Appendix 7.1

Hydrodynamic model update and validation report

TIDAL LAGOON SWANSEA BAY

SWANSEA BAY TIDAL LAGOON WATER QUALITY

HYDRODYNAMIC MODEL UPDATE AND VALIDATION REPORT

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SUMMARY

This document has been prepared by Intertek Energy and Water Consultancy Services (Intertek) as part of Swansea Bay Tidal Lagoon Environmental Impact Assessment (EIA).

This report describes the validation of the existing Swansea Bay hydrodynamic model,against newly available hydrodynamic data, following updates to the model domain and bathymetry. The model has been developed with the specific purpose to quantify the effects that the Swansea Bay Tidal Lagoon development may have on local water quality.

The aim of this report is to provide sufficient evidence to demonstrate that the Swansea Bay hydrodynamic model is suitable for use in the assessment of impacts on water quality associated with the construction and presence of a tidal lagoon in Swansea Bay.

The ultimate objectives of the model validation are:

a. to accurately replicate the hydrodynamic regime in Swansea Bay and estuarine waters;

b. to validate the model against pertinent tidal data;

c. to present a scientifically defensible hydrodynamic model; and

d. to provide a suitable tool for assessing design options.

The model is considered to be in overall good agreement with the measured tidal elevation and current velocity data.

It is recommended that the Swansea Bay model is fit for purpose to simulate the hydrodynamics in Swansea Bay.

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FIGURES

LIST OF ABBREVIATIONS

ADCP	-	Acoustic Doppler Current Profiler
ATT	-	Admiralty Tide Tables
AWAC	-	Acoustic Wave and Current Profiler
BODC	-	British Oceanographic Data Centre
BW	-	Bathing Water
CD	-	Chart Datum
CFL	-	Courant-Friedrich-Lévy
DCWW	-	Dŵr Cymru Welsh Water
EIA	-	Environmental Impact Assessment
GMT	-	Greenwich Mean Time
HW	-	High Water
LW	-	Low Water
MSL	-	Mean Sea Level
MVADCP	-	Moving Vessel ADCP
NGR	-	National Grid Reference
POL	-	Proudman Oceanographic Centre
SfW	-	Shellfish Water
UKHO	-	United Kingdom Hydrographic Office
u	-	Component of depth-averaged velocity in the East-West direction [m/s]
v	-	Component of depth-averaged velocity in the North-South direction [m/s]

1 INTRODUCTION

1.1 BACKGROUND

1.1.0.1 This document has been prepared by Intertek Energy and Water Consultancy Services (Intertek) as part of Swansea Bay Tidal Lagoon Environmental Impact Assessment (EIA).

1.1.0.2 This report describes the validation of the existing Swansea Bay hydrodynamic model, against newly available hydrodynamic data, following updates to the model domain and bathymetry. The model has been developed with the specific purpose to quantify the effects that the Swansea Bay Tidal Lagoon development may have on local water quality.

1.2 AIM AND OBJECTIVES

1.2.0.1 The ultimate aim of this report is to provide sufficient evidence to demonstrate that the Swansea Bay hydrodynamic model is suitable for use in the assessment of impacts on water quality associated with the construction and presence of a tidal lagoon in Swansea Bay.

1.2.0.2 The ultimate objectives of the model validation are:

a) accurately replicate the hydrodynamic regime in Swansea Bay and estuarine waters prior to construction of the tidal lagoon within the model domain;

b) validate the model against pertinent tidal data of appropriate temporal and spatial resolution;

c) present a scientifically defensible model based on standard validation guidance and metrics; and

d) provide a suitable tool for assessing the performance of a variety of design options.

1.3 GEOGRAPHICAL OVERVIEW

1.3.0.1 Figure 1-1 presents a geographical summary of the study area. The model covers Swansea Bay and extends south into the Bristol Channel. The spatial extent of the model extends from Worms Head on the south-western tip of the Gower Peninsula to Porthcawl on the east. The model includes the tidal reaches of the River Neath (Afon Nedd), River Tawe (Afon Tawe) and River Afan (Afon Afan).

1.3.0.2 The model is centred on Swansea Bay the area of interest in this study and covers the critical assets that might affect water quality within the proposed Swansea Bay Tidal Lagoon and surrounding waters. The model domain is shown in Figure 1-1.

1.4 TIME AND SPACE COORDINATE DEFINITIONS

1.4.0.1 All dates and times are specified in Greenwich Mean Time (GMT).

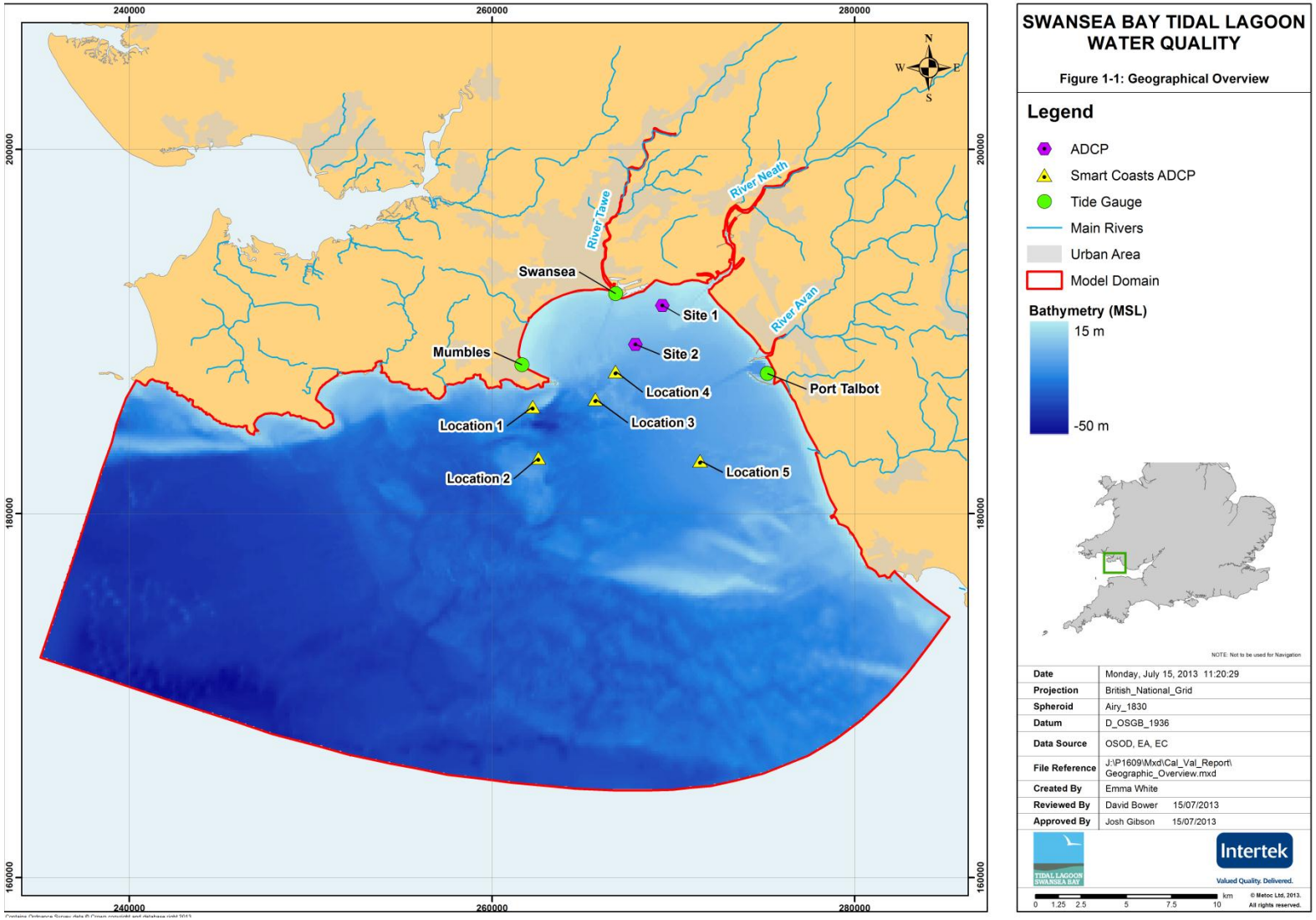
1.4.0.2 Unless otherwise stated, horizontal positions (latitudes and longitudes in degrees, or Eastings and Northings, in metres) are expressed in the Ordnance Survey of Great Britain 1936 (OSGB36) coordinate system.

1.4.0.3 Unless otherwise stated, vertical positions are expressed to mean sea level (MSL). Conversions to vertical datums of ODN and local Chart Datum (CD) are provided based on data provided in the UK Hydrographic Office publications.

1.4.0.4 Model element locations, expressed as (x,y) coordinates, are referenced to Ordnance Survey of Great Britain 1936 (OSGB36).

1.4.0.5 Current direction refers to the direction towards which the current is flowing, in degrees clockwise from true north (°T).

Figure 1-1 : Geographical Overview



2 MODELLING APPROACH

2.0.0.1 A new model of the study site and surrounding coastalarea has been constructed. The model is based on an existing model of Swansea Bay which has been refined for the specific purpose of this study. The updated model is validated against measured hydrodynamic data collected in recent deployments. The result is a tidal model capable of accurately representing the current scenario in terms of both circulation (hydrodynamics) and pollutant transport (advection dispersion).

2.0.0.2 For continuity the model is constructed using the same bathymetric data used in the coastal process model built by ABPmer. Specifics of the hydrodynamic model refinement are detailed in Section 2.2.

2.1 OVERVIEW OF THE EXISTING MODEL

2.1.0.1 The existing model was constructed using the Delft3D modelling system, Delft3D is an accurate and robust suite of software available for conducting marine simulations, with the software being used extensively for academic research and consultation throughout the world.

2.1.0.2 The Swansea Bay model was originally constructed and validated in the early 1990s by Delft Hydraulics and Wallace Evans, to support Dŵr Cymru Welsh Water's (DCWW) investment programme, particularly the design of the Swansea and Afan WwTWs.

2.1.0.3 During 2005 and 2006 the model was extensively updated, re-calibrated and validated as part of DCWW's AMP4 investment programme, when the model was used to assess combined impacts of continuous and intermittent discharges on local Bathing Waters. During this time the model was audited by Professor Roger Falconer of Cardiff University and accepted as fit for use by NRW (then the Environment Agency).

2.1.1 Domain and computational mesh

2.1.1.1 The model domain extends from the tip of the Gower Peninsular to Porthcawl and some 15 km to 20 km offshore. The model is two-dimensional, built on a curvilinear grid, with resolution varying from 50 m in Swansea Bay to 200 m at the offshore boundary. Regions of the model of higher resolution include the Bay, estuaries and coastal areas. The far field regions are the offshore close to the boundaries.

2.1.1.2 Besides the updates to the Rivers Tawe and Neath described in Section 2.2.1 the model domain remains unchanged from its existing configuration.

2.1.2 Model Boundaries

Open Boundary

2.1.2.1 A time-varying water level and flux condition is stipulated at the model's seaward boundary. This acts to simulate tidal forcing offshore of the bay, in turn allowing the model to compute the temporally- and spatially-varying tidal flow in the computational domain.

2.1.2.2 The open boundary is comprised of a number of individual boundaries along the seaward extent of the model. The flux and water level time series for these boundaries are generated by tidal prediction using harmonic constants for the tidal constituents listed in Table 2-1.

Table 2-1 : Harmonic Constituents

Astronomical Constituents	Harmonic Constituents
O_1	$3MS_2$
K_1	$2MN_2$
μ_2	$2SM_2$
N_2	MN_4
M_2	M_4
S_2	MS_4
K_2	M_6
	$2MS_6$

2.1.2.3 For each boundary the tidal harmonic constituentvalues are given in Appendix A. These constituents permit calculation of tidal current velocity and direction for any given period. The harmonic constants used in the new Swansea Bay model are the same as those used for the existing model

Internal Boundaries

2.1.2.4 Hydrodynamic models may be influenced by larger river discharges. These have been accounted for by entering the key rivers as sources of flow in the model.

2.1.2.5 Table 2-2 presents river flow statistics for the Rivers Tawe, Neath and Afan. The flow statistics have been estimated for the downstream using the river flows at the gauging stations and the catchment areas.

Table 2-2 : River Flow Statistics

River	Gauging Station	Mean Flow (m^3/s)	10 %'ile Flow [m^3/s]	95 %'ile Flow [m^3/s]
Tawe	Ynystanglws	12.48	30.28	1.47
Neath	Resolven and Cilfrew	12.17	30.33	1.06
Afan	Marcroft Weir	5.29	12.11	0.88

2.2 MODEL UPDATES

2.2.0.1 Model updates were carried out specifically for the purpose of modelling hydrodynamics in relation to the proposed tidal lagoon study. These updates are detailed herein. The product of the update is a model, and supporting input data and tools, that are robust, accurate and verified, and provides the necessary level of confidence for application to the proposed study.

