purposes, to the point where there are now many different parameters to describe both wave height and period. For non-directional waves, Cardno’s wave analysis conducts two separate analyses and reports 164 different wave parameters, including 7 different periods and 6 different wave heights. The two analyses are:

- Time Domain analysis. A mean water level is calculated from all of the data, which is then removed from the data. Starting from the beginning of the record, an algorithm steps through the modified data to find when values change from negative to positive (zero crossing), as well as the lowest (trough) and highest (crest) levels between zero crossings. The troughs and crests are used to calculate wave heights, while the time between zero crossings is used to calculate periods.
- Frequency Domain or Spectral Analysis. This is done using a fast fourier transform technique, essentially attempting to match a series of sine waves with different periods, to the recorded data. Sine waves that match the data well report a larger amplitude while those that don’t match the data report lower amplitude. Data from a frequency domain analysis is usually plotted as Energy vs Frequency (see below), with wave heights usually calculated based on the area under the line, and periods based on peaks in the energy (eg T_P) or weighted average energy.



As different parameters are used for different purposes, there is no single wave height or wave period parameter that is correct and covers all situations. Following are three examples of the use of different wave parameters:

A coastal engineer designing a breakwater is interested in a number of different wave height parameters including:

- To size armour, they may required the overall energy contained in the waves, best described by a parameter called HM0, the total area under the Energy vs Frequency curve from a frequency domain analysis,
- To determine if the breakwater will be overtopped, the maximum wave height, H_{Max}, calculated from a time domain analysis.

A naval architect reviewing underkeel clearance for a large vessel is interested in wave parameters split into specific wave period bands and calculated from a frequency domain analysis:

- <5-7 seconds – generally too small to affect a large vessel,
- 7-100 seconds – will cause a large ship to heave, pitch and roll,
- >100 seconds – too long to cause pitch and roll, but a large ship will heave.

A ship, platform or shore observer who has been asked to provide an estimate of wave height will be observing waves in the time domain:

- A human observer will generally overestimate the "average" wave height as they tend to ignore the smaller waves. Due to this, human observers generally report significant wave height (H_S). In a computer based analysis, this is calculated as being the average height of the highest 1/3 of all measured waves.
- While ignoring smaller waves for estimating wave height, a human observer will generally include all waves when estimating wave period. Due to this, a human observer tends to report the average period of all the waves that occur, referred to as the zero crossing period (T_Z).

2 Wave Buoy Calibration Software

2.1 Calibration Software Implementation

Due to the wide variety of different wave parameters and the fact that some inherently only reflect larger waves (eg H_S) and longer periods (eg T_P – period with peak energy), it is important to choose the correct wave parameters when conducting a Waverider buoy calibration. With most wave shaped measurements (eg AC electricity, sound waves), the Root Mean Square wave amplitude (H_{RMS}) over a series of waves is used as a measure of the average wave height and performance of wave generating capacity (eg power supplies). For Waverider calibrations, this is the measured value used as the basis of performance. Similarly, the average zero crossing period (T_Z) is used as the basis of the wave period.

Cardno have developed two programs to undertake a Waverider buoy calibration. The first is a tailored version of Cardno's real time data acquisition and analysis program, OceanSense, and the second is a program specific for WRB calibration, LTWaveCal.

For calibrations, a special version of OceanSense has been tailored to read data from a DIWAR receiver, DIWAR, or a WAREC, as well as providing wave data analyses at 1 minute intervals rather than the standard 10 minute interval implemented in the BoM system. The data intervals have been reduced to allow analysis of 256 data points (the Burst Length) in order to speed up the calibration procedure. Whilst the software is setup to analyse 256 points by default, the user may select up to 4096 points. Both raw and 1 minute analysed data is saved to hard disk in a binary format.

LTWaveCal has been written to specifically read data from this version of OceanSense. LTWaveCal allows the user to load data, plot one or many spectra (a spectrum shows the frequency spread of wave energy measured by a buoy), and plot a calibration graph. Once graphs are created, they may be printed or copied to the Windows Clipboard for pasting into applications such as Microsoft Word.

2.2 Software Installation

The calibration software installation package should be run, all required files will be extracted and installed.

2.3 Collecting Calibration Data

1) Start OceanSense. The program will save analyzed wave data to the min1 subdirectory.

2) Connect the RS232 DB9 cable from the DIWAR into comm1 of the computer. OceanSense should start reading the raw data (it should already be setup to read DIWAR data from **COM1** at **2400, none, 8, 1**.)

   - To change comm settings for the DIWAR or WAREC, select File->Logon from the main menu, input the password ("lt??99") in lower case and press enter.
   - From the main menu, choose Configure->Sensors. Double click on the sensor you are interested in and the sensor configuration form will be displayed.

   Ensure the non directional buoy being calibrated is Channel 1 (or A) on the DIWAR receiver.

   For more information on running OceanSense, see the Technical manual.

3) Run the waverider calibrator at each required frequency for at least 7 minutes. This will allow the calibrator to settle on the correct frequency and OceanSense to analyse a number of wave records at a steady frequency.

   Using a stopwatch, the actual rotational frequency for each setting should be recorded separately. If the actual rotational frequency is significantly different to the setting on the calibrator, the setting should be modified to produce a frequency close to those required.

