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THE HEBRIDES WAVERIDER INSTALLATIONS

BY

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## THE HEBRIDES WAVERIDER INSTALLATIONS

A diary of the main events affecting site instrumentation, 1975-1981

### INTRODUCTION

This document gives details of site instrumentation and attendant problems associated with the Hebrides Waverider installations.

Originally, there was only one Waverider system, the so-called offshore installation. Later, a shallow water site was instrumented (the inshore site) and more recently still, a third site, the deepwater site, was commissioned. All three sites are running concurrently as at August 1981.

A site logbook was maintained from the beginning, which has provided the bulk of information contained herein. Other sources include a Waverider calibration logbook, field reports and cruise reports, and a file of details on every major occurrence affecting each Waverider owned by IOS.

#### A NOTE ON CALIBRATION:

Waverider buoys are calibrated at NMI Hythe by placing them in a rig which rotates them in a 3 m diameter vertical circle. The signals are monitored by a standard Warep receiver, operating on the 5-0-5 m range.

The method of logging the calibration information has changed during the lifetime of the Hebrides installation. Originally, the Warep receiver was used; this contains a chart recorder which was used to record the Waverider signals, giving a sinusoidal trace some 3 cm peak-peak. Departures from the 3 cm nominal (after making allowance for the accelerometer/integrator fall-off in output) were expressed as a percentage above or below the calculated figure for each rotation speed of the rig. An average percentage deviation was then taken over all rig rotation speeds, and this was given as the calibration figure for the buoy.

This buoy calibration method relies on the manufacturer's design specification for the receiver and the precision of the chart recorder being maintained however. The receiver should produce a 1 cm chart deflection (ie a 1 volt analogue output change) for an input signal change of 1.86 Hz, equivalent to a vertical movement of 1 m by the buoy. The mean (steady state) input frequency is 259 Hz, and the smallest measurable chart deflection is about  $\pm 0.2$  mm. Warep chart recorder accuracy is given as 4%, and analogue voltage output as equal to or less than 3.5%, both within a 0°C-40°C temperature range. A wave measurement accuracy of better than 1% is desirable, but was clearly not being achieved by this early method of calibration. However, in order to provide more accurate calibration information, it was first necessary to calibrate the Warep receiver.

In the early years, this was impossible to do accurately: the sensitivity of the Warep was greater than that of the measurement equipment then available. However, improvements in instrumentation have made accurate calibration of Wareps possible. The Warep used

for Waverider buoy calibrations (number 1194) has been calibrated in the laboratory periodically. Known frequencies are fed into it, and the analogue voltage output is measured on a precision chart recorder, which is itself calibrated with a precision DC voltage source. Hence receiver sensitivity in  $\text{Hz V}^{-1}$  can be obtained.

Since August 1977, Warep 1194 has been calibrated eight times. The sensitivity figures obtained were:

Date	Sensitivity, $\text{Hz V}^{-1}$	% deviation from nominal
August 1977	1.87	+ 0.54
12.4.78	1.855	- 0.27
7.6.78	1.858	- 0.11
18.9.78	1.871	+ 0.59
13.2.79	1.858	- 0.11
14.11.79	1.850	+ 0.54
26.9.80	1.852	- 0.43
2.6.81	1.871	+ 0.59

Thus, over four years, the sensitivity of Warep 1194 has varied by less than 0.6%. It would seem reasonable to assume therefore that although no specific calibration information is available for the early years the performance of the Warep has remained with 1% of nominal since purchase, and that this is probably true of all Wareps held by IOS.

Since 28.5.78 the Waverider calibration procedure has been as follows:

The buoy is operated in the NMI rig at a number of rotation speeds, and the Warep analogue output is recorded on the precision chart recorder (a Hewlett Packard HP7132A). The buoy calibration traces are taken and uncorrected values of buoy sensitivity in  $\text{V m}^{-1}$  are obtained. A correction factor appropriate to each period of rotation is applied to these sensitivities, and an average sensitivity value is calculated for rotation periods between 5 and 20 seconds approximately.