2.2.1 Modelling Software

2.2.1.1 The existing Swansea Bay model has been ported into the latest version of WL Delft's Delft3D software.

2.2.2 Bathymetry

2.2.2.1 Model Bathymetry has been updated to include the most complete and up to date sources available. For continuity the bathymetric data is the same as that used in the project coastal process model. Details of the sources of bathymetric data are given in Section 3.1.

2.2.2.2 Additionally the barrage at the mouth of the Tawe is included in the model domain. This allows a more accurate representation of the estuaries' tidal prism.

2.2.3 Mesh Improvements in the Neath and Tawe Rivers

2.2.3.1 The model domain was extended to above the normal tidal limit for the River Tawe, so that a number of sewage discharges could be better represented in the model. At the same time, grid size in the lower Neath was halved to improve resolution in this area of the model, close to the proposed lagoon.

2.2.4 Model Validation

2.2.4.1 The model was validated against recent metocean deployments in Swansea Bay, using the original model calibration coefficients. The details of these metocean deployments are described in Chapter 3.

3 DATA SOURCES

3.0.0.1 Data applicable to the Swansea Bay hydrodynamic modelling system are described in this section. Data is sourced from specific metocean deployments, project partners and existing datasets (specifically bathymetry).

3.1 BATHYMETRIC DATA

3.1.0.1 A new bathymetry based on the most up-to-date survey data available, including a bathymetric survey of the lagoon area undertaken by TLSB in 2011. The new bathymetry was provided by ABPmer who are undertaking the coastal process assessment. As such the water quality model will be based on the same base data as the coastal process model.

Table 3-1 : Bathymetric Data Sources

Source	Extent	Year	Reference Datum
ABP Swansea	Swansea Approach Channel	2012	Chart Datum
TLSB	Proposed Lagoon Location	2012	Chart Datum
Coastline Response study	Swansea Bay Intertidal Area	1991	Ordnance Datum (Newlyn)
United Kingdom Hydrographic Office (UKHO)	Outer Swansea Bay and Bristol Channel	1980-1998	Chart Datum
Neath Estuary Working Group	Neath Estuary	2010	Chart Datum

3.1.0.2 The data provided by TLSB consist of high resolution multibeam survey data, collected by Titan Surveys. Resolution of this data is 1x1 m, sufficient for accurate representation of the proposed development area.

3.1.0.3 In regions where the bathymetric data provided by ABPmer did not cover Intertek's model domain data from the previous model was used. This data was used exclusively for regions in the far field of the model away from the study site.

3.2 TIDAL DATA

3.2.1 Tidal Levels

3.2.1.1 Tidal level data from three tide gauges were provided by ABPmer. The data was sourced from ABP port and National Tide and Sea Level Facility (NTSLF). Additional tidal level data were measured during current velocity surveys carried out by Titan and EMU in 2012.

3.2.1.2 Details of the tidal level data are given in Table 3-2.

3.2.1.3 The geographic positions of the gauges are presented in Figure 1-1.

Table 3-2 : Tidal Level Data

Tidal Gauging Station	Provider	Start Date	Finish Date	Timestep	Easting	Northing
Swansea	ABP	16/02/2012	17/05/2013	10 minute	266815	192085
Port Talbot	ABP	16/02/2012	17/05/2013	10 minute	275185	187695
Mumbles	NTSLF	07/03/2012	17/05/2013	15 minute	263280	187500
AWAC Site 1	Titan	16/02/2012	12/04/2012	10 minute	269397	191445
AWAC Site 2	Titan	16/02/2012	11/04/2012	10 minute	267897	189265
Smart Coast 1	EMU	21/07/2012	31/08/2012	10 minute	262249	185868
Smart Coast 2	EMU	20/07/2012	28/08/2012	10 minute	262566	183059
Smart Coast 3	EMU	20/07/2012	31/08/2012	10 minute	265705	186276
Smart Coast 4	EMU	20/07/2012	31/08/2012	10 minute	266820	187805
Smart Coast 5	EMU	20/07/2012	27/08/2012	10 minute	271481	182899

3.2.2 Current Velocity

3.2.2.1 Tidal level, speed and direction data were measured by Titan in 2012. Data was collected with the use of two Noretek Acoustic Wave and Current Profilers (AWAC), at two deployments within Swansea Bay. Additional current velocity was measured during the EU funded Smart Coasts project, undertaken by Aberystwyth and Cardiff Universities. These surveys were carried out by EMU Ltd. in 2012.

3.2.2.2 Details of the ADCP geographical positioning are given in Table 3-3 below. The geographic positions of the AWACs are presented in Figure 1-1.

Table 3-3: ADCP deployments

Site	Geodetic (WGS84)		Grid (OS Nat Grid)	
	Latitude	Longitude	Easting	Northing
AWAC Site 1	51°36.3991'N	003°53.2427'W	269397	191445
AWAC Site 1	51°35.2188'N	003°54.4930'W	267897	189265
Smart Coast 1	51°33.289'N	003°59.314'W	262249	185868
Smart Coast 2	51°31.803'N	003°58.944'W	262566	183059
Smart Coast 3	51°33.576'N	003°56.167'W	265705	186276
Smart Coast 4	51°34.394'N	003°55.379'W	266820	187805
Smart Coast 5	51°31.817'N	003°51.207'W	271481	182899

4 HYDRODYNAMIC VALIDATION

4.0.0.1 The model was validated, using existing calibration coefficients, by comparing predictions of water level and flow velocity against measured data.. The validation was undertaken over a complete spring / neap tidal cycle.

4.0.0.2 Model fit to field data can be assessed in two ways:

a) visual comparison of the model output against observed data: the shape, trend, range and limits of model output and observed data; or

b) statistical comparison of the difference between observation and the model to determine the frequency with which the model fits observation within defined limits against a set of statistical metrics.

4.0.0.3 In practice both methods should be used, as no single method provides a comprehensive assessment of model performance.

4.0.0.4 For continuity in the modelling approach, the metrics by which the degree of validation is measured are the same as those compiled and utilised by ABPmer. These metrics are drawn from academic best practise[i,ii,iii]. A compilation of the guidance metrics is given by ABPmer[iv].

4.0.0.5 The performance metrics provide a comparative measure to ensure that the hydrodynamic scheme is fit for purpose. A description of the performance metrics is set out in Section 4-2. In each of the tables given in this section results are derived by subtracting observed values from measured values. A positive value indicates that the model is over-predicting observed values, whilst a negative value indicates that the model is under-predicting observed values.

4.1 VALIDATION GUIDELINES

4.1.0.1 The performance metrics used to assess the performance of the hydrodynamic model are set out below.

4.1.1 Water Levels

4.1.1.1 *Mean surface elevation difference*: Calculated as the mean difference (bias) in water level across the full spring-neap time-series (model minus observed value). The mean difference is also expressed as a percentage of the mean tidal range;

4.1.1.2 *Mean phase difference*: Calculated as the mean magnitude of time difference between the model and observed data, over a spring neap cycle; and

4.1.1.3 *RMS surface elevation*. This value is calculated as the RMS (root mean square) value for the surface elevation difference, over a spring neap cycle.

4.1.2 Current Speeds

4.1.2.1 *Mean flow speed difference*: Calculated as the mean difference between the magnitudes throughout the full spring-neap cycle. This is also calculated as a percentage value relative to the maximum observed speed;

4.1.2.2 *Mean flow direction difference*: calculated as the mean of the difference in flow direction recorded throughout the full spring-neap cycle;

4.1.2.3 *RMS of peak flow*: this value is the RMS error of the peak flow speed difference. This is calculated using the same method as above, upon the application of a time adjusted fit; and

4.1.2.4 *Scatter Index*: The scatter index is calculated as the RMS error, normalised by the mean value.

4.2 RECOMMENDED VALUES

4.2.0.1 The guidance limits set out by ABPmer (2011) state the following as recommended values for model calibration.

4.2.1 Water Levels

4.2.1.1 Mean level differences should be within ±0.2 m, while the percentage difference should be within 15 % of spring and 20 % of neap tidal ranges. Water level phasing at high and low water should be within ±20 minutes, while RMS scores should be less than 0.2.

4.2.2 Current Speeds

4.2.2.1 Modelled flow should be within ±0.2 m/s or ± 10 – 20 % of equivalent peak observed speeds, while modelled directions should be within ±20° of observed directions, and phasing within ±20 minutes. RMS scores should be less than 0.2, while Scatter Index scores should be less than 0.5.

4.2.3 Validation Performance Criteria Applied to the Model

4.2.3.0 Table 4-1 summarises the performance metrics by which the model validation is measured.

Table 4-1: Model validation guidelines.

Parameter	Metric	Recommended Allowable Deviation	
		Absolute Difference	Percentage Difference
Water Level	Mean Surface Elevation Difference	± 0.2 m	15% for springs 20% for neaps
	Mean Phase Difference	± 20 minutes	-
	RMS surface Elevation	< 0.2	-
Current Speed	Mean Flow Speed Difference	± 0.2 m/s	10 % - 20 %
	Mean Flow Direction Difference	± 20°	-
	RMS of peak flow	< 0.2	-
	Scatter Index	< 0.5	-

Notes:* 10% of observed spring tidal ranges, and 15% of observed neap tidal ranges

** There should be a sound relationship between phasing of currents and elevations

4.3 VALIDATION DATA

4.3.1 Data Collection Programme

4.3.1.1 As described in section 3.2 a number of recent (2012) water level and velocity data sets have been used for model validation, over a total of 10 sites. A summary of the datasets used is provided below.

4.3.2 Field Data Locations

4.3.2.1 The location of field measurement sites, their depths and the source of these data are provided in Table 4-2. The geographic positions of the field data locations are presented in Figure 1-1.

Table 4-2 : Summary of tide gauge and current meter deployments

Site	Easting	Northing	Water depth [m]	Details
Port Talbot	275185	187695	5.34	ABP Tide gauge
Swansea	266815	192085	5.06	ABP Tide gauge
Mumbles	263280	187500	5.13	NTSLF Tide gauge
AWAC Site 1	269397	191445	8.41	ADCP
AWAC Site 2	267897	189265	10.6	ADCP
Smart Coast ADCP 1	262249	185868	5.18	ADCP
Smart Coast ADCP 2	262566	183059	5.12	ADCP
Smart Coast ADCP 3	265705	186276	5.19	ADCP
Smart Coast ADCP 4	266820	187805	5.19	ADCP
Smart Coast ADCP 5	271481	182899	5.16	ADCP

4.3.3 Analysis of Field Data

4.3.3.1 The field data was analysed to provide details of the length of record of the field data together with maxima and, where appropriate, ranges of the data. In addition, the field data has also been analysed to provide tidal constituents and subsequently re-predicted for the same period as the measurements. This process enabled the removal of short-term meteorological and instrumental effects from the field data.

Port Talbot Tide Gauge

4.3.3.2 Tidal elevation data is available from ABP's Port Talbot tide gauge for the period16/02/2012 ~ 17/05/2012. Figure B-1 shows the recorded and re-predicted elevations for that period.

4.3.3.3 In this period the highest measured tidal elevation was 5.16 metres above mean sea level and the lowest recorded elevation was 5.04 metres below mean sea level.

4.3.3.4 The mean tidal ranges at Port Talbot[v] are:

Spring - 8.6 metres

Neap - 3.8 metres

Swansea Tide Gauge

4.3.3.5 Tidal elevation data is available from ABP's Swansea tide gauge for the period16/02/2012 ~ 17/05/2012. Figure B-2 shows the recorded and re-predicted elevations for that period.

4.3.3.6 In this period the highest measured tidal elevation was 5.04 metres above mean sea level and the lowest recorded elevation was 4.76 metres below mean sea level. The mean tidal ranges at Swanseav are:

Spring - 8.6 metres

Neap - 4.1 metres

Mumbles Tide Gauge

4.3.3.7 Tidal elevation data is available from Mumbles tide gauge for the period07/03/2012 ~ 17/05/2012. Figure B-3 shows the recorded and re-predicted elevations for that period.

4.3.3.8 In this period the highest measured tidal elevation was 5.11 metres above mean sea level and the lowest recorded elevation was 4.28 metres below mean sea level. The mean tidal ranges at Mumbles are:

Spring - 8.4 metres

Neap - 3.8 metres

Site 1 AWAC Deployment

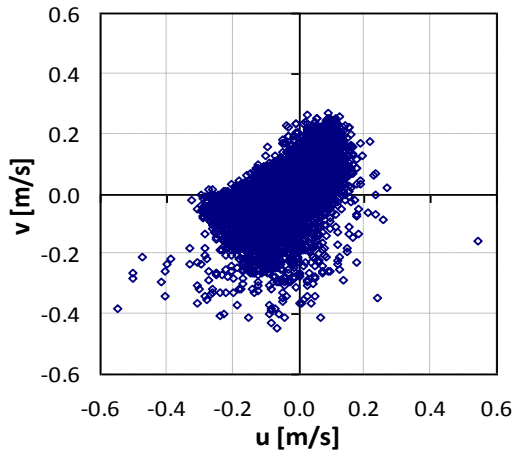
4.3.3.9 Tidal elevation and current velocity data is available at AWAC Site 1 for the period16/02/2012 ~ 12/04/2012. Figure B-4 shows the recorded elevations for that period.