   For compatibility with previous calibrations conducted by BoM, the frequencies to test should be in line with those previously used, however if possible it should include those frequencies listed below.

Frequency (rpm)	**Frequency (Hz / rps)**	**Period (sec)**
2	0.03333	30
2.5	0.04167	24
3	0.05	20
4	0.06667	15
5	0.08333	12
6	0.1	10
8	0.13333	7.5
10	0.16667	6
12	0.2	5
14	0.23333	4.3
16	0.26667	3.75

   If the waverider buoy is being used to measure waves of a particular period, it may be necessary to conduct additional tests at frequencies closer to this period.

4) Once all required frequencies have been tested, close OceanSense.

5) Before removing the buoy from the calibrator, run LTWaveCal to check data has been collected and the calibration curve appears correct with no abnormalities.

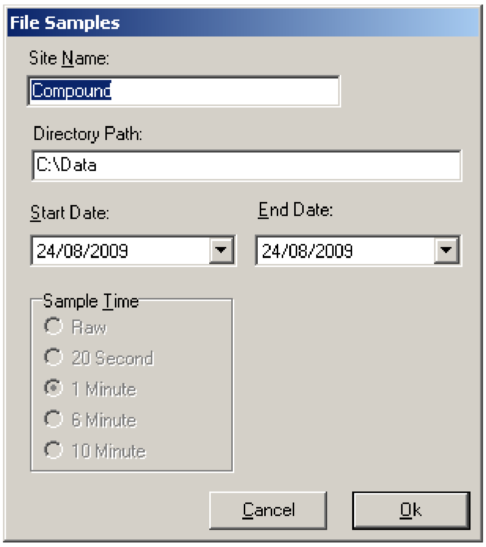
2.4 LTWAVECAL – Calibration Plotting

LTWaveCal allows the plotting and review of analysed data collected from a waverider buoy mounted in a waverider buoy calibrator.

1) Start LTWaveCal.

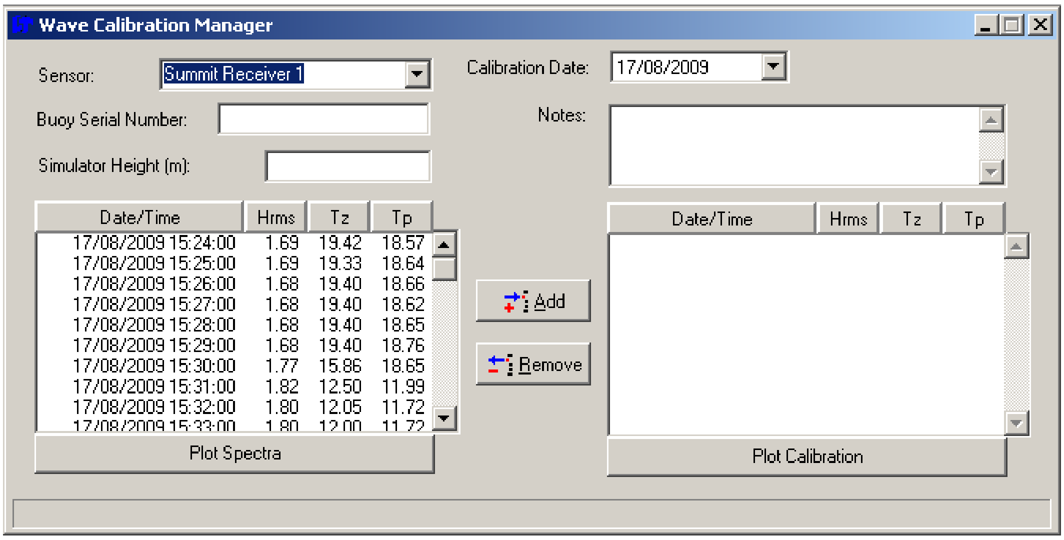
2) Select File->Open from the main menu. The “File Samples” form (see below) will appear. By default it is setup to read data files from C:\Data\Compound and both start and end dates will default to the current day.

   Select specific start and end dates as required and click OK.



3) Assuming data files exist for the date(s) selected, the “Wave Calibration Manager” form will appear. It will automatically read through the min1 data file(s) searching for valid DIWAR (channel 1) data. The valid values will appear in the left hand side ‘Spectrum‘ list box.

   If you are calibrating a directional waverider buoy, you should select “Datawell WAREC” from the ‘Sensor’ list on the top left hand side of the form.