(Note: At periods shorter than 5 seconds, mean line variation (due to accelerometer instability) sometimes occurs, and above 20 seconds the sensitivity fall-off is so steep that the corrections are less

reliable. Both factors could cause errors in individual sensitivity figures, hence they are not counted for the overall average sensitivity. However, the traces taken at the extremes of the range are a useful check on buoy performance.) This average buoy sensitivity figure is multiplied by the receiver sensitivity figure (obtained as described above) giving an average value for buoy sensitivity in  $\text{Hz m}^{-1}$ . This calibration method is now employed by NMI.

The receiving and logging system used at the data-gathering site can then be calibrated and a precise overall calibration figure for the installation calculated.

From January 1981, IOS(T) started logging wave information direct from the AF tone outputs in some installations. The Waverider signal (ie 259 Hz mean) is converted to half-second frequency readings according to the formula:-

$$\text{digital count per half-second} = (290 - f) \times 64$$

where  $f$  is the instantaneous frequency output of the Waverider. Hence the conversion from frequency to voltage to digital count is removed. Buoys will be calibrated in this way when software becomes available to analyse the waveforms. Corrections will still have to be made for buoy response fall-off, and it will be necessary to use a frequency logger for buoy calibration.

The range of rig rotation speeds was changed by NMI late in 1975 from 3.5-18 seconds (0.28-0.053 Hz) to 3.5-40 seconds (0.28-0.025 Hz). This gave a better test of the Waverider response curve, which falls off rapidly above a 20 second rotation period.

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11.9.81

THE HEBRIDES WAVERIDER INSTALLATION - A DIARY

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<u>Date</u>	<u>Instrument No</u>	<u>Event</u>
22.4.75	6459	Waverider calibrated at NMI, Hythe. Sensitivity minus 2.2%.
30.1.76	1289	Warep (waverider receiver) and recording system installed at Range Control Building (RCB), RA Range, S Uist. Nominal sensitivity 10-0-10 m.
28.2.76	6459	Waverider laid on in Offshore position at 1015 $\lambda$ on 26.990 MHz in 40 m depth from RRS Challenger. Position 057° 18' 12"N, 007° 38' 18"W. Sub-surface float (SSF) mooring.
5.3.76	401B	Rapco data logger records first data at 1200 $\lambda$ .
13.4.76	6242	Waverider calibrated - sensitivity minus 0.5%. Some mean-line variation apparent between 3-5 sec rotation period.
29.7.76	401B	Rapco data logger removed.
	401A	Rapco data logger installed - nominal sensitivity 10-0-10 m.
	1289	Warep chart record sensitivity changed to 15-0-15 m.
2.8.76	-	Attempted first receiving system calibration. Unsuccessful because input period measurements could not be measured sufficiently accurately.
3.8.76	6459	Waverider removed approx 1200.
	6242	Waverider laid on same mooring at approx 1300 operating on 26.990 MHz from lobster fishing boat 'Bluebell'.
February '77	-	Mean-line variation displayed on records.
31.3.77	1289	Warep/interface output calibration - sensitivity $53.76 \text{ mV Hz}^{-1}$ .
18.4.77	6242	Waverider operating on 26.990 MHz removed - mooring abandoned.
	6850	Waverider operating on 27.065 MHz laid on new sub-surface float mooring from RRS Challenger in 42 m water.