4.3.3.10 In this period the highest measured tidal elevation was 5.13 metres above mean sea level and the lowest recorded elevation was 3.79 metres below mean sea level.The figure shows that under spring tidal conditions, Site 1 dries at low water.

4.3.3.11 Figure B-5 and Figure B-6 show the measured current speed and current direction, respectively. Peak measured current speeds are in excess of 0.88 m/s. Measured current directions typically vary between 30°N and 255°N.

4.3.3.12 Due to the drying nature of the site, measured tidal elevations and tidal velocities at this site were not suitable for tidal analysis. However, as an alternative to tidal re-prediction, the field and modelled data has been adjusted to remove the drying period from subsequent comparisons. This approach ensures that comparisons with modelled data are only made when the current meters results are considered to be valid. Figure 4.1 shows a scatter plot of tidal currents at Site 1.

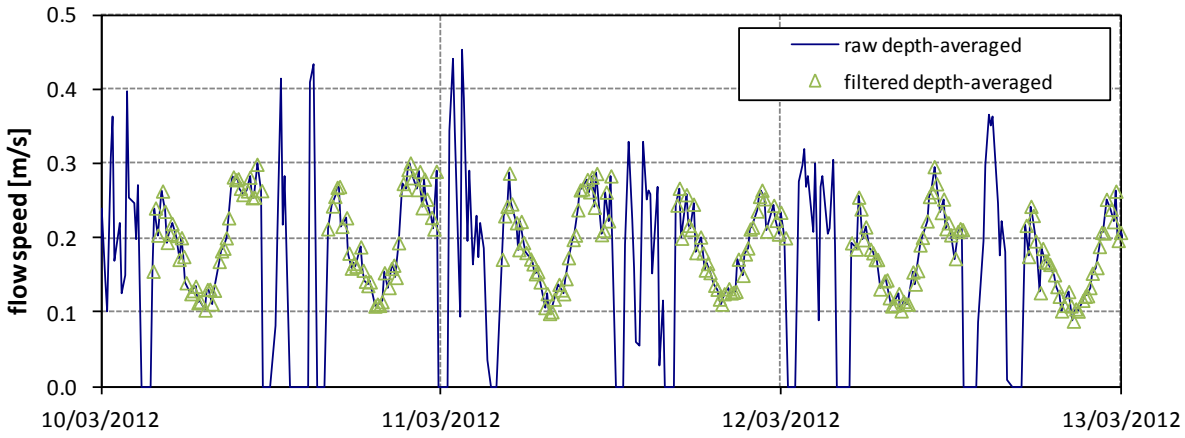
Figure 4-1: Scatter Plot of Tidal Currents at AWAC Site 1



4.3.3.13 This scatter plot shows that there is no clear tidal direction at this site and that current directions are constantly changing. Furthermore, this plot shows that current velocities are generally below 0.3 m/s.

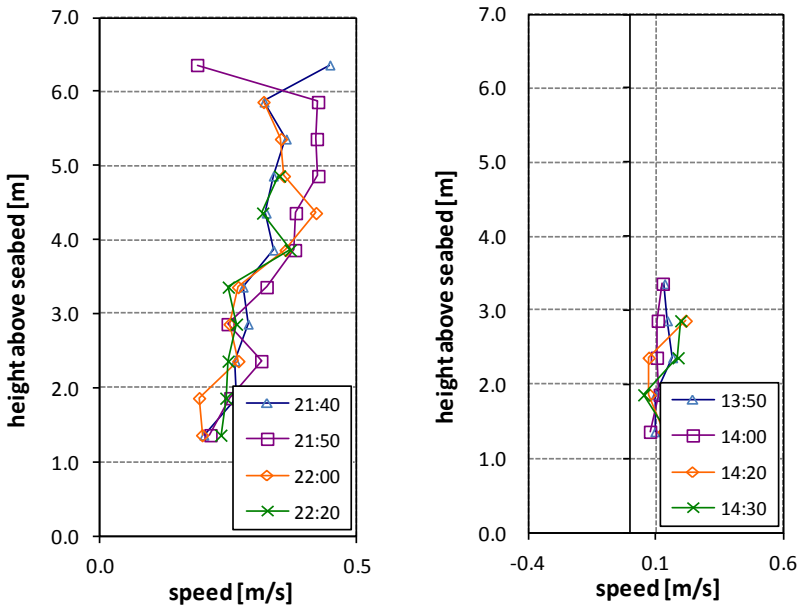
4.3.3.14 Figure 4-2 shows measured and filtered currents speeds at AWAC site 1 over a period of 3 days when the position of the gauge dried. This figure shows that current speeds and directions measured during the drying period do not form a reliable basis for the validation process.

Figure 4-2: Current speed detail – AWAC Site 1



4.3.3.15 Figure 4-3 shows measured current speeds through the water column at this site. The figure demonstrates that current speeds through the water column are relatively constant, indicating that the use of a two dimensional model is appropriate.

Figure 4-3: Current speed at depth – AWAC Site 1



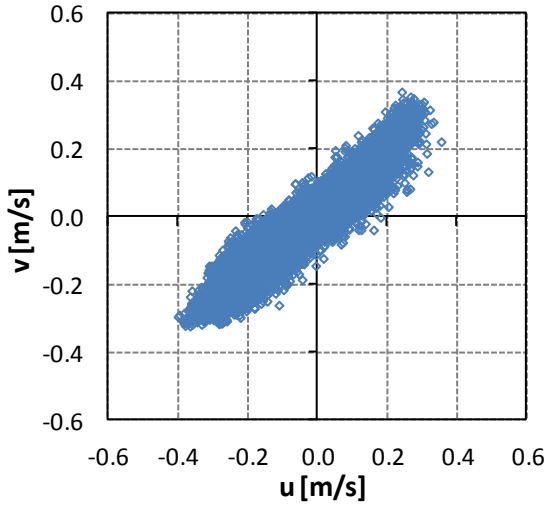
Site 2 AWAC Deployment

4.3.3.16 Tidal elevation and current velocity data is available at AWAC Site 2 for the period16/02/2012 ~ 11/04/2012. Figure B-7 shows the recorded and re-predicted elevations for that period.

4.3.3.17 In this period the highest measured tidal elevation was 5.18 metres above mean sea level and the lowest recorded elevation was 4.96 metres below mean sea level.

4.3.3.18 Figure B-8 and Figure B-9 show the measured and re-predicted current speed and current direction, respectively. Peak measured current speeds are around 0.5 m/s. Measured current directions typically vary between 45°N and 235°N. Figure 4.4 shows a scatter plot of tidal currents at Site 2.

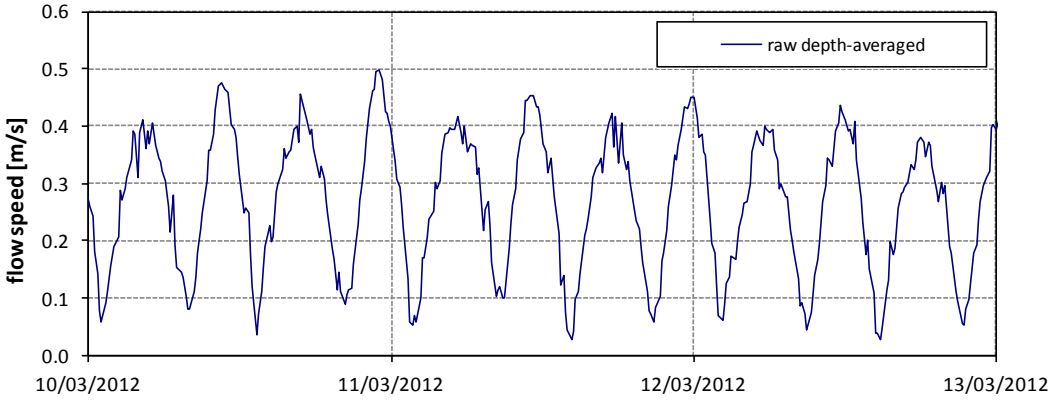
Figure 4-4: Scatter Plot of Tidal Currents at AWAC Site 2



4.3.3.19 This scatter plot shows a clear tidal signal with the current flooding to the north east and ebbing to the south west. Furthermore, this plot shows that maximum current velocities are in excess of 0.35 m/s.

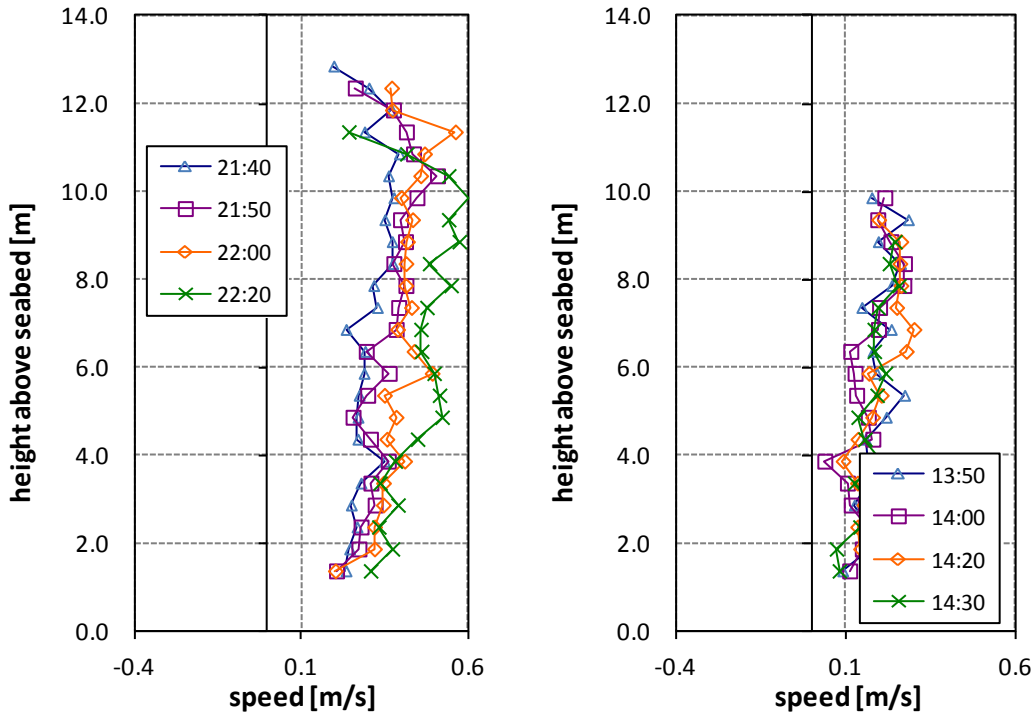
4.3.3.20 Figure 4-5 shows measured currents speeds at AWAC site 2 over the same period of 3 days. This figure shows a clear tidal current speed signal and indicates that current speeds and directions measured at this site form a reliable basis for the validation process.

Figure 4-5: Current speed detail – AWAC Site 2



4.3.3.21 Figure 4-6 shows measured current speeds through the water column at this site. The figure demonstrates that current speeds through the water column are relatively constant, indicating that the use of a two dimensional model is appropriate.

Figure 4-6: Current speed at depth – AWAC Site 2



Smart Coast ADCP Deployment Site 1

4.3.3.22 Current velocity data is available at Smart Coast Site 1 for the period21/07/2012 ~ 31/08/2012. Figure B-10 shows the recorded and re-predicted elevations for that period.

4.3.3.23 In this period the highest measured tidal elevation was 4.82 metres above mean sea level and the lowest recorded elevation was 5.18 metres below mean sea level.

4.3.3.24 Figure B-11 and Figure B-12 show the measured and re-predicted current speed and current direction, respectively. Peak measured and re-predicted current speeds are in excess of 1 m/s. Measured and re-predicted current directions typically vary between 90°N and 270°N.

Smart Coast ADCP Deployment Site 2

4.3.3.25 Current velocity data is available at Smart Coast Site 2 for the period20/07/2012 ~ 28/08/2012. Figure B-13 shows the recorded and re-predicted elevations for that period.

4.3.3.26 In this period the highest measured tidal elevation was 4.73 metres above mean sea level and the lowest recorded elevation was 4.34 metres below mean sea level.

4.3.3.27 Figure B-14 and Figure B-15 show the measured and re-predicted current speed and current direction, respectively. Peak measured and re-predicted current speeds are in excess of 1.2 m/s. Measured and re-predicted directions typically vary between 75°N and 260°N.