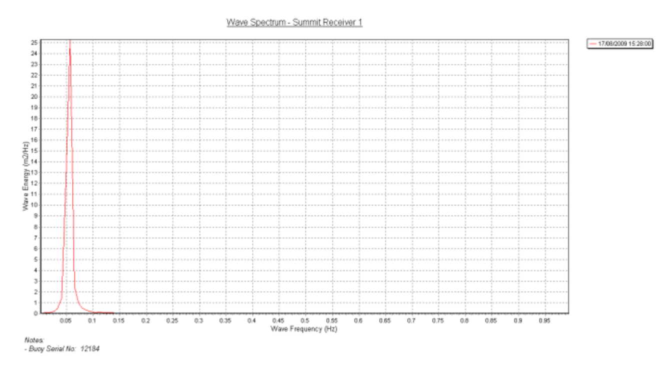


4) Set the Simulator Height

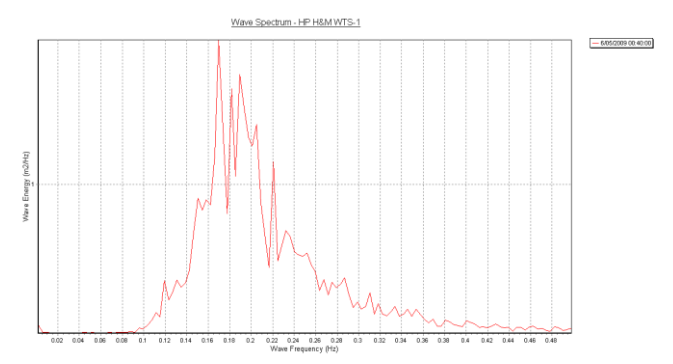
5) Set the buoy serial number and add any additional notes that may be required.

Note - Purpose of Spectra Plots

As part of the Wave Calibration process, it is possible to plot the full wave energy spectra from each set of analysed data. The wave spectra plot shows the amount of energy that occurred at each frequency during the analysis period. For a Waverider being calibrated, this plot should usually show a single narrow, well defined peak at the frequency of revolution (see plot below).

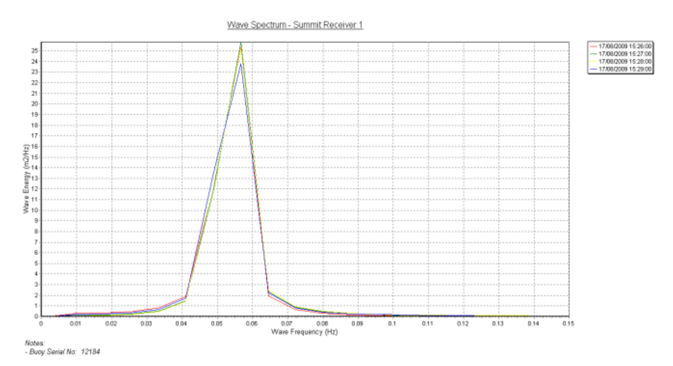


For a Waverider measuring real data, there may be multiple peaks and energy is likely to be spread out over a range of frequencies (see plot below).



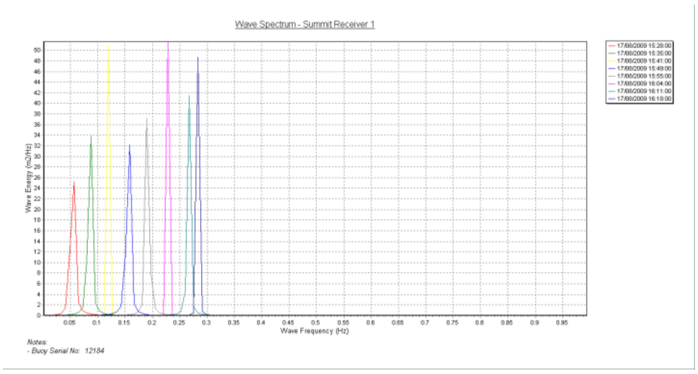
The frequency of revolution of the original BoM calibrator tended to drift during a single calibration, with frequency stabilizing for short periods of time before drifting either higher or lower. For this reason, the ability to plot the spectra was required to allow the user to inspect the spectra from one “frequency setting”, and choose the “best defined” spectra.

An inspection of data collected by the calibrator showed that the calibrator stabilized quickly, and at a constant frequency, with very little or no drift in frequency (see plot below). Due to this for data collected using the new calibrator it may not be necessary to plot multiple spectra from within one “frequency setting” to determine the optimum spectra to use as part of the calibration.

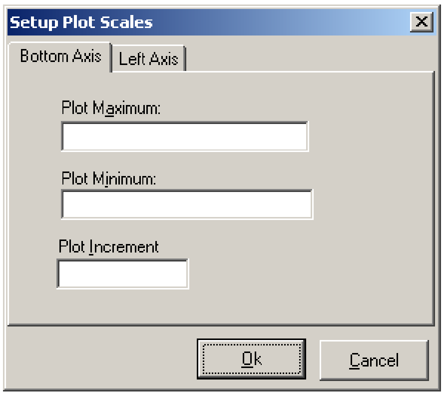


6) If spectra plotting is required, select one or many wave analysis records (to select many, hold down the Ctrl key and click on the records), then press the “Plot Spectra” button below the complete analysis list to

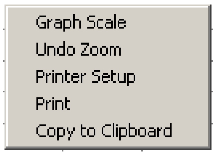
display the spectral graph window (see example plot below). Any number of Spectral plots can be plotted, with any number of spectra in each plot.



7) By default, the plot scales are set to the minimum and maximum of the data range. To set the scales to user values, either
   - From the main menu select “Options->Spectra Plot”. This will change the default settings for the present and all future plots,
   - Right click on the graph window to bring up a popup menu and choose “Graph Scale”. This will change the scale settings for that window ONLY.



