South West of England Regional Development Agency (SW RDA)

Wave Hub Wave Monitoring Project

Interim Report Number 3

February 2010

Halcrow Group Limited

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Contents Amendment Record

This report has been issued and amended as follows:

Issue	Revision	Description	Date	Signed
1	0.0	Draft Metocean Survey Report	02 Feb 10	RW
1	1.0	Metocean Survey Report	01 Mar 10	RC

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Contents

1 Executive Summary

Halcrow Group Ltd has been appointed by the South West of England Regional Development Agency (SW RDA) acting on behalf of RWE Npower Renewables Limited, to undertake a metocean field campaign in support of the proposed Wave Hub development. This report serves to summarise field activities and data acquired to date.

A Nortek Acoustic Waves and Current (AWAC) instrument was deployed in the study area to record directional wave and current information. The instrument was placed at a depth of approx 60m off the Cornish coastline (Hayle), UK.

The aim is to collect 18 months of data, which will require a service visit approximately every 3 months. To date there have been four completed deployments, due to an instrument malfunction no data was recorded during the second deployment.

This interim report summarises the data collected during the fourth deployment, which covers the period between 10 August 2009 and 27 January 2010. This fourth deployment was longer than intended, due to stormy conditions during December 2009 and January 2010.

During the fourth deployment the instrument functioned as planned and recorded for the entirety of the deployment period. In summary, current flows are tidally dominated with oscillation of flow between the northeast and southeast. Current flows often exceed 0.8 m/s during spring tide events, with a maximum flow of 1.19 m/s recorded on 22 August 2009. Wave heights and period show a high degree of variance over the deployment period. The predominant wave direction is from the west, influenced by Atlantic storm systems. The largest waves recorded exceeded 10m (Hmax) on 4 November 2009. Mean significant wave height (Hm0) for the fourth deployment was 2.20 m. Peak wave periods (Tp) of over 12 seconds are common during periods of larger wave events. Mean wave period (Tm02) was 5.59 seconds.

2 Methodology

2.1 Project Overview

The study area is situated approximately 20km to the northwest of Hayle, Cornwall, UK. This is the proposed location for the WaveHub installation.

The WaveHub project is a renewable energy project designed to allow the offshore installation of technologies that can supply energy from wave energy. The Cornish coastline is open to the Atlantic Ocean and receives a constant high energy wave climate.

One instrument was deployed, in a single mooring system at the site:

Location: 50° 22.090'N, 5° 37.620'W

Water depth: 60 m

Instrumentation: Nortek AWAC
MSI Trawl resistant mooring
ORE Shallow water release
RJE Acoustic beacons (2)

Measurements: Directional Waves
Directional Current Profiles
Water levels

During the 18-month field campaign there are a minimum of four planned service visits. These enable periodic recovery of data, servicing of instruments and redeployment ahead of the final recovery and demobilisation. To date four service visits have been completed, one further visit is planned before the final demobilisation. A summary is given below:

Deployment 1 (26 November 2008 to 21 March 2009)

AWAC fully operational

Deployment 2 (21 March 2009 to 19 June 2009)

AWAC malfunctioned. No data recovery.

Deployment 3 (1 July 2009 to 10 August 2009)

AWAC fully operational

(Test deployment after the problems encountered during deployment 2)

Deployment 4 (10 August 2009 to 27 January 2010)

AWAC fully operational

The third deployment was scheduled to be of a shorter duration. This was so that the instrument could be tested to ensuring it was operating correctly following the problems encountered during the second deployment. This test period was fruitful and yielded data for the entire deployment.

This interim report summarises the data collected during the fourth deployment.

2.2 Health and Safety

A comprehensive health and safety risk assessment was conducted and documented before fieldwork commenced. These documents were read and acknowledged by all personnel who took part in the fieldwork. The documents were adhered to throughout the course of fieldwork.

A pre-deployment health and safety talk was also held before fieldwork commenced with all sea-going staff in attendance. This ensures that all personnel have an understanding of the work to be conducted and how to accomplish it safely. The talk presents the opportunity for all personnel to ask questions, voice any concerns and add comments.

2.3 Terms of Reference

The following outlines units and conventions used in this study:

- Current speeds are expressed in meters per second (m/s)
- Current directions are expressed in degrees relative to True North (deg TN) and describe the direction **toward** which the current is flowing
- Water levels are expressed as total water depth in meters (m).
- Wave height is expressed in meters (m)
- Wave period is expressed in seconds (s)
- Wave directions are expressed in degrees relative to True North (deg TN) and describes the direction **from** which waves approach
- Temperature is expressed in degrees Celsius (deg C)

- Geographical positions are quoted in degrees and decimal minutes relative to WGS84
- Times are quoted in local time (GMT)

2.4 Instrument Configurations

The AWAC unit was configured to average 20 minutes of velocity data in 4 m depth bins based on burst data recorded over 1 minute. Water level data are recorded alongside these measurements at the same frequency.

The AWAC unit was also configured to record wave data every 2 hours based on approximately 20 minutes of burst data sampled at a frequency of 1Hz. Water level data are also recorded alongside these measurements at the same frequency.

2.5 Mooring Configuration

A trawl resistant mooring system was used, manufactured by Mooring System Inc. The mooring was equipped with an ORE Offshore Shallow Water Release (SWR) to enable instrument recovery. This system responds to an acoustic signal from a deck unit, at which point a buoy (attached to the mooring) is released to the surface providing a visual reference point and means to lift the mooring on board to the vessel. Two RJE International acoustic beacons were attached to the mooring frame to act as a backup should the primary method of recovery fail; these can be detected by an underwater hydrophone giving a fix on the location. An illustration of the mooring platform has been included in Appendix A.