Smart Coast ADCP Deployment Site 3

4.3.3.28 Current velocity data is available at Smart Coast Site 3 for the period20/07/2012 ~ 31/08/2012. Figure B-16 shows the recorded and re-predicted elevations for that period.

4.3.3.29 In this period the highest measured tidal elevation was 4.71 metres above mean sea level and the lowest recorded elevation was 4.36 metres below mean sea level.

4.3.3.30 Figure B-17 and Figure B-18 show the measured and re-predicted current speed and current direction, respectively. Peak measured and re-predicted current speeds are in excess of 0.9 m/s. Measured and re-predicted directions typically vary between 50°N and 230°N.

Smart Coast ADCP Deployment Site 4

4.3.3.31 Current velocity data is available at Smart Coast Site 4 for the period21/07/2012 ~ 31/08/2012. Figure B-19 shows the recorded and re-predicted elevations for that period.

4.3.3.32 In this period the highest measured tidal elevation was 4.74 metres above mean sea level and the lowest recorded elevation was 4.39 metres below mean sea level.

4.3.3.33 Figure B-20 and Figure B-21 show the measured and re-predicted current speed and current direction, respectively. Peak measured and re-predicted current speeds are in excess of 0.7 m/s. Measured and re-predicted directions typically vary between 45°N and 225°N.

Smart Coast ADCP Deployment Site 5

4.3.3.34 Current velocity data is available at Smart Coast Site 5 for the period20/07/2012 ~ 27/08/2012. Figure B-22 shows the recorded and re-predicted elevations for that period.

4.3.3.35 In this period the highest measured tidal elevation was 4.84 metres above mean sea level and the lowest recorded elevation was 4.35 metres below mean sea level.

4.3.3.36 Figure B-23 and Figure B-24 show the measured current speed and current direction, respectively. Peak measured and re-predicted current speeds are in excess of 0.7 m/s. Measured and re-predicted directions typically vary between 90°N and 270°N.

4.4 HYDRODYNAMIC VALIDATION RESULTS

4.4.0.1 The model was validated for a 14 day neap/spring tidal period in March 2012 for the 3 tide gauges and the AWACs deployments. The model was validated over a 14 day neap/spring tidal period in July 2012 for the 5 Smart Coast deployments.

4.4.1 Validation on Water Levels

4.4.1.1 Modelled tidal elevations were compared against measured elevations at 10 sites (see Table 4-2).

4.4.1.2 It should be noted that the AWAC site 1 dried in some periods of the tide and therefore comparisons with the measured data should be treated with some caution.

4.4.1.3 In order to quantify the model validation, a number of quantitative statistics have been calculated to compare modelled and measured tidal elevations. In addition, modelled tidal elevations have been compared to tidal elevations re-predicted from tidal constituents.

4.4.1.4 The results for the 10 tidal elevation measurement sites are presented in Table 4-3 (comparison with raw measured data) and Table 4.4 (comparison with re-predicted measured data). More detailed comparisons for each site are provided in Appendix C (Tables C-1to C-10).

4.4.1.5 Time series plots of modelled and measured tidal elevations are provided in Appendix D (Figure D-1 to D-10).

Table 4-3: Modelled and measured tidal elevation comparison

Tide Gauge	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)
Port Talbot	-0.03	-0.3%	0.00	0.22
Swansea	-0.04	-0.4%	-5.00	0.15
Mumbles	-0.10	-1.2%	-14.00	0.18
AWAC Site 1	0.02	0.2%	-11.00	0.14
AWAC Site 2	0.03	0.3%	-11.00	0.12
Smart Coast Site 1	0.01	0.1%	-2.00	0.24
Smart Coast Site 2	0.02	0.2%	6.00	0.20
Smart Coast Site 3	0.00	0.1%	-1.00	0.19
Smart Coast Site 4	0.02	0.3%	0.00	0.19
Smart Coast Site 5	0.00	0.0%	-6.00	0.18

Table 4-4: Modelled and re-predicted tidal elevation comparison

Tide Gauge	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)
Port Talbot	-0.02	-0.2%	2.50	0.17
Swansea	-0.03	-0.3%	0.50	0.12
Mumbles	0.01	0.2%	8.50	0.19
AWAC Site 1[a]	0.02	0.2%	-11.00	0.14
AWAC Site 2	0.00	0.0%	-8.50	0.15
Smart Coast Site 1	-0.04	-0.4%	7.00	0.22
Smart Coast Site 2	0.02	0.2%	3.00	0.19
Smart Coast Site 3	-0.01	-0.1%	-1.00	0.17
Smart Coast Site 4	0.00	0.0%	-1.00	0.17
Smart Coast Site 5	0.01	0.1%	-1.00	0.16

[a] comparison over drying period excluded

4.4.2 Validation on Current Velocities

4.4.2.1 Modelled tidal current velocities were compared against measured velocities at 7 sites (see Table 4-2).

4.4.2.2 It should be noted that the AWAC site 1 dried in some periods of the tide and therefore comparisons with the measured data at this site should be treated with some caution.

4.4.2.3 In order to quantify the model validation, a number of quantitative statistics have been calculated to compare modelled and measured tidal elevations.

4.4.2.4 The results for the 7 current velocity measurement sites are presented in Table 4-5 (comparison with raw measured data) and Table 4.6 (comparison with re-predicted measured data). More detailed comparisons for each site are provided in Appendix C (Tables C-11 to C-17).

4.4.2.5 Time series plots of modelled and measured current speeds and directions are provided in Appendix D (Figure D-11 to D-24).

Table 4-5: Modelled and measured current velocity comparison

Current Meter	Mean Speed Diff (m/s)	Mean Speed Diff (%)	Mean Dir Diff (°)	RMS Flow (m/s)	Scatter Index
AWAC Site 1	0.00	-0.6%	-19.99	0.07	0.65
AWAC Site 2	0.02	4.3%	-1.68	0.05	0.27
Smart Coast ADCP 1	-0.03	-3.3%	-8.41	0.06	0.12
Smart Coast ADCP 2	0.02	1.9%	-3.70	0.06	0.10
Smart Coast ADCP 3	0.00	-0.1%	-7.56	0.05	0.13
Smart Coast ADCP 4	0.01	1.2%	-15.31	0.06	0.19
Smart Coast ADCP 5	0.02	2.1%	-25.24	0.07	0.20

Table 4-6: Modelled and Re-predicted current velocity comparison

Current Meter	Mean Speed Diff (m/s)	Mean Speed Diff (%)	Mean Dir Diff (°)	RMS Flow (m/s)	Scatter Index
AWAC Site 1[a]	0.01	3.6%	-0.92	0.05	0.35
AWAC Site 2	0.02	3.5%	-0.32	0.03	0.16
Smart Coast ADCP 1	-0.04	-4.1%	-8.16	0.06	0.12
Smart Coast ADCP 2	-0.04	-4.1%	-8.16	0.06	0.12
Smart Coast ADCP 3	0.00	0.2%	-8.02	0.02	0.06
Smart Coast ADCP 4	0.01	1.6%	-14.01	0.03	0.10
Smart Coast ADCP 5	0.01	1.9%	-24.30	0.03	0.10

[a] comparison over drying period excluded

4.4.3 Summary of Validation Statistics

Tidal Elevations

4.4.3.1 The results presented in Table 4-3 show the agreement between modelled and raw tidal elevation data. Comparison with validation metrics shows that there is good agreement at all sites for the mean water level difference, the percentage mean water level difference and the mean phase difference. Modelled elevations at all sites, except Port Talbot and Smart Coast Site 1, are in good agreement when considered in relation to the RMS WL metric. For Port Talbot and Smart Coast Site 1, the calculated RMS WL metric were calculated to be 0.22 and 0.24, respectively. These values are slightly higher than the target of 0.2 metres.

4.4.3.2 The results presented in Table 4-4 show the agreement between modelled and re-predicted tidal elevation data, except in the case of AWAC Site 1, which shows comparison between modelled and adjusted water levels (see Section 4.3.3.). Similarly, to the raw data assessment, comparisons shows that there is good agreement at all sites for the mean water level difference, the percentage mean water level difference and the mean phase difference. Modelled elevations at all sites, except Smart Coast Site 1, are in good agreement when considered in relation to the RMS WL metric. For Smart Coast Site 1, the calculated RMS WL metric was calculated to be 0.22 metres, slightly higher than the target value.

4.4.3.3 The slightly higher RMS WL at two sites is not considered significant to the model validation. Given the very high tidal range in Swansea Bay an RMS water level difference of 0.24 metres is considered acceptable, and represents an error of less than 3%. Other metrics and time series comparisons (Appendix D) show very good agreement. The model is considered to be in overall good agreement with the measured and re-predicted tidal elevation data.

Current Velocities

4.4.3.4 The results presented in Table 4-5 and Table 4-6 show the agreement between modelled and raw and re-predicted current velocity data, respectively. Comparison with calibration metrics shows that there is good agreement at all sites for the mean speed difference and the percentage mean speed difference. Mean direction differences are in good agreement when considered in relation to the metric at all sites except for Smart Coast ADCP 5, where the mean difference is slightly higher than the prescribed value. Similarly, at AWAC

Site 1, the Scatter Index metric is exceeded, when all recorded data is included in the comparison. However, at this site drying occurs under spring tide conditions making agreement with metric particularly difficult.

4.4.3.5 Overall, the metrics and time series comparisons (Appendix D) show very good agreement. The model is considered to be in overall good agreement with the measured and re-predicted current velocity data.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 MODEL VALIDATION

5.1.0.1 The modelled and field data show good agreement at all sites for the mean water level difference, the percentage mean water level difference and the mean phase difference. At two sites, the calculated RMS WL metric slightly exceeds the target value, although the relative difference is only 3% of the total tidal range. However, other metrics and time series comparisons (Appendix D) show good agreement. The model is considered to be in overall good agreement with the measured and re-predicted tidal elevation data.

5.1.0.2 The modelled and field data show good agreement at all sites for the mean speed difference and the percentage mean speed difference. Mean direction differences are in good agreement when considered in relation to the metric at all sites except for Smart Coast ADCP 5. Drying at AWAC Site 1 makes agreement with the metric particularly difficult and the Scatter Index metric is exceeded at this site. Overall, the metrics and time series comparisons (Appendix D) show good agreement. The model is considered to be in overall good agreement with the measured and re-predicted current velocity data.

5.2 RECOMMENDATION

5.2.0.1 It is recommended that the Swansea Bay model is fit for purpose to simulate the hydrodynamics in Swansea Bay.

6 REFERENCES

[i] Barlett *et al*., 1998; Quality Control Manual for Computational Estuarine Modelling. R&D Technical Report 113. Environment Agency.
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[iii] van Waveren *et al*., 1999. Good Modelling Practice Handbook. STOWA Report 95-05. ISBN 90-5773-056-1.
[iv] ABPmer 2013. Swansea Bay Tidal Lagoon Process. Model Setup, Calibration and Validation. Report number R.2108TN. June 2013.
[v] Admiralty Tide Tables. NP 201-12 2012.

Appendix A Boundary Conditions

TABLES

Table A- 1: Boundary Conditions

Boundary	Start Location	End Location
West Boundary 1	U01	U02
West Boundary 2	U02	U03
West Boundary 3	U03	U19
South Boundary 1	H20	H06
South Boundary 2	H06	H07
South Boundary 3	H07	H08
South Boundary 4	H08	H09
South Boundary 5	H09	H10
South Boundary 6	H10	H12
South Boundary 7	H12	H13
South Boundary 8	H13	H14
South Boundary 9	H14	H15
South Boundary 10	H15	H16
South Boundary 11	H16	H17
South Boundary 12	H18	H19

Table A- 2: Boundary Conditions – U01

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	7.63E-02	0.00E+00	L2	2.61E-02	3.84E+01
MSF	3.03E-02	5.01E+01	S2	1.76E-01	1.16E+02
O1	2.30E-03	2.45E+02	K2	6.16E-02	1.11E+02
K1	2.20E-03	1.58E+01	MN4	2.35E-02	2.87E+02
EPSILON2	1.05E-02	1.56E+02	M4	6.65E-02	3.08E+02
MU2	3.39E-02	1.64E+02	MS4	4.52E-02	3.59E+02
N2	9.38E-02	4.88E+01	M6	1.19E-02	1.10E+02
M2	5.75E-01	6.23E+01	2MS6	1.17E-02	1.58E+02
MKS2	8.90E-03	2.10E+02	M8	1.07E-02	3.43E+02

Table A- 3: Boundary Conditions – U02

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	1.43E-02	0.00E+00	L2	2.18E-02	5.05E+01
MSF	1.06E-02	5.54E+01	S2	2.55E-01	1.28E+02
O1	4.90E-03	2.51E+02	K2	8.93E-02	1.24E+02
K1	4.50E-03	1.85E+01	MN4	1.62E-02	3.26E+02
EPSILON2	8.60E-03	1.70E+02	M4	4.58E-02	3.45E+02
MU2	2.00E-02	1.67E+02	MS4	3.36E-02	3.90E+01
N2	1.35E-01	6.14E+01	M6	9.70E-03	1.36E+02
M2	7.69E-01	7.69E+01	2MS6	1.00E-02	1.81E+02
MKS2	8.60E-03	2.20E+02	M8	5.00E-03	2.23E+01