8) If plotting or saving of the spectra is required,
   - Maximize the spectra plot window
   - Right click to display the popup menu (see below).
   - This menu has options to setup the printer (“Printer Setup”), print (“Print”) or copy the plot to the Windows clipboard (“Copy to Clipboard”). Once the plot is copied to the clipboard, it can be pasted into other programs such as Microsoft Word.



9) If required, you may zoom-in to an area of interest by left mouse clicking (and holding) at the top/left most point of the area of interest and dragging to the bottom/right point of the area, then releasing the left mouse button.

   To return to full scale,
   - Drag with the left mouse button (same as before) from the bottom/right corner to the top/left and release the mouse button, or
   - Right click to display the popup menu (see above) and select “Undo Zoom”.

10) Choose appropriate wave records for calibration. During the collection of data for calibration, the first two or three analyses after a rotation frequency change will contain data from the previous frequency,

the changing frequency as the calibrator adjusts, and then the new frequency. These will be seen by the Tz value gradually decreasing (or increasing depending on frequency order) until a similar value is reached for a number of analyses timesteps. Similarly, the wave height may vary before becoming steady due to the buoys naturally changing frequency response. These effects will be seen by "smearing" or a double peak in the spectra plot.

A good initial starting point to deciding which analyses are best to use, is to inspect the listing of Tz and Hrms, and select analyses where Tz and Hrms have similar values to those of the analyses above them. This will be a good indication that the calibrator has stabilized at the correct frequency, and that the analysis only contains data from a single frequency.

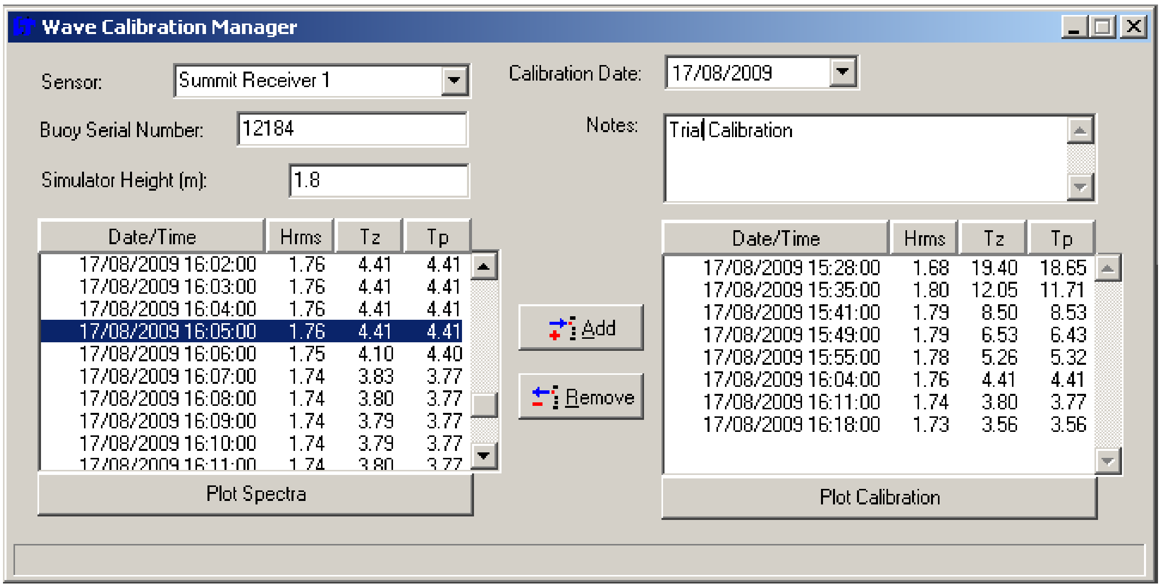
11) Once appropriate wave records have been chosen, they need to be transferred to the calibration list:

- Highlight the required wave analyses in the full list of analyses (either one at a time or in a group by holding the Ctrl key while selecting) in the left hand list box.
- Click on the "Add" button (between the list boxes) to copy them across to the right 'calibration' list, used to store the spectral records to be used in the calibration plot.