4.8.77	6459	Waverider calibrated - sensitivity minus 4%.
10.8.77	6850	Waverider operating on 27.065 MHz removed at approx 1230, using 'Bluebell'.
	6459	Waverider operating on 27.065 MHz laid on same SSF mooring at approx 1330.
5.1.78	1140	Warep/interface output calibration - sensitivity $53.84 \text{ mV Hz}^{-1}$ .
18.3.78	1289	Simulated sine-wave calibration of Warep, cassette logger and Rapco logger 401A. Static calibration of Warep 1289/interface output - sensitivity 53.32 $\text{mV Hz}^{-1}$ . Static calibration logged on Rapco - close agreement between calibration figures (error less than 1.25%, ie the accuracy of AVO EA113 used to measure interface output voltages).
28.3.78	6459	Waverider adrift - picked up on Vorran Island, S Uist.
25.5.78	67042	Waverider calibrated - sensitivity $1.807 \text{ Hz m}^{-1}$ .
	6851	Waverider calibrated - sensitivity $1.822 \text{ Hz m}^{-1}$ .
25.6.78	67042	Waverider laid on new sub-surface float mooring in offshore position, operating on 27.065 MHz in 47.5 m water, from MT 'Notre Dame'.
	6851	Waverider laid on buoyant chain mooring in inshore I position, operating on 26.990 MHz, in 14.6 m water, from MT 'Notre Dame'.
26.6.78	1140	Warep commissioned as inshore receiver operating on charts only. Sensitivity $\pm 5 \text{ m}$ .
23.7.78	454A	3-channel Rapco logger commissioned to record from offshore Warep 1289 (channels 2, 3) and from inshore Warep 1140 (channel 1). Single-channel Rapco logger 401A retained, recording in parallel from offshore Warep 1289. Calibration of receiving/recording systems. Offshore receiver sensitivity $53.54 \text{ mV Hz}^{-1}$ , taken from Rapco record. No record taken of inshore receiving sensitivity.
24.10.78	6459	Waverider calibrated - sensitivity $1.815 \text{ Hz m}^{-1}$ .
	67151	Waverider calibrated - sensitivity $1.899 \text{ Hz m}^{-1}$ .

27.10.78	67042	Offshore Waverider washed up near Grenitote, N Uist.
29.11.78		Removed following receiving/recording equipment:
	1140	Inshore Warep
	1289	Offshore Warep
	401A	Single channel Rapco logger (offshore)
	454A	Three channel Rapco logger (offshore and inshore) Also interfaces, offshore cassette recorder and electric clock (synchronising offshore/inshore chart recordings).
30.11.78	454C	Two channel Rapco logger installed - Channel 1 recording from offshore receiver, Channel 2 recording from inshore receiver. Eddystone receiver 964/7c/448 installed as offshore receiver; Eddystone receiver 964/7c/409 installed as inshore receiver. Both receivers incorporate logger interfaces, cassette recorders, Chessel chart recorders. Check calibrations of both receiving systems performed, no figures available.
3.12.78	67151	Waverider laid on new SSF mooring in offshore position in 45 m water, operating on 27.065 MHz, from MT 'Notre Dame'.
15.2.79	67042	Waverider calibrated - sensitivity $1.813 \text{ Hz m}^{-1}$ .
	67144	Waverider calibrated - sensitivity $1.849 \text{ Hz m}^{-1}$ .
5.3.79	67151	Offshore Waverider washed up on beach at Ardivachar, S Uist.
28.3.79	-	Calibration of two recording systems (Two Eddystone receivers, one Rapco two-channel logger 454C). Sensitivities: offshore $53.60 \text{ mV Hz}^{-1}$ , inshore $53.50 \text{ mV Hz}^{-1}$ .
	454C	Two channel Rapco logger removed.
	1022	Two channel Microdata logger commissioned - tape channel 1 offshore, tape channel 2 inshore. (Note: These tape channel number correspond to display channel numbers 5 and 6 respectively when selecting information to be shown on the LCD readout on the Microdata front panel.)
29.3.79	1022	Microdata logger records first wave information at 1200.

30.3.79 67144 Waverider laid on new SSF mooring operating on 27.065 MHz, in WRONG offshore position, some 7 N miles S of correct offshore position (due to confusion over Decca Navigator numbers). Water depth 48.5 m.

22.5.79 67151 Waverider calibrated - sensitivity  $1.840 \text{ Hz m}^{-1}$ .  
67043 Waverider calibrated - sensitivity  $1.823 \text{ Hz m}^{-1}$ .