2.6 Data Processing

All data recorded were downloaded and processed using a combination of the instrument manufacturer software and Halcrow's SANDS database, which has been specifically developed for this operation.

In addition to data being plotted and visually inspected for general quality, data were subject to a number of quality control filters, whereby data considered poor were error flagged and removed from further analysis. Data quality control methods are described in more detail in Appendix F.

A magnetic declination of -**3.58 W** was applied to all directional measurements to correct directions relative to True North.

3 Results

3.1 Data Return

The deployment and recovery were successful. The instrument performed as planned, recording data for the whole of the deployment. The data recorded during this autumn / winter deployment supports those trends identified in the first and third deployments. Peak wave and current measurements are comparable to those measured during the first deployment, and are of greater magnitude in comparison to the summer conditions that were recorded during deployment 3. The following sections summarise the data collected during the fourth deployment.

3.2 Current measurements

Table 3.1 provides a summary of all depth-averaged current flow data recorded. Depth-averaged directional rose plots and time series are further presented in Appendix B.

Table 3.1

Station	Record	Mean	Max	Directional Trends
1	Cm (m/s)	0.37	1.19	Northeast to southwest oscillation

Current flows are tidally dominated with oscillation of flow between the northeast and southwest. Current flows often exceed 0.8 m/s during spring tide events, with a maximum flow of 1.19 m/s recorded on 22 August 2009.

3.3 Wave measurements

Table 3.2 provides summaries of mean significant wave heights (Hm0) and mean wave periods recorded (Tm02). Directional rose plots and time series are presented in Appendix C.

Table 3.2

Station	Record	Mean	Max	Directional Trends
1	Hm0 (m)	2.20	6.38	Predominantly from westerly directions
	Tm02 (s)	5.59	10.57	

Waves recorded show a good range occurring during the autumn / winter months. A number of long period swell events occurred during the deployment period. Waves approach predominantly from a westerly direction, influenced by Atlantic storm systems. The largest waves recorded exceeded 10 m (Hmax) on 4 November 2009. Peak wave periods (Tp) of over 12s are common during periods of larger wave events.

3.4 Water level measurements

Table 3.3 provides a summary of total water levels (sensor height plus elevation of sensor above the sea bed) recorded. Time series plots of water level are further presented in Appendix D.

Table 3.3

Station	Record	Min	Mean	Max
1	Dt (m)	56.40	59.89	63.36

Water levels are semi-diurnal and appear to be reasonable. There is good consistency of data between water level and current velocities, which provides further evidence of the robustness of the data.

Appendix A

Figures

Figure A1 Site location (Image provided by Google Earth Pro)