Table A- 4:Boundary Conditions – U03

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	-8.50E-03	0.00E+00	L2	2.15E-02	4.42E+01
MSF	1.12E-02	2.29E+02	S2	2.69E-01	1.35E+02
O1	6.20E-03	2.62E+02	K2	9.38E-02	1.31E+02
K1	5.70E-03	2.99E+01	MN4	8.30E-03	3.39E+02
EPSILON2	8.40E-03	1.60E+02	M4	2.37E-02	3.57E+02
MU2	2.18E-02	1.47E+02	MS4	1.90E-02	5.49E+01
N2	1.43E-01	6.82E+01	M6	7.80E-03	1.57E+02
M2	7.97E-01	8.28E+01	2MS6	8.10E-03	2.00E+02
MKS2	8.90E-03	2.16E+02	M8	2.70E-03	1.17E+01

Table A- 5: Boundary Conditions – U19

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	-2.98E-02	0.00E+00	L2	1.89E-02	4.07E+01
MSF	1.58E-02	2.32E+02	S2	2.58E-01	1.38E+02
O1	6.40E-03	2.68E+02	K2	8.96E-02	1.34E+02
K1	5.90E-03	3.51E+01	MN4	7.30E-03	3.24E+02
EPSILON2	7.40E-03	1.55E+02	M4	2.10E-02	3.44E+02
MU2	2.06E-02	1.36E+02	MS4	1.65E-02	4.45E+01
N2	1.36E-01	7.13E+01	M6	3.40E-03	1.96E+02
M2	7.52E-01	8.56E+01	2MS6	3.40E-03	2.31E+02
MKS2	8.10E-03	2.14E+02	M8	1.70E-03	3.42E+00

Table A- 6:Boundary Conditions – H20

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	0.00E+00	0.00E+00	L2	2.88E-02	1.11E+02
MSF	1.90E-03	2.21E+02	S2	9.98E-01	2.10E+02
O1	5.76E-02	3.56E+02	K2	3.47E-01	2.07E+02
K1	5.63E-02	1.19E+02	MN4	1.49E-02	1.70E+01
EPSILON2	1.02E-02	2.09E+02	M4	4.49E-02	3.64E+01
MU2	4.87E-02	1.41E+02	MS4	2.93E-02	1.03E+02
N2	5.54E-01	1.46E+02	M6	1.67E-02	1.85E+01
M2	2.90E+00	1.62E+02	2MS6	1.46E-02	7.29E+01
MKS2	1.94E-02	2.76E+02	M8	1.20E-03	2.20E+02

Table A- 7:Boundary Conditions – H06

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	-7.00E-03	0.00E+00	L2	3.29E-02	1.13E+02
MSF	2.50E-03	2.24E+02	S2	1.03E+00	2.11E+02
O1	5.81E-02	3.56E+02	K2	3.59E-01	2.08E+02
K1	5.66E-02	1.19E+02	MN4	1.69E-02	2.07E+01
EPSILON2	1.19E-02	2.13E+02	M4	5.09E-02	3.99E+01
MU2	4.96E-02	1.49E+02	MS4	3.39E-02	1.06E+02
N2	5.71E-01	1.47E+02	M6	1.83E-02	2.23E+01
M2	3.00E+00	1.63E+02	2MS6	1.59E-02	7.72E+01
MKS2	2.09E-02	2.79E+02	M8	1.10E-03	1.57E+02

Table A- 8:Boundary Conditions – H07

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	-9.40E-03	0.00E+00	L2	3.46E-02	1.12E+02
MSF	3.70E-03	2.26E+02	S2	1.05E+00	2.11E+02
O1	5.83E-02	3.56E+02	K2	3.64E-01	2.08E+02
K1	5.67E-02	1.19E+02	MN4	1.80E-02	2.07E+01
EPSILON2	1.27E-02	2.13E+02	M4	5.40E-02	3.99E+01
MU2	5.09E-02	1.51E+02	MS4	3.60E-02	1.06E+02
N2	5.79E-01	1.47E+02	M6	1.79E-02	2.34E+01
M2	3.04E+00	1.63E+02	2MS6	1.55E-02	7.88E+01
MKS2	2.16E-02	2.78E+02	M8	1.40E-03	1.33E+02

Table A- 9: Boundary Conditions – H08

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	-8.80E-03	0.00E+00	L2	3.80E-02	1.12E+02
MSF	2.70E-03	2.26E+02	S2	1.07E+00	2.12E+02
O1	5.87E-02	3.56E+02	K2	3.72E-01	2.09E+02
K1	5.69E-02	1.19E+02	MN4	1.90E-02	2.29E+01
EPSILON2	1.41E-02	2.16E+02	M4	5.72E-02	4.21E+01
MU2	5.21E-02	1.56E+02	MS4	3.85E-02	1.08E+02
N2	5.91E-01	1.48E+02	M6	1.82E-02	2.63E+01
M2	3.11E+00	1.64E+02	2MS6	1.56E-02	8.25E+01
MKS2	2.29E-02	2.80E+02	M8	2.20E-03	1.14E+02

Table A- 10: Boundary Conditions – H09

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	-8.80E-03	0.00E+00	L2	3.80E-02	1.12E+02
MSF	2.70E-03	2.26E+02	S2	1.07E+00	2.12E+02
O1	5.87E-02	3.56E+02	K2	3.72E-01	2.09E+02
K1	5.69E-02	1.19E+02	MN4	1.90E-02	2.29E+01
EPSILON2	1.41E-02	2.16E+02	M4	5.72E-02	4.21E+01
MU2	5.21E-02	1.56E+02	MS4	3.85E-02	1.08E+02
N2	5.91E-01	1.48E+02	M6	1.82E-02	2.63E+01
M2	3.11E+00	1.64E+02	2MS6	1.56E-02	8.25E+01
MKS2	2.29E-02	2.80E+02	M8	2.20E-03	1.14E+02

Table A- 11: Boundary Conditions – H10

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	-1.20E-02	0.00E+00	L2	4.19E-02	1.12E+02
MSF	3.90E-03	2.27E+02	S2	1.10E+00	2.12E+02
O1	5.91E-02	3.55E+02	K2	3.82E-01	2.09E+02
K1	5.71E-02	1.19E+02	MN4	2.09E-02	2.26E+01
EPSILON2	1.59E-02	2.17E+02	M4	6.27E-02	4.19E+01
MU2	5.47E-02	1.62E+02	MS4	4.22E-02	1.08E+02
N2	6.05E-01	1.48E+02	M6	1.76E-02	3.02E+01
M2	3.20E+00	1.64E+02	2MS6	1.51E-02	8.74E+01
MKS2	2.44E-02	2.81E+02	M8	3.20E-03	1.04E+02

Table A- 12: Boundary Conditions – H12

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	-1.09E-02	0.00E+00	L2	4.81E-02	1.14E+02
MSF	1.80E-03	2.22E+02	S2	1.13E+00	2.14E+02
O1	5.96E-02	3.56E+02	K2	3.93E-01	2.11E+02
K1	5.74E-02	1.20E+02	MN4	2.27E-02	2.39E+01
EPSILON2	1.85E-02	2.21E+02	M4	6.81E-02	4.35E+01
MU2	5.82E-02	1.72E+02	MS4	4.58E-02	1.10E+02
N2	6.23E-01	1.50E+02	M6	1.61E-02	3.87E+01
M2	3.30E+00	1.65E+02	2MS6	1.36E-02	9.87E+01
MKS2	2.65E-02	2.84E+02	M8	4.80E-03	1.01E+02

Table A- 13: Boundary Conditions – H13

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	-1.37E-02	0.00E+00	L2	5.04E-02	1.15E+02
MSF	2.80E-03	2.25E+02	S2	1.14E+00	2.15E+02
O1	5.97E-02	3.56E+02	K2	3.97E-01	2.12E+02
K1	5.75E-02	1.20E+02	MN4	2.38E-02	2.32E+01
EPSILON2	1.95E-02	2.23E+02	M4	7.13E-02	4.29E+01
MU2	5.99E-02	1.76E+02	MS4	4.76E-02	1.09E+02
N2	6.29E-01	1.50E+02	M6	1.52E-02	4.31E+01
M2	3.34E+00	1.66E+02	2MS6	1.28E-02	1.05E+02
MKS2	2.73E-02	2.85E+02	M8	5.40E-03	1.00E+02

Table A- 14: Boundary Conditions – H14

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	-1.00E-02	0.00E+00	L2	5.49E-02	1.18E+02
MSF	4.00E-04	8.75E+01	S2	1.16E+00	2.18E+02
O1	5.99E-02	3.57E+02	K2	4.01E-01	2.14E+02
K1	5.75E-02	1.21E+02	MN4	2.35E-02	2.41E+01
EPSILON2	2.16E-02	2.27E+02	M4	7.05E-02	4.42E+01
MU2	6.29E-02	1.84E+02	MS4	4.68E-02	1.12E+02
N2	6.35E-01	1.53E+02	M6	1.44E-02	5.39E+01
M2	3.38E+00	1.68E+02	2MS6	1.24E-02	1.18E+02
MKS2	2.88E-02	2.88E+02	M8	6.60E-03	1.01E+02

Table A- 15: Boundary Conditions – H15

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	-1.18E-02	0.00E+00	L2	5.81E-02	1.19E+02
MSF	5.00E-04	7.72E+01	S2	1.16E+00	2.19E+02
O1	6.01E-02	3.57E+02	K2	4.04E-01	2.16E+02
K1	5.76E-02	1.21E+02	MN4	2.37E-02	2.28E+01
EPSILON2	2.31E-02	2.29E+02	M4	7.10E-02	4.32E+01
MU2	6.58E-02	1.89E+02	MS4	4.66E-02	1.11E+02
N2	6.40E-01	1.54E+02	M6	1.34E-02	6.37E+01
M2	3.42E+00	1.69E+02	2MS6	1.19E-02	1.30E+02
MKS2	2.98E-02	2.90E+02	M8	7.20E-03	1.03E+02

Table A- 16: Boundary Conditions – H16

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	-1.00E-02	0.00E+00	L2	5.97E-02	1.21E+02
MSF	2.80E-03	5.44E+01	S2	1.16E+00	2.20E+02
O1	6.01E-02	3.58E+02	K2	4.04E-01	2.17E+02
K1	5.76E-02	1.22E+02	MN4	2.27E-02	2.36E+01
EPSILON2	2.39E-02	2.31E+02	M4	6.81E-02	4.43E+01
MU2	6.67E-02	1.92E+02	MS4	4.45E-02	1.13E+02
N2	6.40E-01	1.55E+02	M6	1.35E-02	6.52E+01
M2	3.42E+00	1.71E+02	2MS6	1.21E-02	1.32E+02
MKS2	3.03E-02	2.92E+02	M8	7.60E-03	1.03E+02

Table A- 17:Boundary Conditions – H17

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	-5.30E-03	0.00E+00	L2	6.20E-02	1.23E+02
MSF	7.00E-03	5.09E+01	S2	1.16E+00	2.22E+02
O1	6.03E-02	3.58E+02	K2	4.04E-01	2.19E+02
K1	5.76E-02	1.23E+02	MN4	1.93E-02	2.70E+01
EPSILON2	2.51E-02	2.33E+02	M4	5.89E-02	4.89E+01
MU2	6.86E-02	1.97E+02	MS4	3.90E-02	1.20E+02
N2	6.41E-01	1.57E+02	M6	1.37E-02	6.74E+01
M2	3.43E+00	1.72E+02	2MS6	1.24E-02	1.36E+02
MKS2	3.11E-02	2.94E+02	M8	7.90E-03	1.08E+02

Table A- 18: Boundary Conditions – H18

Constituent	Amplitude (m)	Phase (degrees)	Constituent	Amplitude (m)	Phase (degrees)
A0	-5.30E-03	0.00E+00	L2	6.20E-02	1.23E+02
MSF	7.00E-03	5.09E+01	S2	1.16E+00	2.22E+02
O1	6.03E-02	3.58E+02	K2	4.04E-01	2.19E+02
K1	5.76E-02	1.23E+02	MN4	1.93E-02	2.70E+01
EPSILON2	2.51E-02	2.33E+02	M4	5.89E-02	4.89E+01
MU2	6.86E-02	1.97E+02	MS4	3.90E-02	1.20E+02
N2	6.41E-01	1.57E+02	M6	1.37E-02	6.74E+01
M2	3.43E+00	1.72E+02	2MS6	1.24E-02	1.36E+02
MKS2	3.11E-02	2.94E+02	M8	7.90E-03	1.08E+02