26.6.79 67213 Waverider calibrated - sensitivity  $1.846 \text{ Hz m}^{-1}$ .  
67214 Waverider calibrated - sensitivity  $1.824 \text{ Hz m}^{-1}$ .

July 1979 1022 Intermittent problems with Microdata logger tape-transport mechanism reported from RA personnel.

12.8.79 67144 First report of offshore Waverider being in wrong position.

16.8.79 67213 Waverider deployed on 'buoyant chain' mooring on 26.990 MHz, at inshore II site in 22.8 m water. Distance to beach 3.25 N miles, due W (magnetic) from inshore I site.  
6851 Waverider and mooring recovered from inshore I site.

5.9.79 1022 Last successful data recorded by Microdata.

26.9.79 1022 Microdata logger removed.  
1037 Two channel Microdata logger installed.  
Receiving/logging systems calibrated.  
Sensitivities:  
Offshore - tape channel 1 (display channel 5) -  $53.94 \text{ mV Hz}^{-1}$ .  
Inshore - tape channel 2 (display channel 6) -  $53.69 \text{ mV Hz}^{-1}$ .

13.11.79 67201 Waverider calibrated - sensitivity  $1.826 \text{ Hz m}^{-1}$ .  
13.11.79 6851 Waverider calibrated - sensitivity  $1.850 \text{ Hz m}^{-1}$ .

19.11.79 1037 Isolated-input pcb's fitted to Microdata logger.  
67213 Waverider washed up on beach at Howmore, S Uist.

20.11.79 - Medium Frequency Waves (MFW) sensor installed at correct offshore position.

23.11.79 1022 Microdata logger commissioned as MFW logger at RCB, monitoring offshore Waverider 67144 (wrong position) via Eddystone receiver/448 for three hours daily.

7.12.79 1022 Last data from offshore Waverider 67144 (wrong position) successfully recorded on MFW Microdata logger; tape ejector mechanism failed at this point.

17.12.79	-	MFW sensor washed up on beach, S Uist.
9.1.80	1022	MFW Microdata logger removed from RCB.
12.1.80	67144	Waverider recovered from wrong offshore position.
	67214	Waverider laid in correct offshore position on 27.065 MHz, in 46 m water at 0205 on new SSF mooring from MT Reul na Maidne.
12.1.80	67043	Waverider laid at inshore II position on 26.990 MHz in 22 m water at 0252 on buoyant chain mooring from MT Reul na Maidne. Echo sounder run performed from inshore II position, heading W (magnetic) through correct offshore position and onward.
23.1.80	67213	Waverider calibrated - sensitivity $1.871 \text{ Hz m}^{-1}$ .
28.1.80	1037	Extra data point reported (by data processing section) as being inserted in Microdata header information.
4.2.80	1037	RA staff corrected switch positions in isolating- input pcb's on Microdata logger, hence removing extra data point.
5.2.80	-	Range Safety Officer, RA Range, reported both Waveriders in correct Decca positions.
24.7.80	67419/7	Waverider calibrated sensitivity $1.874 \text{ Hz m}^{-1}$ .
	67420/7	Waverider calibrated sensitivity $1.875 \text{ Hz m}^{-1}$ .
4.8.80	1037	Heading format fault reported on 2-channel Microdata logger.
10.8.80	6851	Waverider operating on 29.725 MHz deployed at deepwater site at 1244z. Position $57^{\circ} 17' 48''\text{N}$ , $07^{\circ} 53' 36''\text{W}$ . Mean water depth 97.6 m.
	67214	Waverider recovered from offshore site at approximately 1530z.
	67420/7	Waverider operating on 27.065 MHz deployed at offshore site in 51.0 m mean water depth at 1605z. Position $57^{\circ} 18' 24''\text{N}$ , $07^{\circ} 38' 00''\text{W}$ .
	67043	Waverider recovered from inshore II site at 1900z approximately.