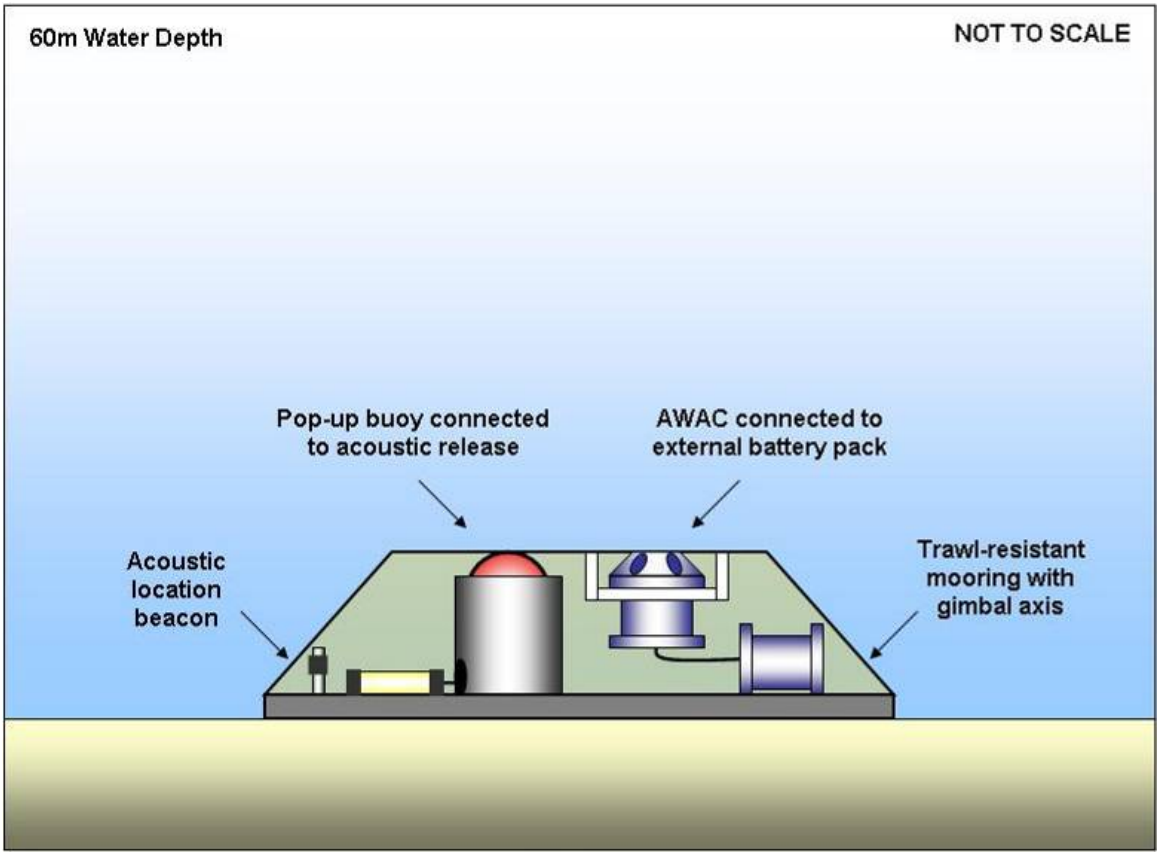

Figure A2 Mooring design

Appendix B

Current Measurements

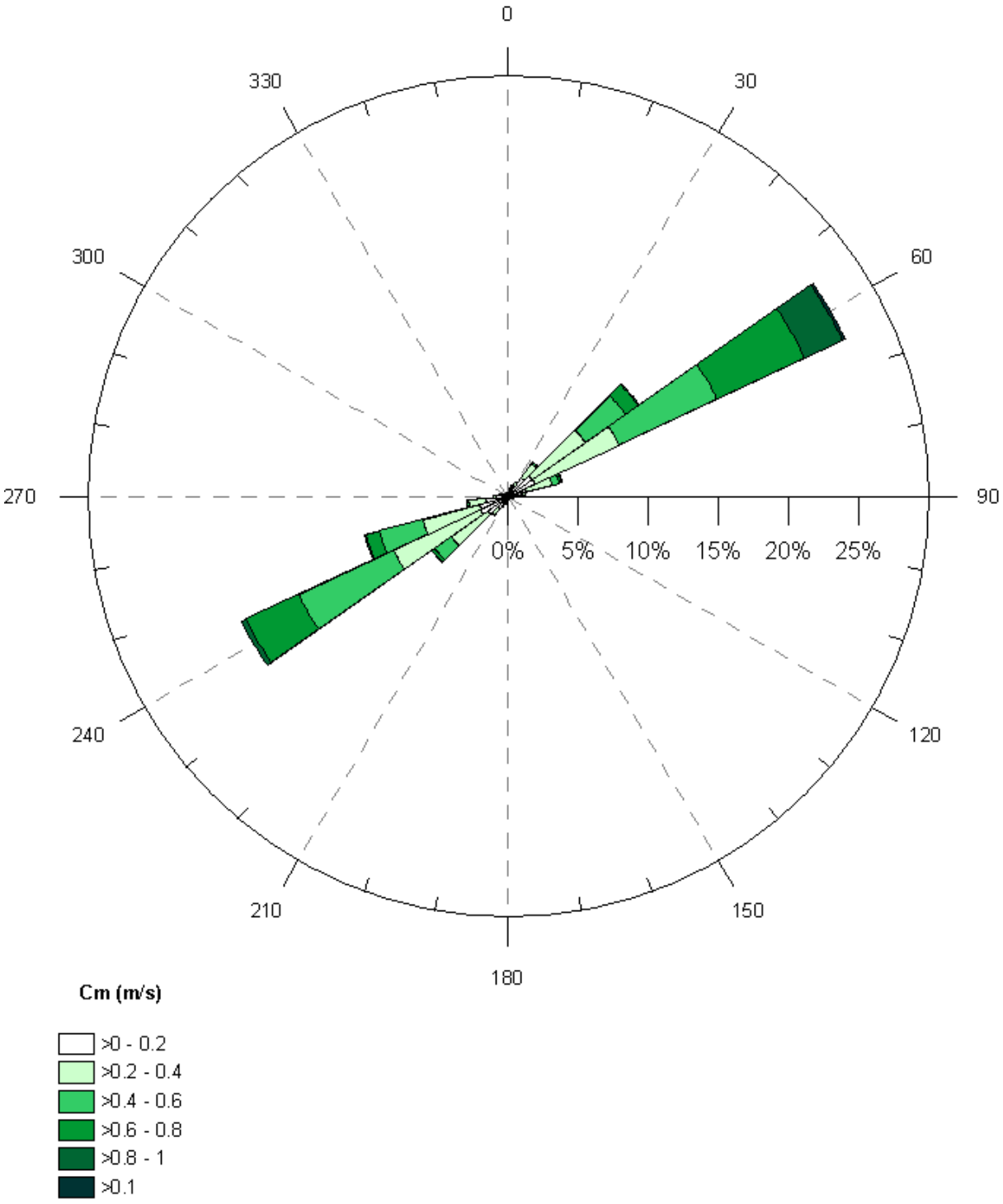

Figure B1 Current rose plot

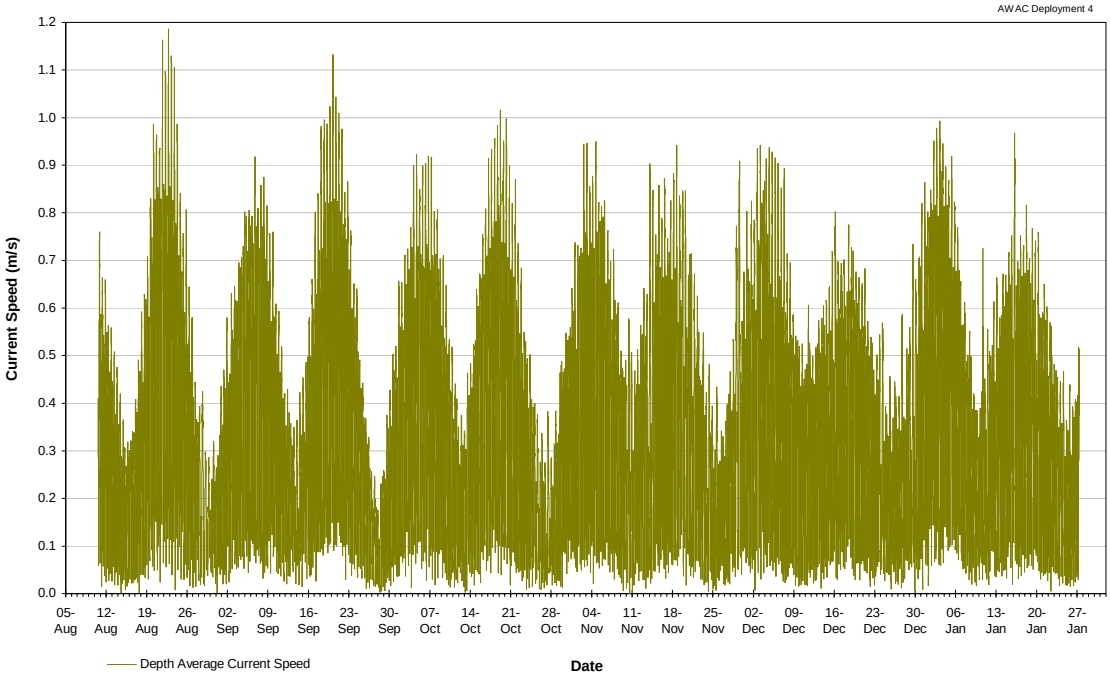

Figure B2 Depth-averaged current velocity plot

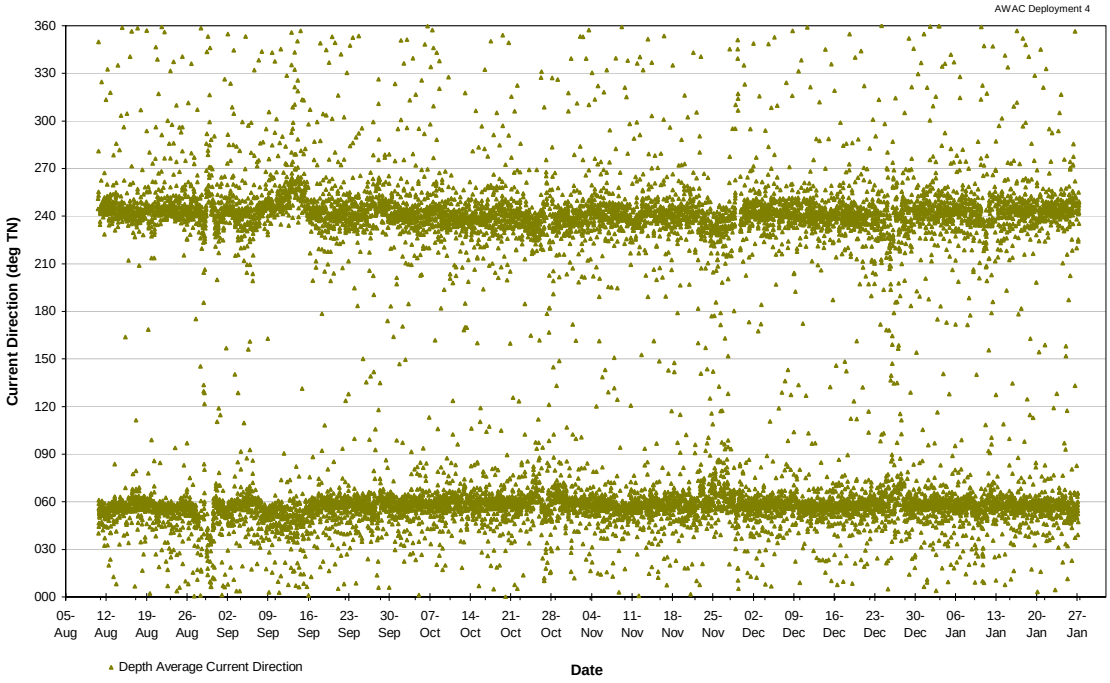

Figure B3 Depth-averaged current direction plot

Appendix C

Wave Measurements

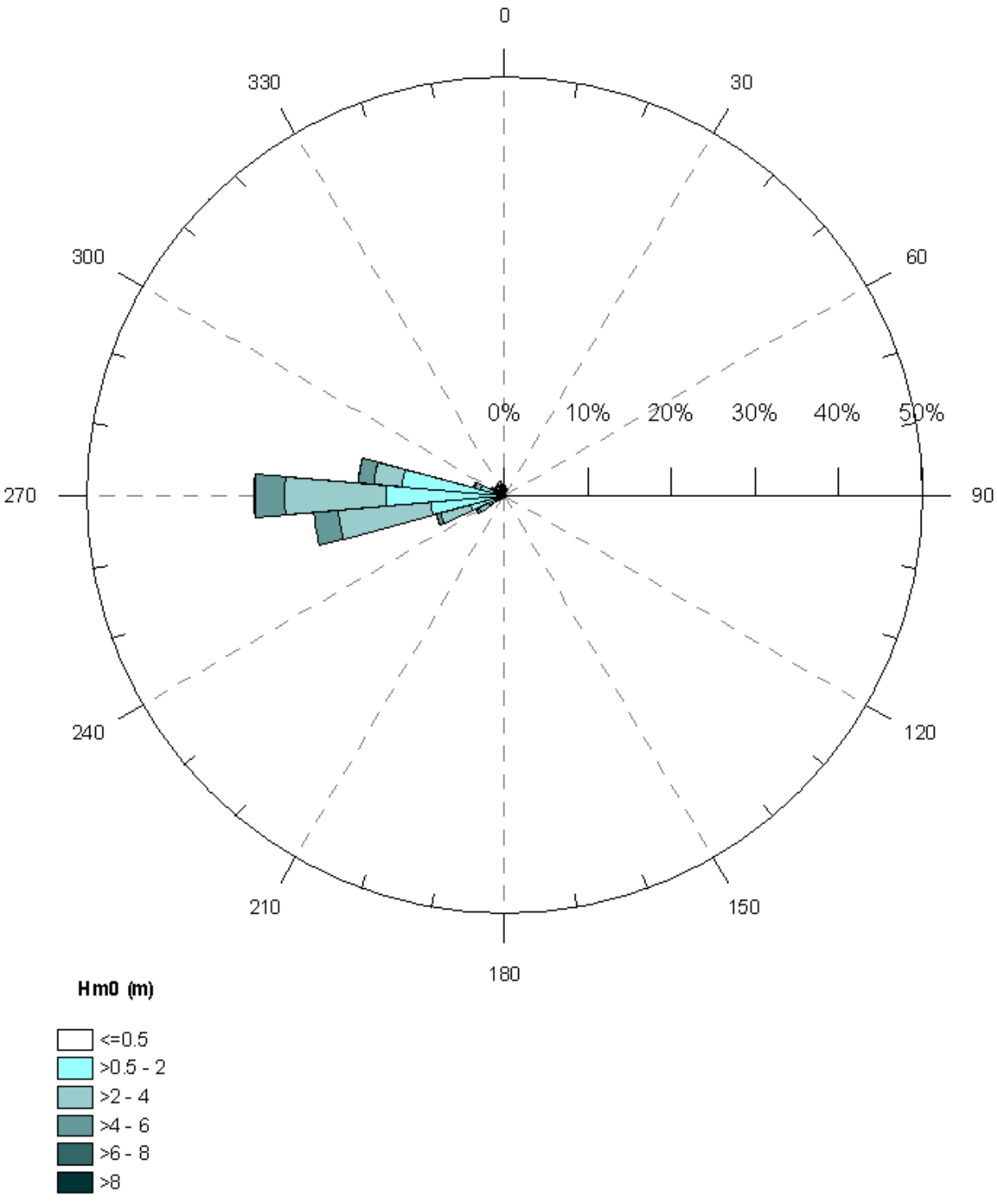

Figure C1 Wave rose plot

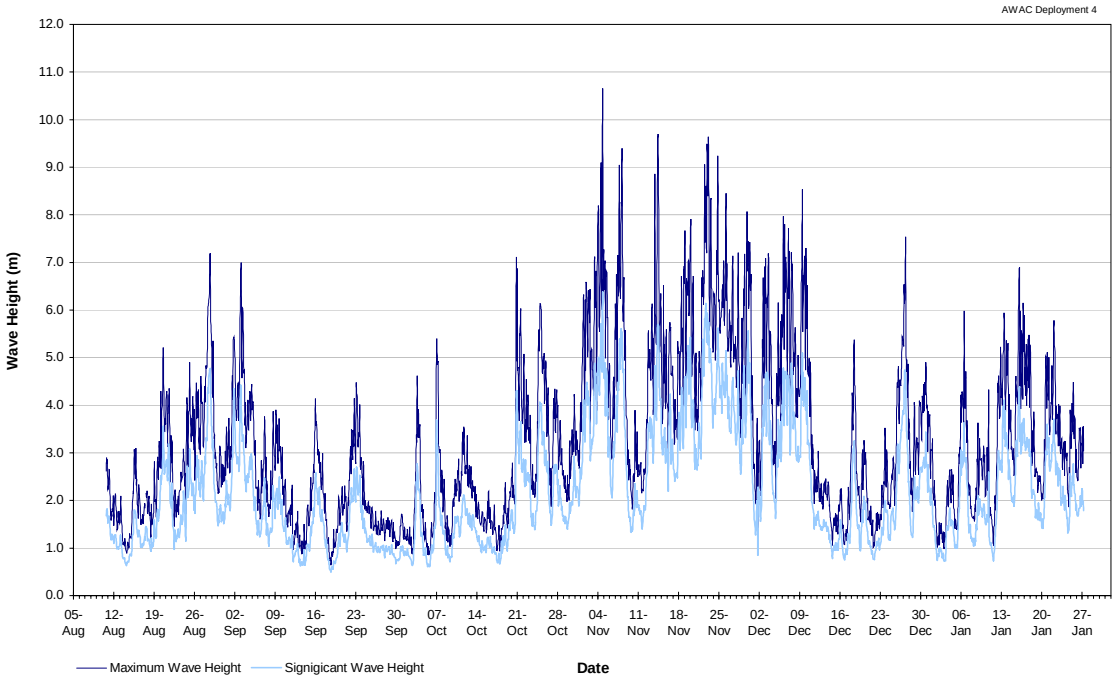

Figure C2 Wave height plot

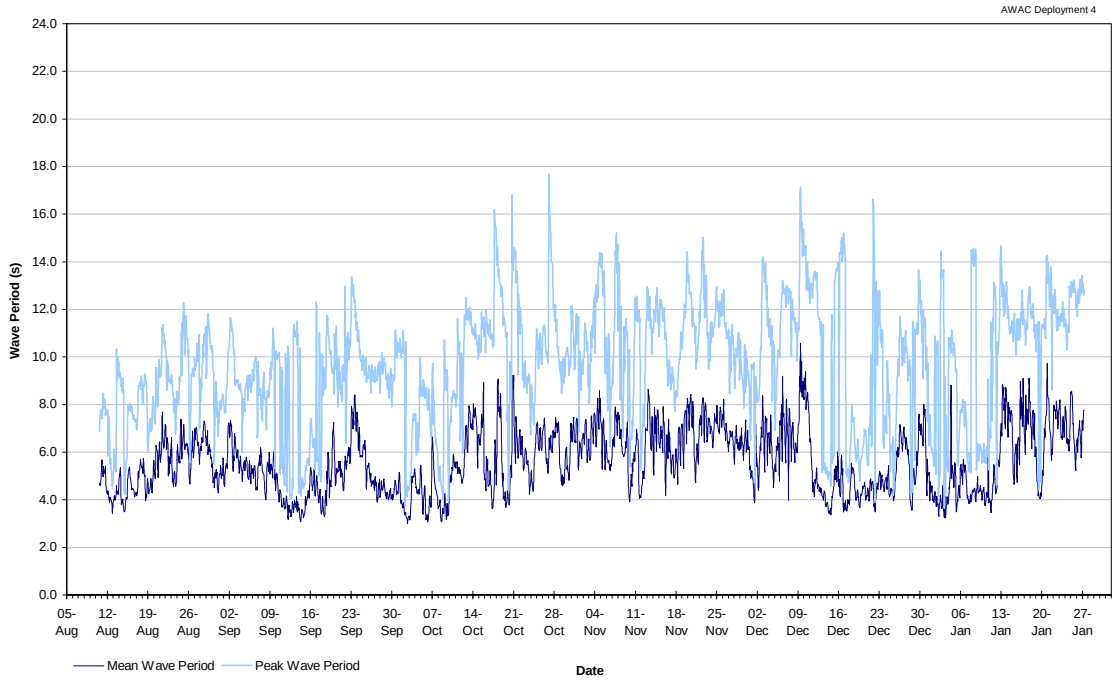

Figure C3 Wave period plot

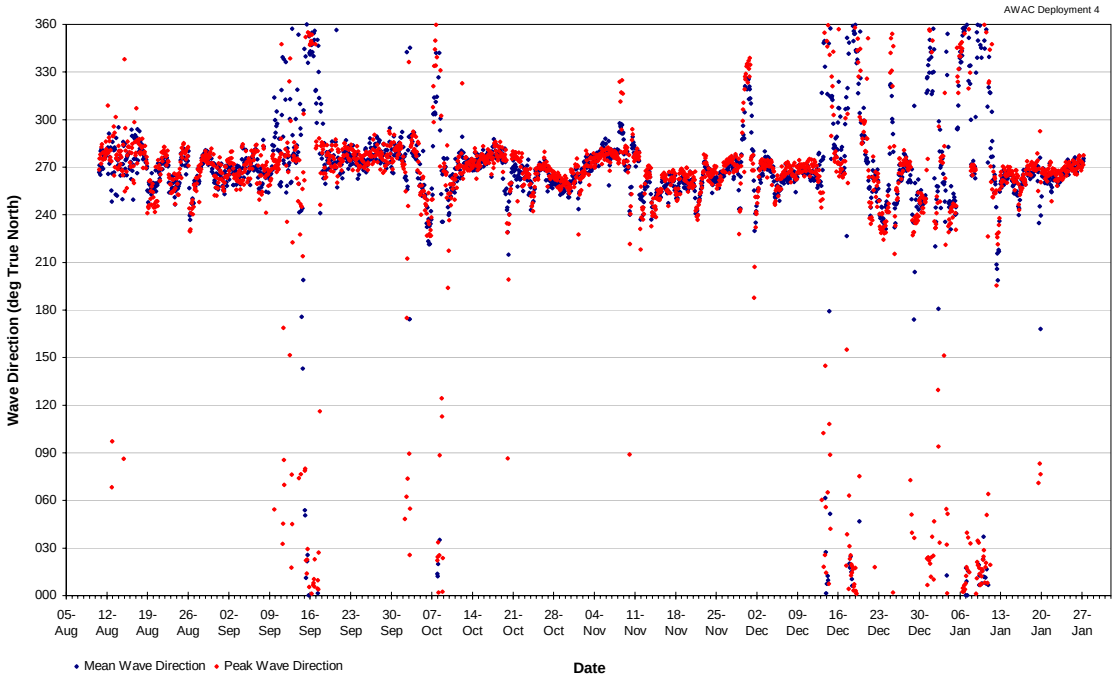

Figure C4 Mean and peak wave direction

Appendix D

Water Level Measurements

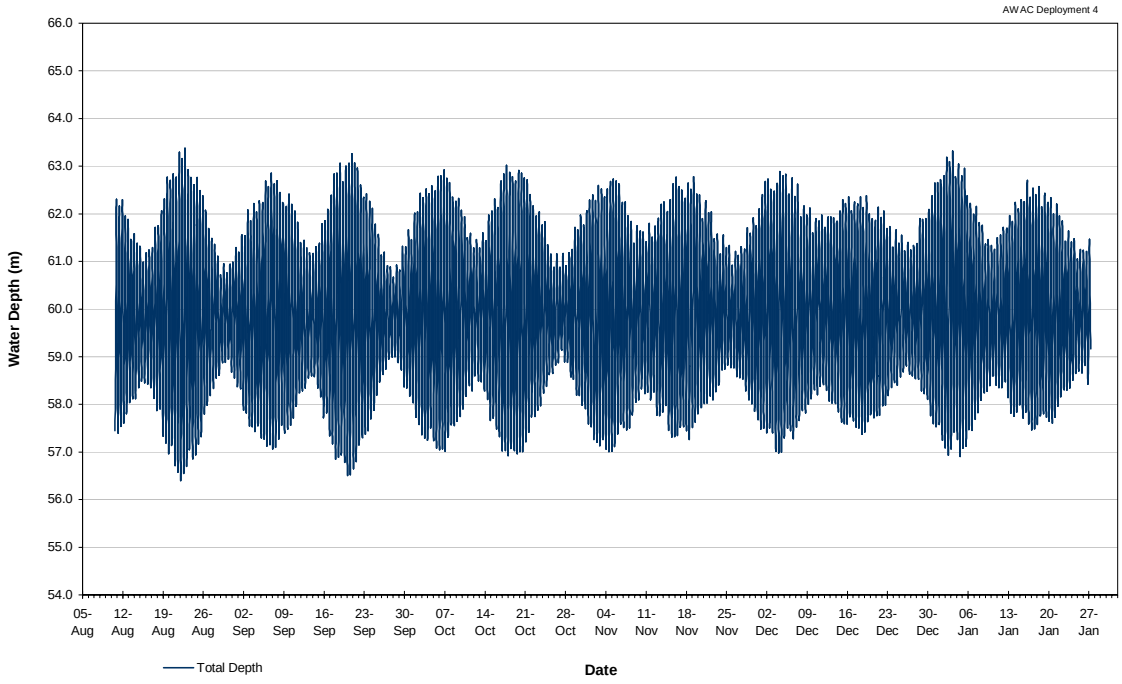

Figure D1 Water depth plot

Appendix E

Survey Logs

Halcrow Group Ltd

DEPLOYMENT SUMMARY

Project: Wave Monitoring at WaveHub site Location: Hayle, Cornwall, UK

Mooring Name	*Equipment Installed*	*Deployed*	*Recovered*	*Coordinates (UTM)*	*Depth (m)*
AWAC #1	Nortek AWAC	26-Nov-08	21-Mar-09	50° 22.025'N 5° 37.109'W	60
	MTRBM (gimbal axis)				
	ORE SWR and PUB				
	RJE Pinger (27khz)				
	RJE Pinger (37khz)				
AWAC #2	as above	21-Mar-09	19-Jun-09	50° 22.025'N 5° 37.109'W	60