Appendix B Field Data

FIGURES

Figure B- 1: Port Talbot Measured and Re-predicted Tidal Elevations

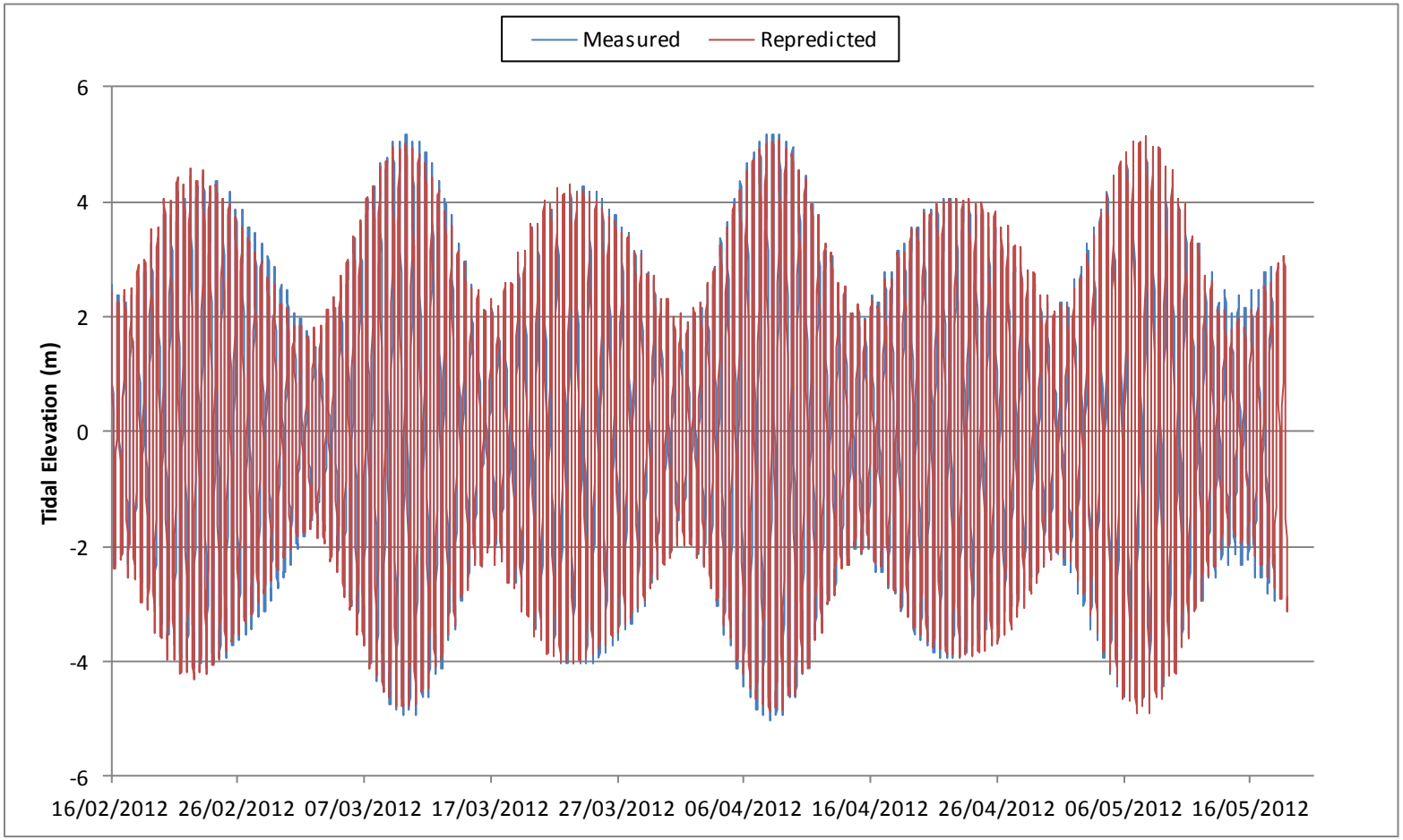


Figure B- 2: Swansea Measured and Re-predicted Tidal Elevations

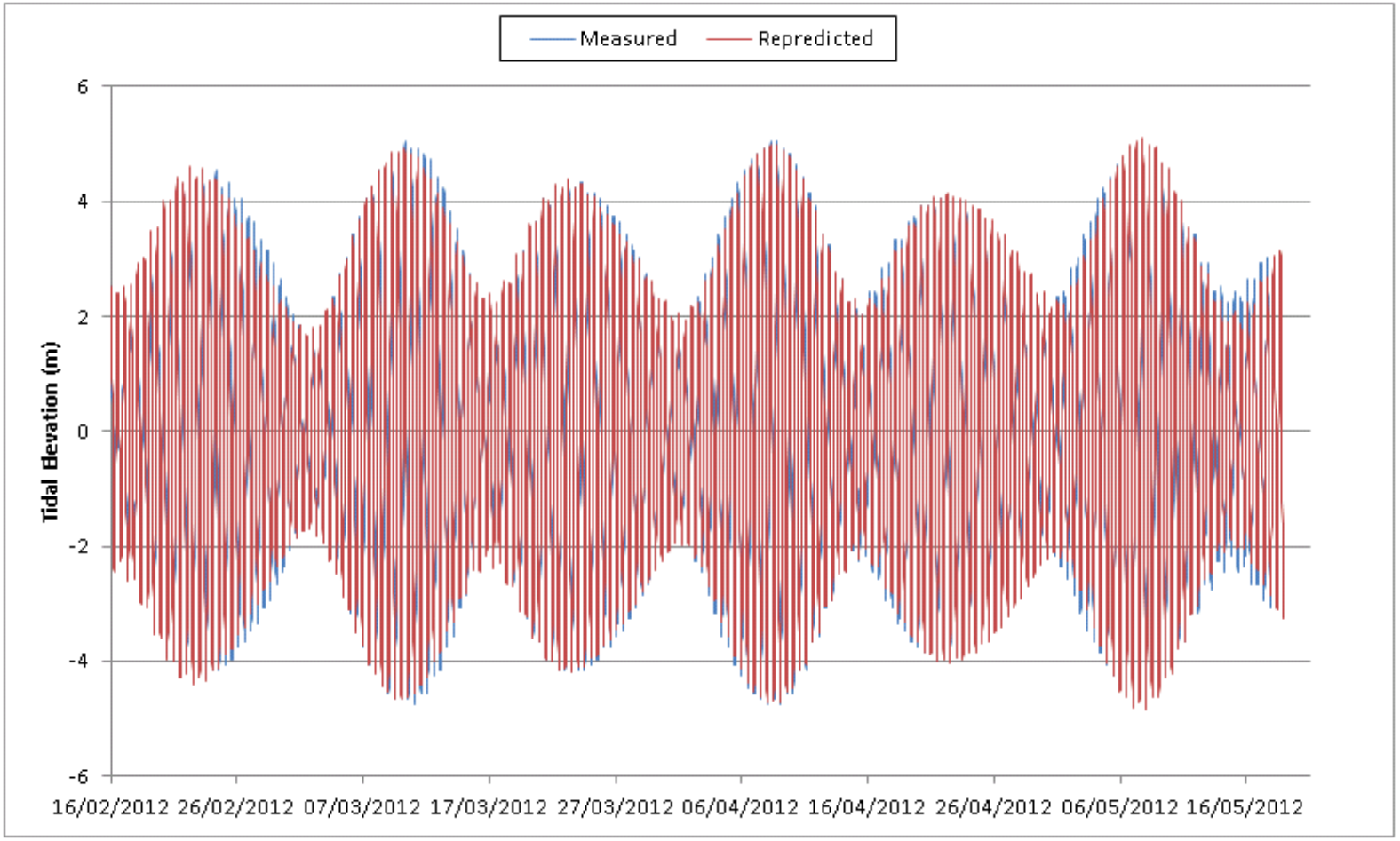


Figure B- 3: Mumbles Measured and Re-predicted Tidal Elevations

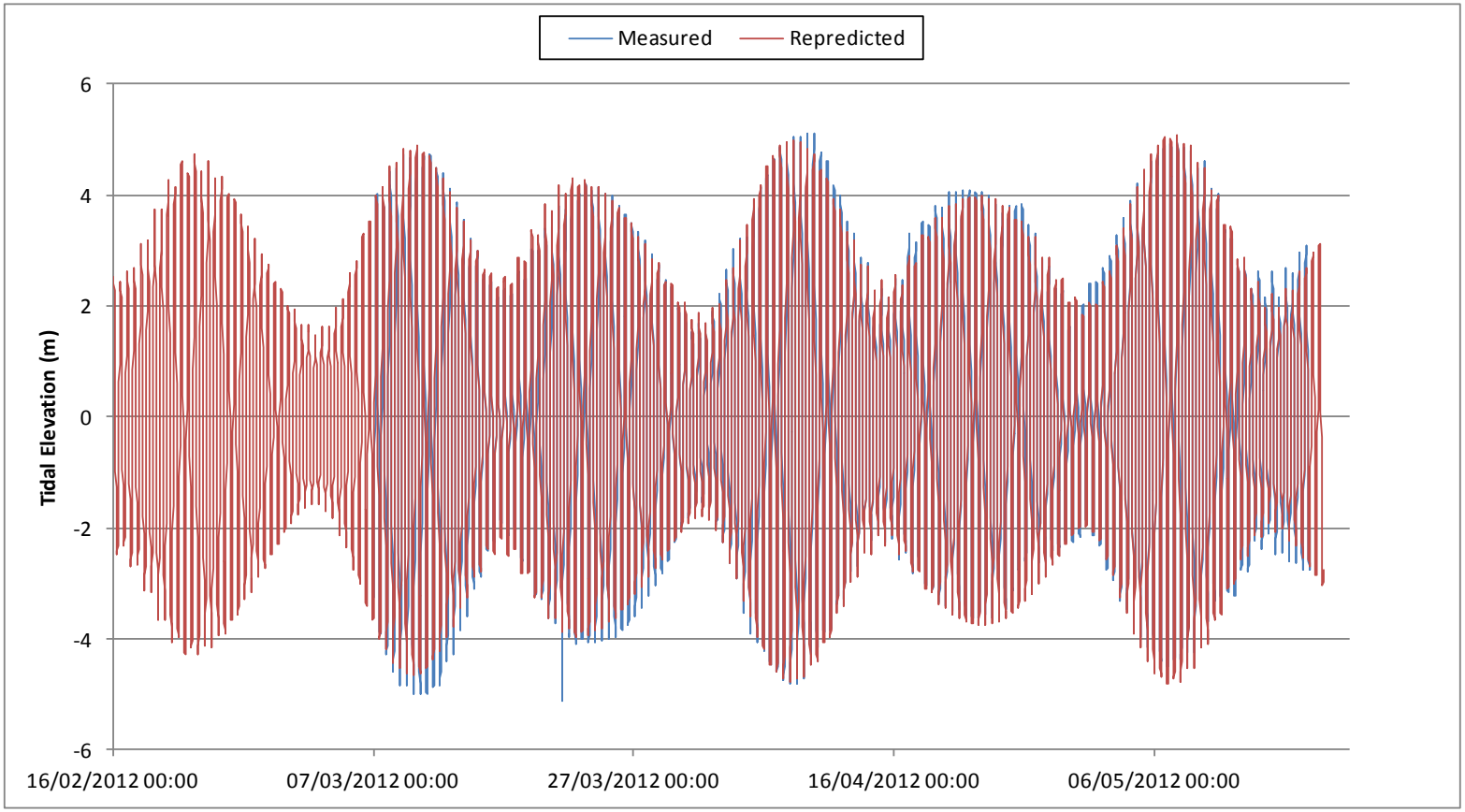