10.8.80 &(Contd)	67419/7	Waverider operating on 26.990 MHz deployed at inshore II site in 26 m mean water depth at 1913z. Position 57° 19' 24"N, 07° 29' 33"W. Performed echo-sounder surveys as follows: Deepwater to offshore and inshore II sites: and 10 km N of offshore site, to 10 km S of offshore site.
12.8.80	-	Dismantled checked and reinstalled half-wave receiving aerial on RCB roof. (Receives signals from offshore and inshore II buoys.)
14.8.80	-	Installed two quarter-wave receiving aerials on RCB roof to receive signals from deepwater buoy; measured signal strengths.
	1037	Removed old 2-channel Microdata logger.
	1036	Installed new 2-channel Microdata logger-records signals from offshore and inshore II buoys.
	1022	Installed single-channel Microdata logger to record signals from deepwater buoy. Calibrated deepwater receiving system - sensitivity $53.75 \text{ mV Hz}^{-1}$ .
15.8.80	1036	Calibrated offshore receiving system - sensitivity $53.87 \text{ mV Hz}^{-1}$ .
	1036	Calibrated inshore II receiving system - sensitivity $53.65 \text{ mV Hz}^{-1}$ .
September '80	1036	Fault appearing on Microdata input pcb reading offshore signal - relay sticking.
22.9.80	1022	Deepwater logger modified to take extended records in conjunction with cloverleaf buoy directional wave records taken by RRS Challenger, (cruise 14/80, leg B). First record 1800z.
	1036	2-channel Microdata logger removed.
	1089	New 2-channel Microdata logger installed and set up to take extended records in conjunction with cloverleaf directional measurements. First record 1600z.
	1022	Received signal-strength tests of deepwater receiving system.

24.9.80	-	Receiving systems re-set to routine operation.
	1089	2-channel Microdata day number re-set 40 days slow.
	-	Receiving system operation checked at 1500z - all OK.
7.10.80	67043	Waverider calibrated sensitivity $1.842 \text{ Hz m}^{-1}$ .
	67214	Waverider calibrated sensitivity $1.845 \text{ Hz m}^{-1}$ .
October '80	1089	Intermittent header information on 2-channel Microdata logger.
28.10.80	1089	RA staff had tried to re-insert correct header information, but reported that no date/time information was now displayed.
4.11.80	1089	2-channel Microdata logger removed.
	1036	New 2-channel Microdata logger fitted. First record 1800z.
	-	RCB Radar reported all buoys on station.
November '80	-	Offshore receiver displaying wildly wandering mean.
11.11.80	-	New phase-lock discriminator board fitted to offshore receiver. Wandering mean still evident.
		Waverider buoy fault probable - to be replaced early in 1981.
20.11.80	67406/9	Waverider calibrated - sensitivity $1.877 \text{ Hz m}^{-1}$ .
27.11.80	67041	Waverider calibrated - sensitivity $1.825 \text{ Hz m}^{-1}$ .
27.11.80	67214	Waverider calibrated - sensitivity $1.862 \text{ Hz m}^{-1}$ .
12.1.81	-	All chart writing mechanisms fitted with disposable pens.
13.1.81	-	Offshore receiving system modified to record whenever a satisfactory signal was being received from the buoy, (ie transmission - initiated recording).
	1022	Microdata logger removed.
	1029	New Microdata logger fitted to record offshore buoy. Logger had been modified to record when receiver was receiving a satisfactory signal from the buoy, and prefixed all readings with a minus sign, (identifier). Logs frequency.
	1036	Two channel Microdata logger modified to log frequency. Records from Deepwater (readings prefixed +ve) and Inshore II (readings prefixed -ve) buoys.

14.1.81 - All receiving systems calibrated.

1036 63.98 Hz<sup>-1</sup>. Deepwater receiver/logger sensitivity - 63.98 Hz<sup>-1</sup>.

1036 64.02 Hz<sup>-1</sup>. Inshore II receiver/logger sensitivity - 64.02 Hz<sup>-1</sup>.

1029 63.99 Hz<sup>-1</sup>. Offshore receiver/logger sensitivity - 63.99 Hz<sup>-1</sup>.

- Normal logging initiated after modifications.

- Severe interference on Inshore receiver.