AWAC #3	as above	01-Jul-09	10-Aug-09	50° 22.025'N 5° 37.109'W	60
AWAC #4	as above	10-Aug-09	27-Jan-10	50° 22.025'N 5° 37.109'W	60
AWAC #5	as above	27-Jan-10		50° 22.025'N 5° 37.109'W	60

COMMENTS

PUB recovery code = 30730

First recovery unsucessful (PUB) on 16 Feb 09

Second recovery attempt unsuccessful (ROV) on 17 Feb 09

In recovery attempts both pingers could be detected by hydrophone

Hydrophone coordinates are best (coords on Magellan GPS)

Returned to location on 21 March 09 for 2nd attempt to recover (ROV). Successful.

Data downloaded and re-deployed on 21 March 09.

Successful recovery of instrument on 19 June 09. Instrument mailfunction.

Re-deployed on 1 July for 1 month period (test)

Successful recovery on 10 August 09. Data recorded successfully

Re-deployed on 10 August

SITE LOCATION

Halcrow Group Ltd

Instrument Log Sheet
Nortek
AWAC

DESCRIPTION

Project	Wave Monitoring at WaveHub site	Deployment number	4
Mooring location	Hayle, Cornwall, UK	Mooring name	AWAC
Instrument type	Nortek AWAC	Serial number	WPR 0867
Frequency (kHz)	600	Firmware	1.17 AST

PROGRAM

CURRENTS		***SETUP***		***CONSEQUENCES***	
Profile interval (s)	1200	Number of batteries	2	Assumed duration (days)	120
Number of cells	16	Memory capacity (MB)	156	Estimated depth (m)	60