Figure B- 4: AWAC Site 1 Measured Tidal Elevations

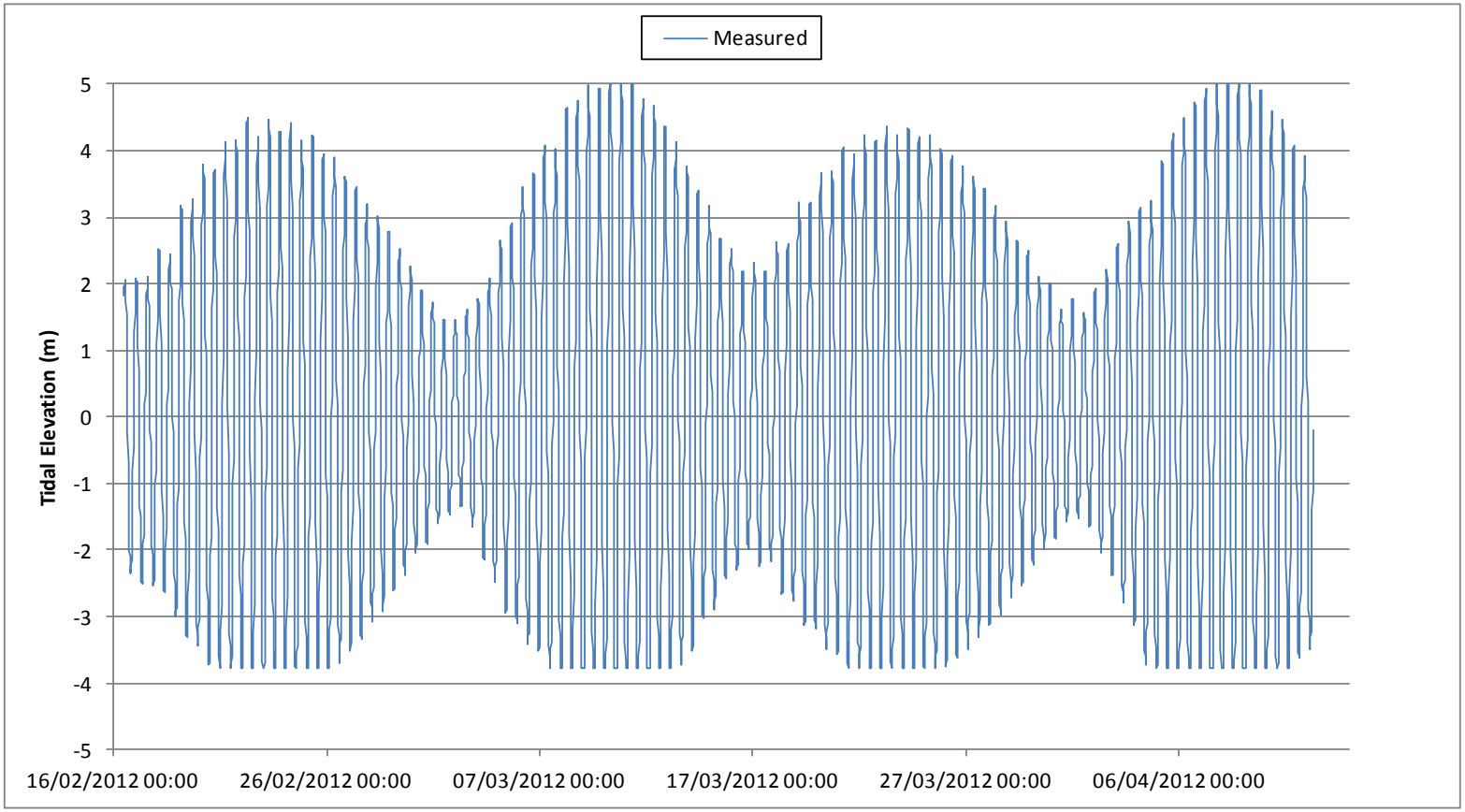


Figure B- 5: AWAC Site 1 Measured Current Speed

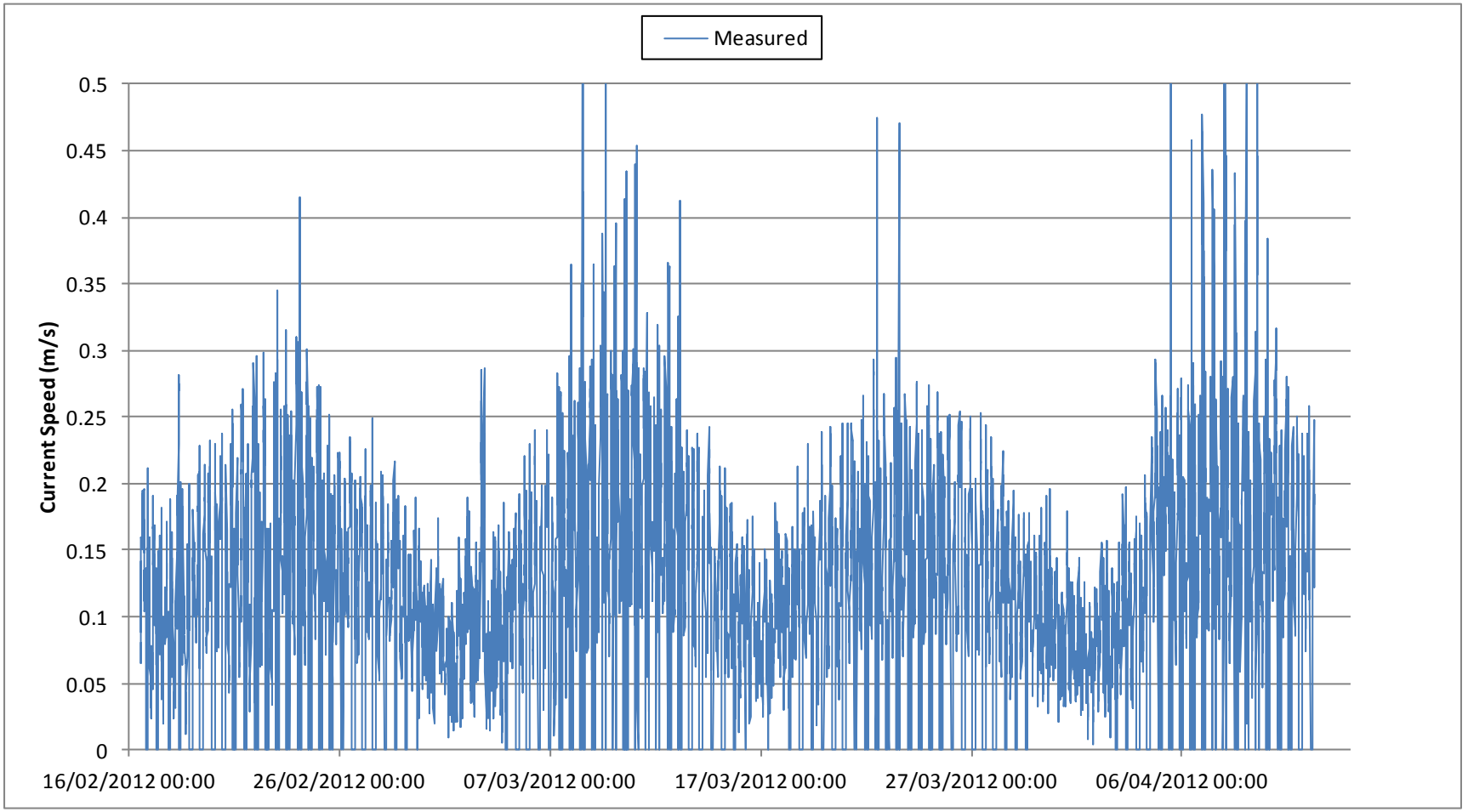


Figure B- 6: AWAC Site 1 Measured Current Direction

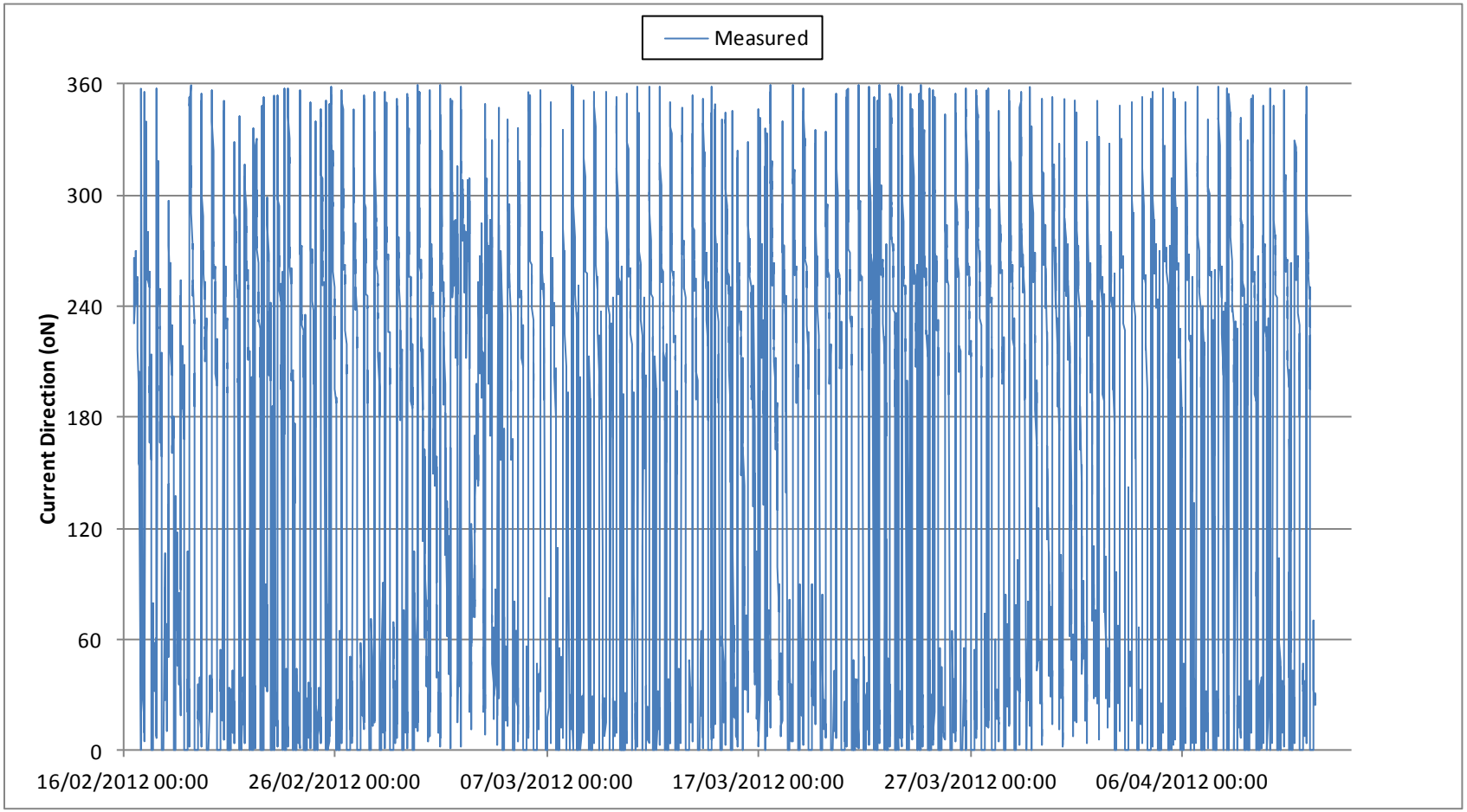


Figure B- 7: AWAC Site 2 Measured and Re-predicted Tidal Elevations

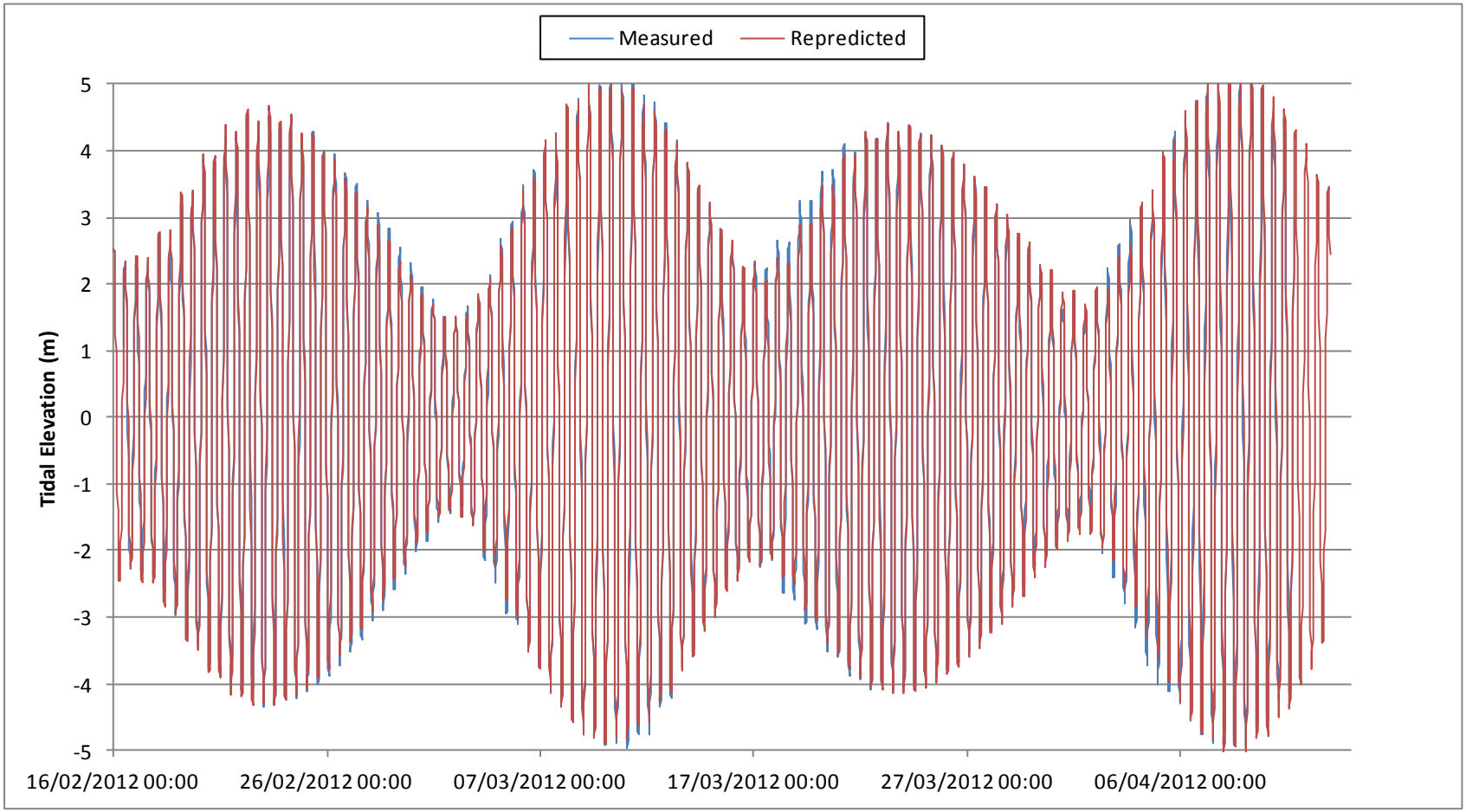