17.1.81 67420 Recovered Offshore buoy using Reul na Maidne.

Mooring lost.

67406/9 New Offshore Waverider deployed in position 57° 18' 21"N, 07° 38' 12"W. 90 cm buoy with boosted transmitter output on 27.065 MHz.

Transmissions clocked 22½ min every 3 hours.

Severe interference caused 50% data loss or more however.

17.1.81 67419/7 Inshore II Waverider transmitter aerial replaced with mooring still on the bottom.

- Performed echo sounder survey to SW of Inshore II position.

20.1.81 67419/7 Inshore II Waverider washed up on beach near Drimsdale Rock, S Uist.

6.2.81 67406/9 Last data received from Offshore site.

28.2.81 - Offshore Eddystone receiver changed.

Complete new unit fitted. (Eddystone receiver no 964/7c/553). Straight line records being received only at night (heavy interference during the day). Offshore buoy fault strongly suspected.

67419/7 Inshore II buoy recovered from finder.

1.3.81 67406/9 Offshore buoy checked visually. In good condition but rubber finder missing.

- Recovered old Inshore II mooring, using Reul na Maidne.

67201 New Waverider deployed in Inshore III position, viz 57° 17' 30"N, 07° 29' 12"W.

- Performed echo sounder survey around Inshore III position.

2.3.81 All receiving systems calibrated accurately. All sensitivities - 64.00 Hz<sup>-1</sup>.

25.4.81	67406/9	Recovered Offshore Waverider and mooring using Reul na Maidne.
	67041	Deployed new Offshore Waverider and mooring. 70 cm buoy operating on 29 MHz. Position 57° 18' 21"N, 07° 38' 12"W.
29.4.81	-	Offshore Eddystone receiver (27.065 MHz) removed. New Eddystone receiver (29 MHz) number EC964/7c/455 fitted.
	1029	Offshore receiving system calibrated - sensitivity - $64 \text{ Hz}^{-1}$ . Good signals being received on all systems.
May '81	67406/9	Waverider examined in laboratory. Accelerometer short circuit identified - probably a manufacturing fault. Buoy to be returned to Datawell for possible replacement under warranty.
	67420	Waverider examined in laboratory. Found accelerometer suspension to be looped. Loop untangled, but tests to continue.
28.5.81	67419/7	Waverider calibrated - sensitivity $1.896 \text{ Hz m}^{-1}$ .
1.8.81	6851	Deepwater buoy recovered, with mooring, using Reul na Maidne.
	67043	New Deepwater buoy and mooring deployed, operating on 29.725 MHz, at 14.15 BST. Mean water depth 100.3 m.
	67041	Offshore buoy and mooring recovered using 115 kg grapnel.
	67214	New Offshore buoy and mooring deployed, operating on 29.825 MHz, at 16.48 BST. Mean depth 47.6 m.
	67201	Inshore III buoy and mooring recovered.
	67213	New Inshore III buoy and mooring deployed, operating on 26.990 MHz, at 17.59 BST. Mean depth 25.0 m.
	-	Echo sounder survey performed between and around Inshore positions I and II.
4.8.81	-	Removed Offshore Eddystone receiver.
		Fitted new Offshore Eddystone receiver no EC964/7c/553 to work on 29.825 MHz.
5.8.81	-	Checked all receiving aerials. Serviced $\lambda/2$ aerial receiving Inshore III transmissions.

5.8.81 (Contd) - Calibrated all receiving systems - all gave -  $64 \text{ Hz}^{-1}$ . Serviced all chart recorders. Discussed areas of broken water around Inshore positions I and II with local fishermen.

6.8.81 - Monitored performance of all receiving systems. Discussed use of Army radar for wave observation with Major Counsell, RA. Photographed area around Inshore positions I and II from RCB.

18.8.81 6851 Waverider calibrated - sensitivity  $1.872 \text{ Hz m}^{-1}$ .  
67041 Waverider calibrated - sensitivity  $1.814 \text{ Hz m}^{-1}$ .