Cell Size (m)	4	Compass update rate (s)	1200	Battery utilization (%)	34
		Power level	HIGH	Memory required (MB)	21.8
WAVES		Switch on date	30-Jun	Vertical velocity sd (cm/s)	1.3
Number of samples	1024	Switch on time	21:30	Horizontal velocity sd (cm/s)	3.9
Sampling rate (Hz)	1				
Interval (s)	7200				

PREPERATION

Batteries tested	y	Computer set to local time	y	Deployment file name	Dep04
Orings greased and replaced	y	AWAC set to computer time	y		
Instrument sealed	Not opened	Memory erased on AWAC?	y		

DEPLOYMENT

Deployment date	10-Aug	Mooring type	MTRBM	Ballast weight (kg)	150
Deployment time (in water)	14:36	Acoustic release	Y	Anchor line	N
Deployment depth (m)	55	Acoustic release type	ORE SWR	Pinger	Y (two)
Height above seabed (m)	1	Acoustic code	144743	Pinger type	27 & 37

RECOVERY

Recovery date	27-Jan-10	Switch off date	27-Jan-10	File names (list below)	Size (MB)
Recovery time	08:20	Switch off time	09:10		55
Physical condition	Good				

COMMENTS (TO INCLUDE GPS POSITION)

Instrument had been deployed since 10 August 09. All data recovered. Mooring & instrument was very clean.

WP47: 50.36980 N; 005.61813 W	100m drift between GPS points	Completed by (Initials)	RC
WP48: 50.36897 N; 005.61904 W	Toward SW (214 deg)	Date	27-Jan