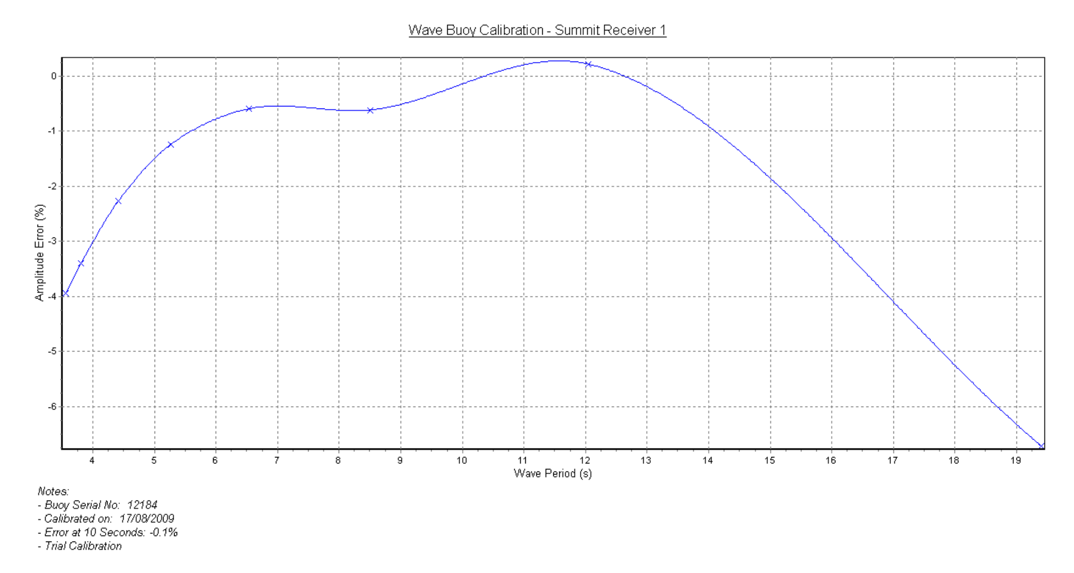
Repeat this step to add all of the records of interest to the calibration list. The program will give a warning message if an attempt is made to add the following records:
- the same record as already appears in the calibration list,
- a record with the same Tz value as a record already in the calibration list.

To remove a record from the calibration list, select the record(s) and click on the Remove button.

12) The figure below shows an example of the "Wave Calibration Manager" once appropriate wave analyses have been added.



13) Once appropriate wave analyses have been added to the calibration list, click on the "Plot Calibration" button to display the calibration curve (see below).



14) As with Spectral plots, Calibration plot scales may be changed from the main menu (Options-> Calibration Plot) or by right clicking on the plot window and selecting "Graph Scale" from the popup menu.

15) As with Spectral plots, a popup menu allows printer setup, printing and copying of the plot to the Windows clipboard. It is recommended that a copy of the plot at a standard scale is saved for all calibrations. This will allow easy comparisons of buoy performance over successive calibrations during a buoy's lifetime.

16) As with Spectral plots, it is possible to zoom into an area of interest (see step 9).

17) The Calibration plot has the additional feature of displaying the error % value at 10 seconds when the 10 second point lies within the calibration curve range.

18) To select new dates for calibration:
- close the Wave Calibration Manager Form (either from File-> Close or by clicking on the form close button [x]),
- Return to step 2.

3 Definition of Wave Parameters

This section describes the parameters that may be found for each wave buoy in a data log file. The files that each parameter may be found in is listed with the parameter. Each parameter may be found in the 10 minute data log.

3.1 Non-directional Datawell wave buoy

Water level data is saved every 6 minutes, while all other data is saved every 10 minutes.

PARAMETER	DESCRIPTION	FILES
Tide Water Level	Average water level measured over the period of the file. (Usually at the bottom of the list.)	Min6 / Min10 / Raw
Wave Analysis Data		
Burst Length	Number of data points used in analysis	Min10
Digitising Interval	Time interval between data points used in analysis	Min10
H_s	Significant wave height measured from the time domain - average of highest 1/3rd of all waves in record.	Min10
H_{rms} td	Root mean square wave height from the time domain.	Min10
H_{Max} td	Maximum wave in a record (zero upcrossing analysis).	Min10
T_Z	Zero crossing period from the time domain.	Min10
T_S	Period of the significant waves.	Min10
T_C	Crest period.	Min10
THMax	Period of the maximum wave.	Min10
EPS td	Spectral width from the time domain.	Min10
T_{02}	The period from spectral moments 0 and 2 (=sqrt(m0/m2).	Min10
T_p	The period at the peak spectral energy.	Min10
H_{rms} fd	Root mean square wave height calculated from the spectra (=sqrt(8*m0)).	Min10
EPS fd	Spectral width calculated from the spectral moment (=sqrt(m0*m4-m2*m2)/(m0*m4)).	Min10
H10	Average of the highest 10% of waves.	Min10
T10	Period of the H10 waves.	Min10
Noise	Number of noise errors in the record.	Min10
Nspike	Number of spike errors in the record.	Min10
NROC	Number of rate of change errors in the record.	Min10
Percent Errors	Total percentage of errors.	Min10
SpikeMax	Largest deviation from the mean water line, crest or trough.	Min10
ROCMax	Largest rate of change between adjacent data points.	Min10
Samax	Longest sequence of data points the same.	Min10
Sigma	Standard deviation calculated for error checking.	Min10
Nwaves	Number of waves (zero upcrossing) in the record.	Min10
$T_Z$max	Maximum zero crossing in the record.	Min10
E60	Energy above 0.60Hz (%)	Min10
E04	Energy below 0.04Hz (%)	Min10
Ierr	Error Flag: = 0 all OK = 1 max allowable adjacent data pts failed = 2 max allowable interpolation distance failed = 3 error count > allowable = 4 minimum number of waves test failed = 5 zero crossing period test failed = 6 energy > 0.60Hz test failed	Min10