Appendix F

Quality Control

AWAC Current Profile Data

Current flow data can be especially difficult to quality control because the large size of the data files, the manufacturer software (STORM) has been used to check the data using a number of quality control checks, identify any data considered to be poor quality and eliminate these from further analysis. Following these quality checks the data have been fed into Halcrow's SANDS database to allow further processing of the data.

i. Sidelobe Reflection

The AWAC is fitted with a 20° head with the result that the region affected by sidelobe reflection is in the upper 10% of the AWAC measurement range (distance between AWAC transducer and sea surface). Therefore only 90% of data have been used in this analysis.

ii. Pitch

Instrument pitch recorded with each data record is compared to a threshold value, and flagged accordingly. Variation in pitch between 0-15 degrees is deemed acceptable. In addition, time series plots of instrument pitch were produced to indicate any poor data return or erroneous data (Figure F1).

iii. Roll

As with instrument pitch, instrument roll recorded with each data record is compared to a threshold value, and flagged accordingly. Variation in roll between 0-15 degrees is deemed acceptable. Time series plots of instrument roll were also produced to indicate any poor data return or erroneous data (Figure F1).

iv. Heading

The instrument heading is also measured with each data record; any data less than 0.0 degrees or greater than 359.9 is classified as poor data and eliminated from analysis. Time series plots of instrument heading were produced to indicate any poor data return or erroneous data (Figure F1).

v. Water Temperature

Water temperature is measured with each data record; any data less than -5°C or greater than 50°C is classified as poor data and eliminated from further analysis (Figure F2).

vi. Signal Strength

The echo intensity for an AWAC is a measure of the signal strength intensity returned to the transducer (SNR). Because the AWAC technology uses the scattering from small particles in the water column to measure currents, reflections from larger objects may overwhelm the scattering from the smaller particles. If the echo intensity is high it may indicate a boundary, shoal of fish, or an obstruction in the water column. The signal strength is measured for each of the four beams and values less than 70 dB are considered to be reasonable for this deployment.

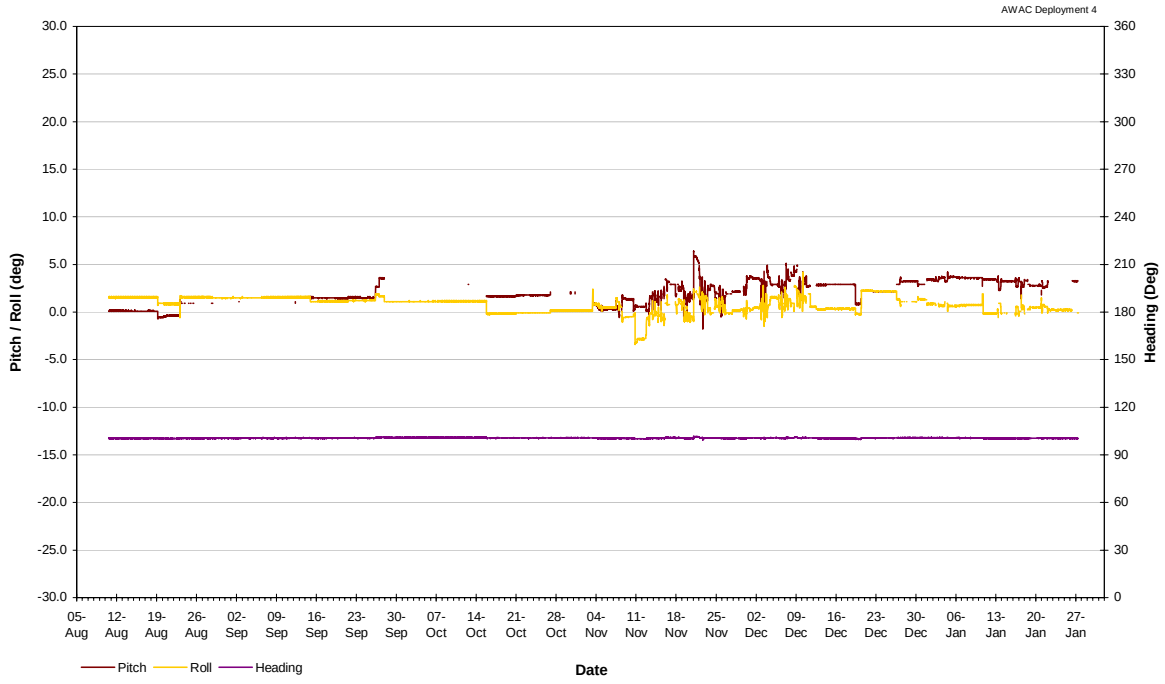

Figure F1 Pitch, roll and heading data

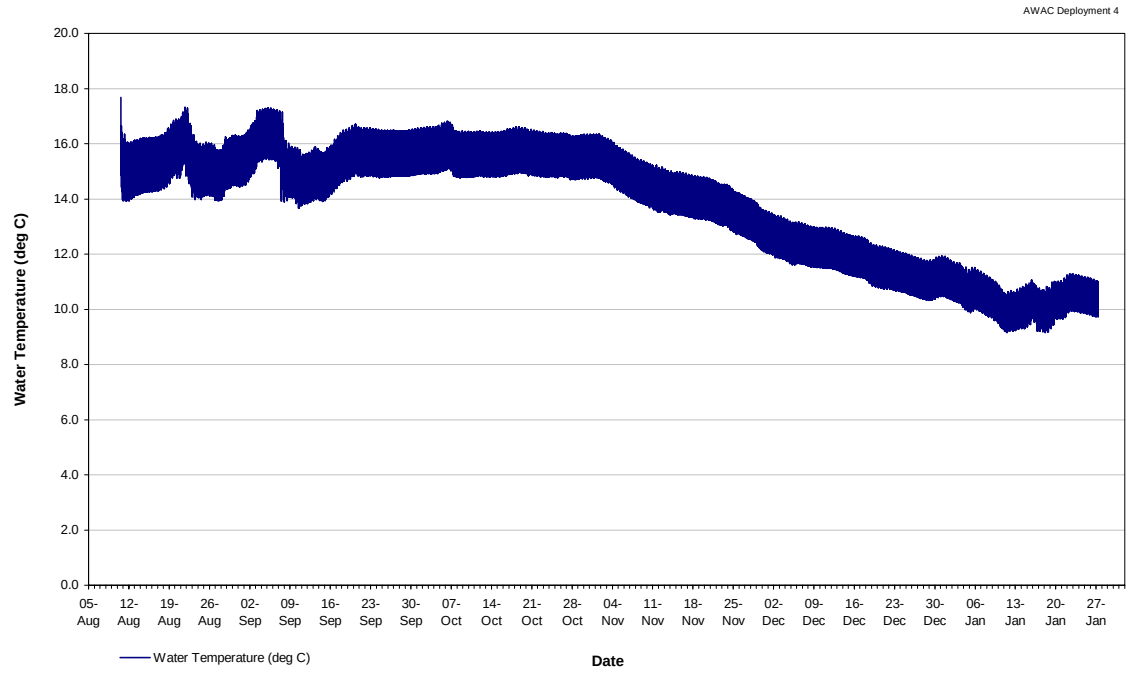

Figure F2 Water temperature