	= 7 energy < 0.04Hz test failed	
M0	Spectral moment 0.	Min10
M1	Spectral moment 1.	Min10
M2	Spectral moment 2.	Min10
M4	Spectral moment 4.	Min10
NORDS	Number of banded ordinates	Min10
Banded Ordinate n (n=0-127)	128 banded spectral ordinates. The significant wave height from the spectra is: 4 x sqrt(sum of all energy ordinates x spectral estimate spacing) Note that there will always be 128 spectral estimates irrespective of burst length. The program will use the appropriate banding to provide 128 spectral estimates of the frequency range from 0 to the Nyquist frequency. If a 4096 data point burst length is selected with 1/256 Hz digitising interval then: The Nyquist frequency will be 1.28 Hz There will be 8 spectral estimates in each banded estimate. The first spectral frequency will be 0.004844Hz (approx) The spectral spacing will be 0.01Hz (approx)	Min10

3.2 Directional Datawell Wave Buoy

Water level data is saved every 6 minutes, while all other data is saved every 10 minutes.

PARAMETER	DESCRIPTION	FILES
Tide Water Level	Average water level measured over the period of the file. (Usually at the bottom of the list.)	Min6 / Min10 / Raw
Wave Analysis Data – OceanSense Calculated		
Burst Length	Number of data points used in analysis	Min10
Digitising Interval	Time interval between data points used in analysis	Min10
H_s	Significant wave height measured from the time domain - average of highest 1/3rd of all waves in record.	Min10
H_{rms} td	Root mean square wave height from the time domain.	Min10
H_{Max} td	Maximum wave in a record (zero upcrossing analysis).	Min10
T_Z	Zero crossing period from the time domain.	Min10
T_S	Period of the significant waves.	Min10
T_C	Crest period.	Min10
THMax	Period of the maximum wave.	Min10
EPS td	Spectral width from the time domain.	Min10
T_{02}	The period from spectral moments 0 and 2 (=sqrt(m0/m2).	Min10
T_p	The period at the peak spectral energy.	Min10
H_{rms} fd	Root mean square wave height calculated from the spectra (=sqrt(8*m0)).	Min10
EPS fd	Spectral width calculated from the spectral moment (=sqrt(m0*m4-m2*m2)/(m0*m4)).	Min10
H10	Average of the highest 10% of waves.	Min10
T10	Period of the H10 waves.	Min10
Noise	Number of noise errors in the record.	Min10
Nspike	Number of spike errors in the record.	Min10
NROC	Number of rate of change errors in the record.	Min10
Percent Errors	Total percentage of errors.	Min10

SpikeMax	Largest deviation from the mean water line, crest or trough.	Min10
ROCMax	Largest rate of change between adjacent data points.	Min10
Samax	Longest sequence of data points the same.	Min10
Sigma	Standard deviation calculated for error checking.	Min10
Nwaves	Number of waves (zero upcrossing) in the record.	Min10
$T_Z$max	Maximum zero crossing in the record.	Min10
E60	Energy above 0.60Hz (%)	Min10
E04	Energy below 0.04Hz (%)	Min10
Ierr	Error Flag: = 0 all OK = 1 max allowable adjacent data pts failed = 2 max allowable interpolation distance failed = 3 error count > allowable = 4 minimum number of waves test failed = 5 zero crossing period test failed = 6 energy > 0.60Hz test failed = 7 energy < 0.04Hz test failed	Min10
M0	Spectral moment 0.	Min10
M1	Spectral moment 1.	Min10
M2	Spectral moment 2.	Min10
M4	Spectral moment 4.	Min10
NORDS	Number of banded ordinates	Min10
Banded Ordinate n (n=0-127)	128 banded spectral ordinates. The significant wave height from the spectra is: 4 x sqrt(sum of all energy ordinates x spectral estimate spacing) Note that there will always be 128 spectral estimates irrespective of burst length. The program will use the appropriate banding to provide 128 spectral estimates of the frequency range from 0 to the Nyquist frequency. If 2048 data point burst length is selected with 2/2.56 Hz digitising interval then: The Nyquist frequency will be 1.5625Hz. There will be 8 spectral estimates in each banded estimate. The first spectral frequency will be 0.002344Hz (approx) The spectral spacing will be 0.005Hz (approx)	Min10
Wave Analysis Data – Buoy Calculated		
Elapse	Spectral age – time since last DWRB spectra	Min10
Hmo	Significant wave height measured from the time domain - average of highest 1/3rd of all waves in record.	Min10
Tz	Zero crossing period from the time domain.	Min10
PkTp	The period at the peak spectral energy.	Min10
AveDir	Weighted average wave direction	Min10
Pdens	Power density at peak	Min10
Jdirn	Spectra of 64 wave directions	Min10
Jrpower	Spectra of 64 relative power ordinates	Min10
Jspread	Spectra of 64 directional spreads	Min10
Wtemp	Water temperature	Min10
Rtemp	Reference temperature	Min10
Status	Status bit	Min10
Vacc	Vertical acceleration offset	Min10
Xacc	X acceleration offset	Min10
Yacc	Y acceleration offset	Min10

Orient	Orientation angle	Min10
Inclin	Inclination	Min10
Voltage	Battery status	Min10

4 OceanSense Automatic QAQC Configuration

Using the water level data from the wave buoy transmission, the OceanSense software carries out two forms of wave analysis, Frequency domain and Time domain analysis. The parameters used to carry out the wave analysis are defined in the “Sampling”, “Raw Data”, “Frequency Domain” and “Time Domain” tabs.

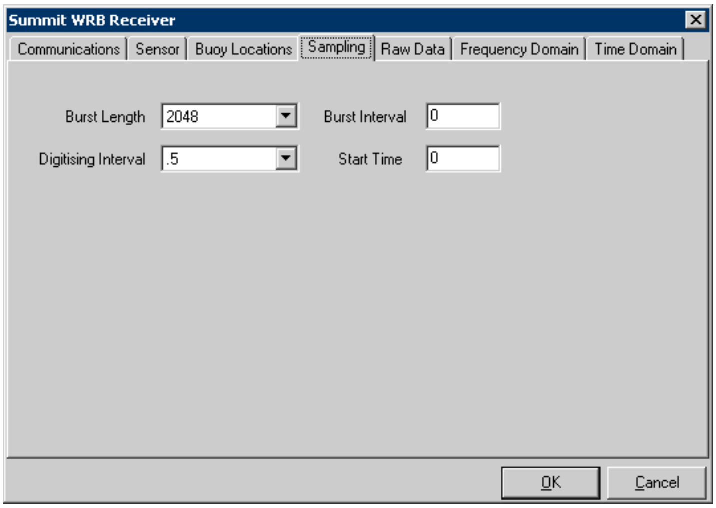


Figure 4.1 DIWAR Receiver – Sampling Tab

4.1 Sampling

These parameters are used by the software to carry out a wave analysis based on the water level data collected by the DIWAR Receiver. To carry out a wave analysis, a number of parameters related to the amount and frequency of data to be used is required. The user can also select the time at which sampling starts and the frequency of wave analysis.

ITEM	COMMENTS
Burst Length	Burst length defines the number of points used to carry out a wave analysis. Any power of 2 data points between 256 and 4096 inclusive can be chosen. The smaller burst lengths have been enabled for quick testing only. For DIWAR Receiver, “4096”.
Digitising Interval	The digitising interval is the frequency at which data is received from the WRB. For DIWAR Receiver, “0.39”.

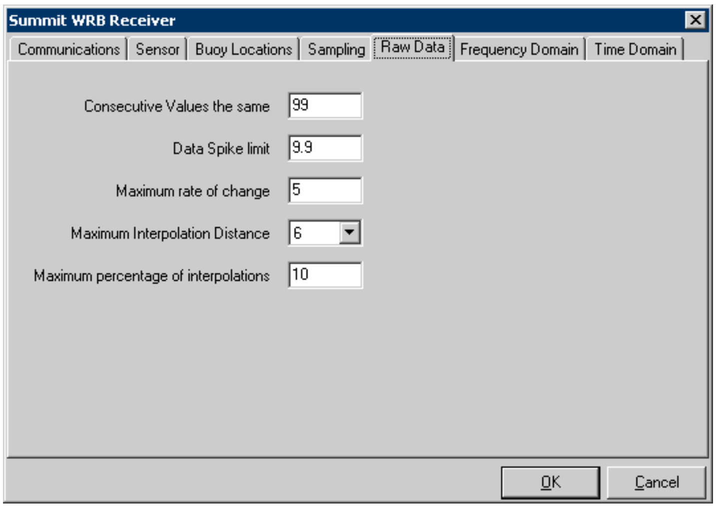


Figure 4.2 DIWAR Receiver – Raw Data Tab

4.2 Raw Data

Once the “Burst Length” number of data points have been collected, the data is checked for errors before an analysis is carried out.

ITEM	COMMENTS
Consecutive Values the same	Defines the number of consecutive data points of the same value which will be allowed. For DIWAR Receiver, “11”.
Data Spike limit	The system will initially fit a mean water to the data and calculate a standard deviation. Respond with the number of standard deviations from the mean water line considered acceptable as valid data. ie how high can a crest be, and how low can a trough be relative to the standard deviation of the record. Note that if the data record is very 'spiky' then this check will become corrupted because the spikes will influence the standard deviation. If a data spike is found the data point is marked for later interpolation. For DIWAR Receiver, “6”.
Maximum rate of change	Using the same standard deviation calculated above enter the number of standard deviations which define the maximum allowable displacement between any two adjacent data points. Again if the burst is 'spiky' the check will not work well. If a data spike is found the data point is marked for later interpolation For DIWAR Receiver, “5”.
Maximum Interpolation Distance	The maximum number of adjacent data points distance which can be corrected by interpolation. Allowable responses are 0 to 6. Linear interpolation is used for single point interpolations. Parabolic curve fitting is used for 6 point interpolations. In parabolic interpolations the average of two estimates is calculated using the two points to the left of the gap and the one point to the right and then vice versa. For DIWAR Receiver, “6”.

Maximum percentage of interpolations	The record must have less than the indicated percentage of data errors. For DIWAR Receiver, “10”.

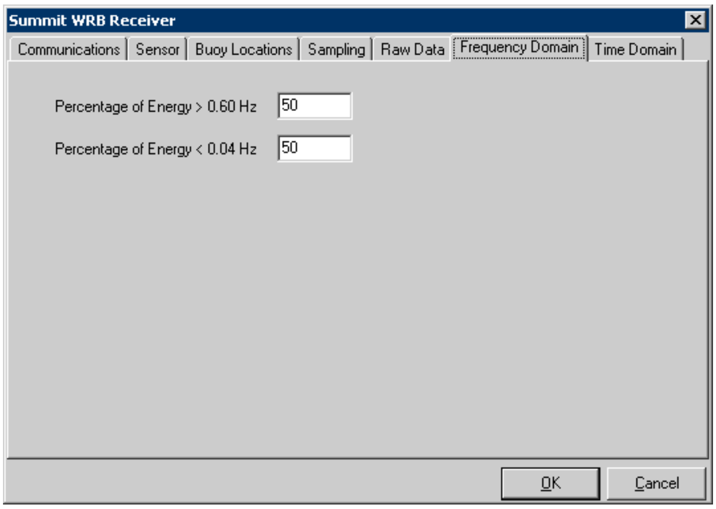


Figure 4.3 - DIWAR Receiver – Frequency Domain Tab

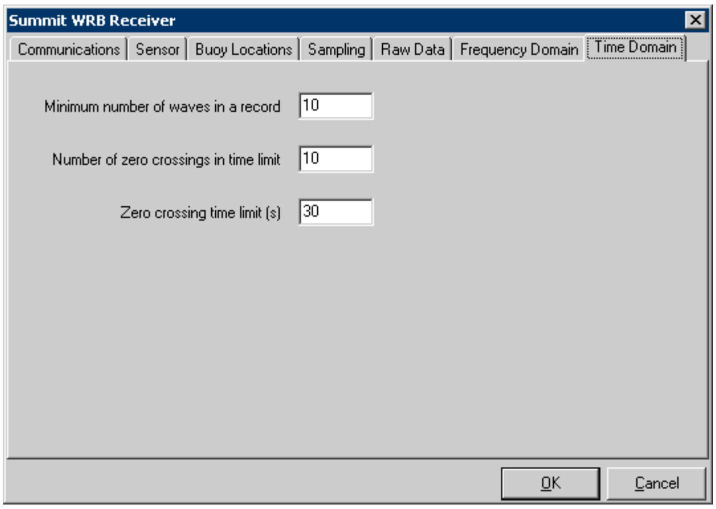


Figure 4.4 - DIWAR Receiver – Time Domain Tab

4.3 Frequency Domain

After the data has passed through the raw data checking, analysis of the data is carried out. Further error checking of the frequency domain analysis is carried out after this step.

ITEM	COMMENTS
Percentage of Energy > 0.60 Hz	The spectra must not contain greater than the indicated percentage of energy above 0.60 Hz. For DIWAR Receiver, “25”.
Percentage of Energy < 0.04 Hz	The spectra must not contain greater than the indicated percentage of energy below 0.04 Hz. For DIWAR Receiver, “25”.

4.4 Time Domain

After the data has passed through the raw data checking, analysis of the data is carried out. Further error checking of the time domain analysis is carried out after this step.

ITEM	COMMENTS
Minimum number of waves in a record	If there is less than the indicated number of waves in a burst then the burst will be rejected. NOTE: The maximum number of waves allowed is 900. If there are greater than 900 waves then the time domain analysis will process the first 900 waves only. The frequency analysis (Fast Fourier Transform) will still process the full record. For DIWAR Receiver, "10".
Number of zero crossings in time limit	If there is more than this number of zero crossings with a period longer than the "Zero crossing time limit (s)" period, then the burst will be rejected. For DIWAR Receiver, "5".
Zero crossing time limit (s)	If there is more than the "Number of zero crossings in time limit" value with a period longer than the this period, then the burst will be rejected. For DIWAR Receiver, "30".

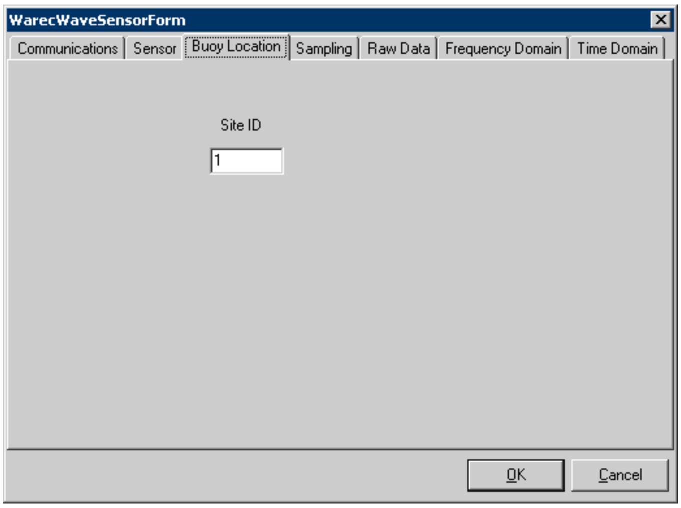


Figure 4.5 – Datawell WAREC – Buoy Location Tab

5 Technical support

All technical support inquiries can be forwarded to the following email:

Metocean.support@cardno.com.au

Alternatively technical support question can be directed to the following phone number:

(02) 9024 7024