Figure B- 8: AWAC Site 2 Measured Current Speed

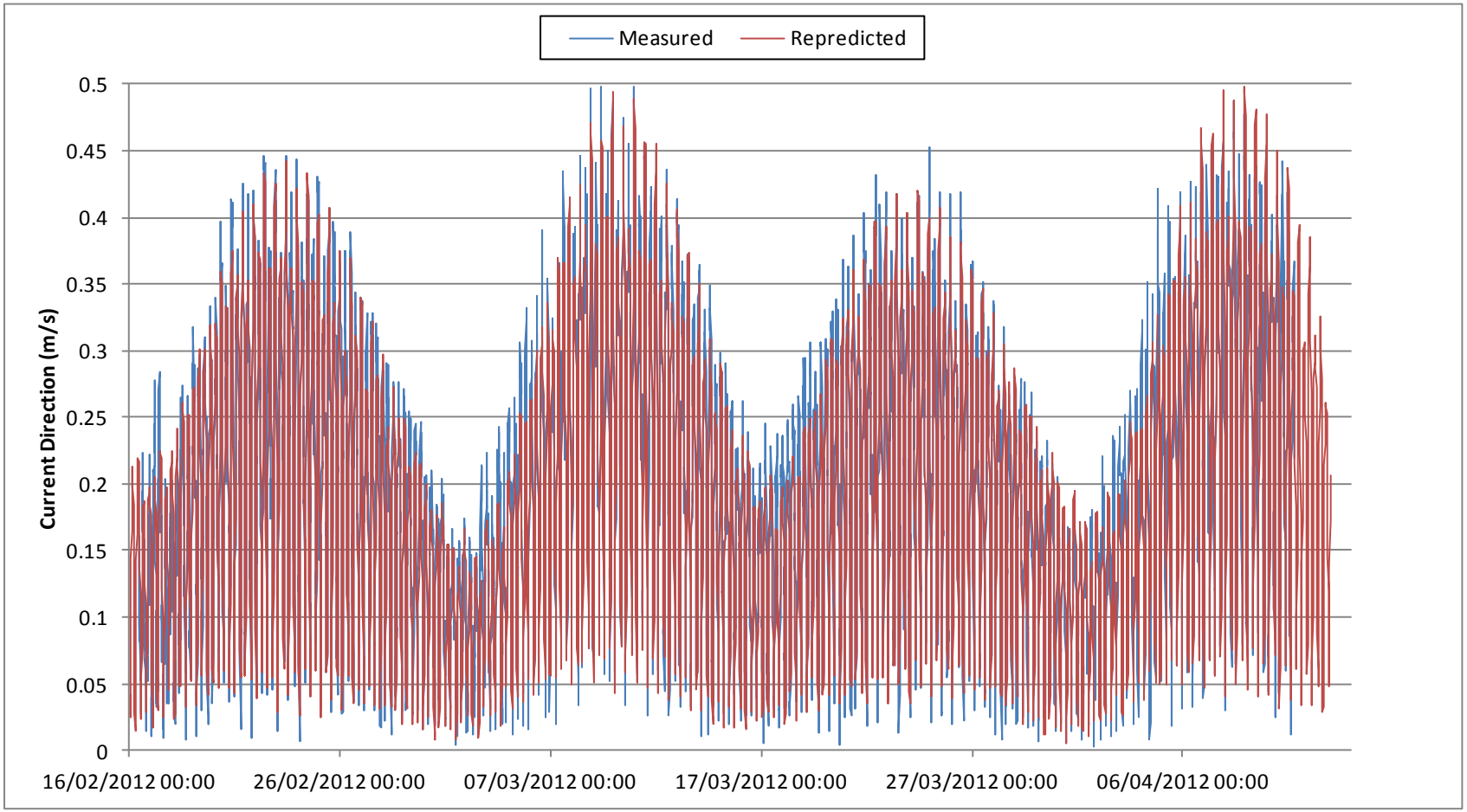


Figure B- 9: AWAC Site 2 Measured Current Direction

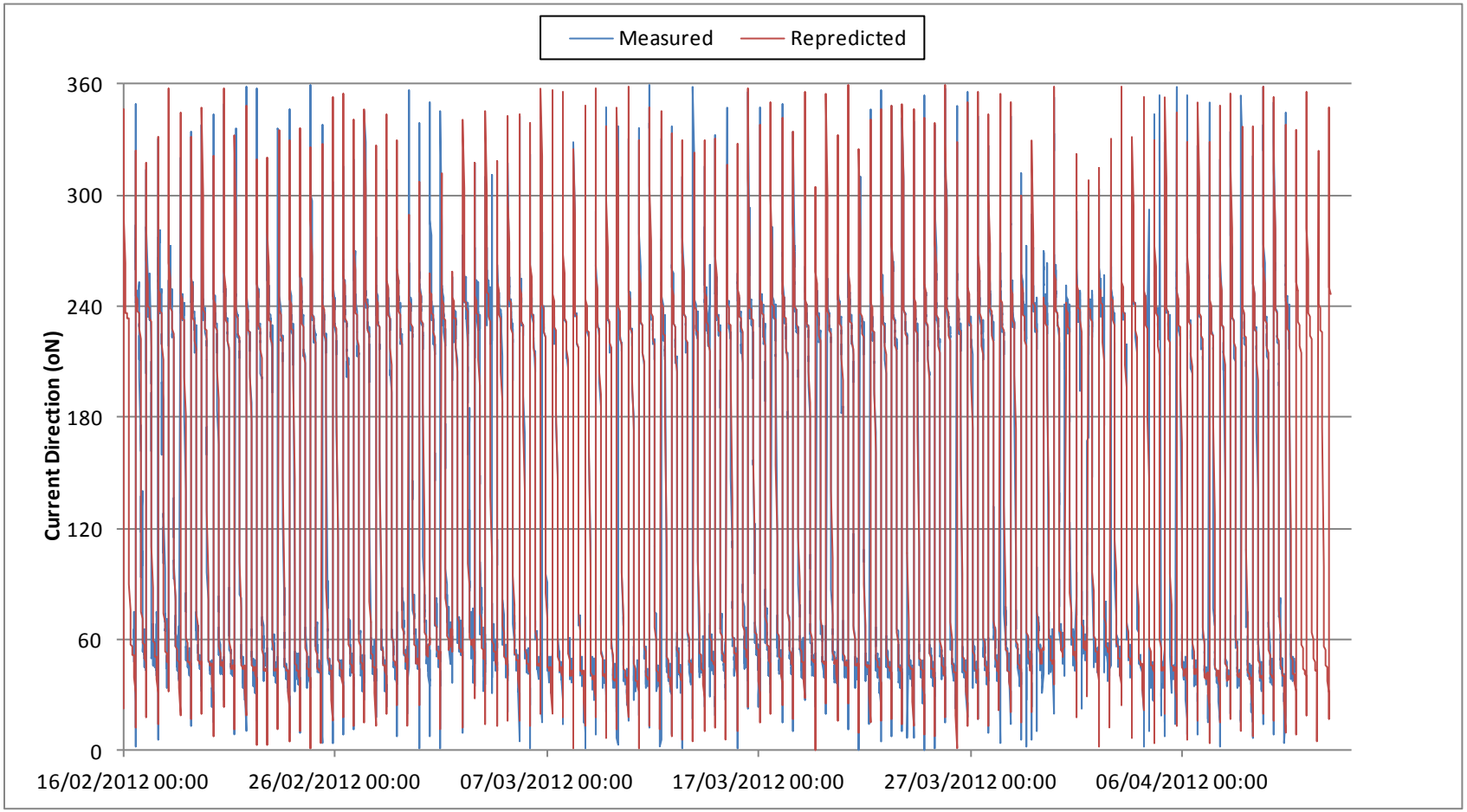


Figure B- 10: Smart Coast Site 1 Measured and Re-predicted Tidal Elevation

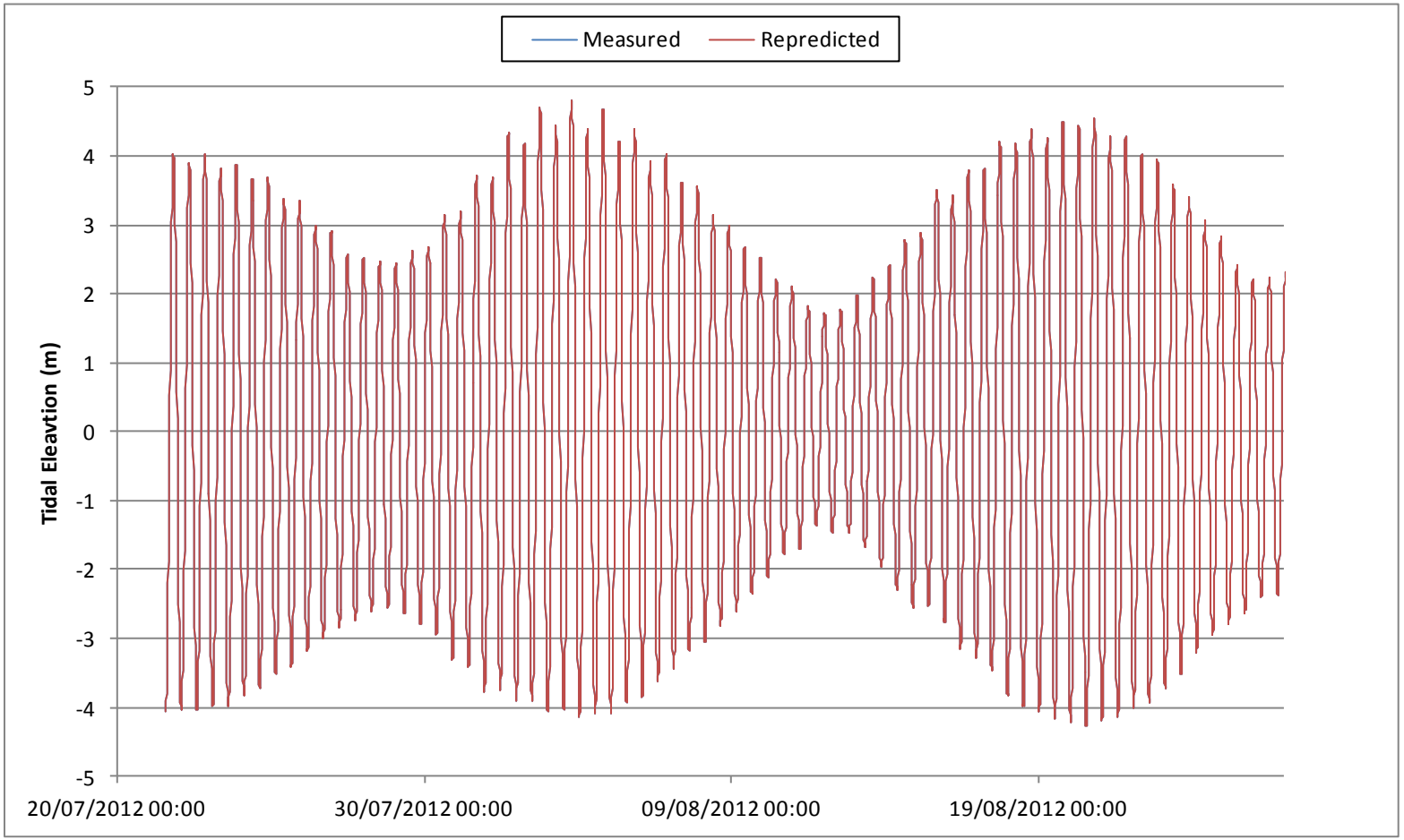


Figure B- 11: Smart Coast Site 1 Measured and Re-predicted Current Speed

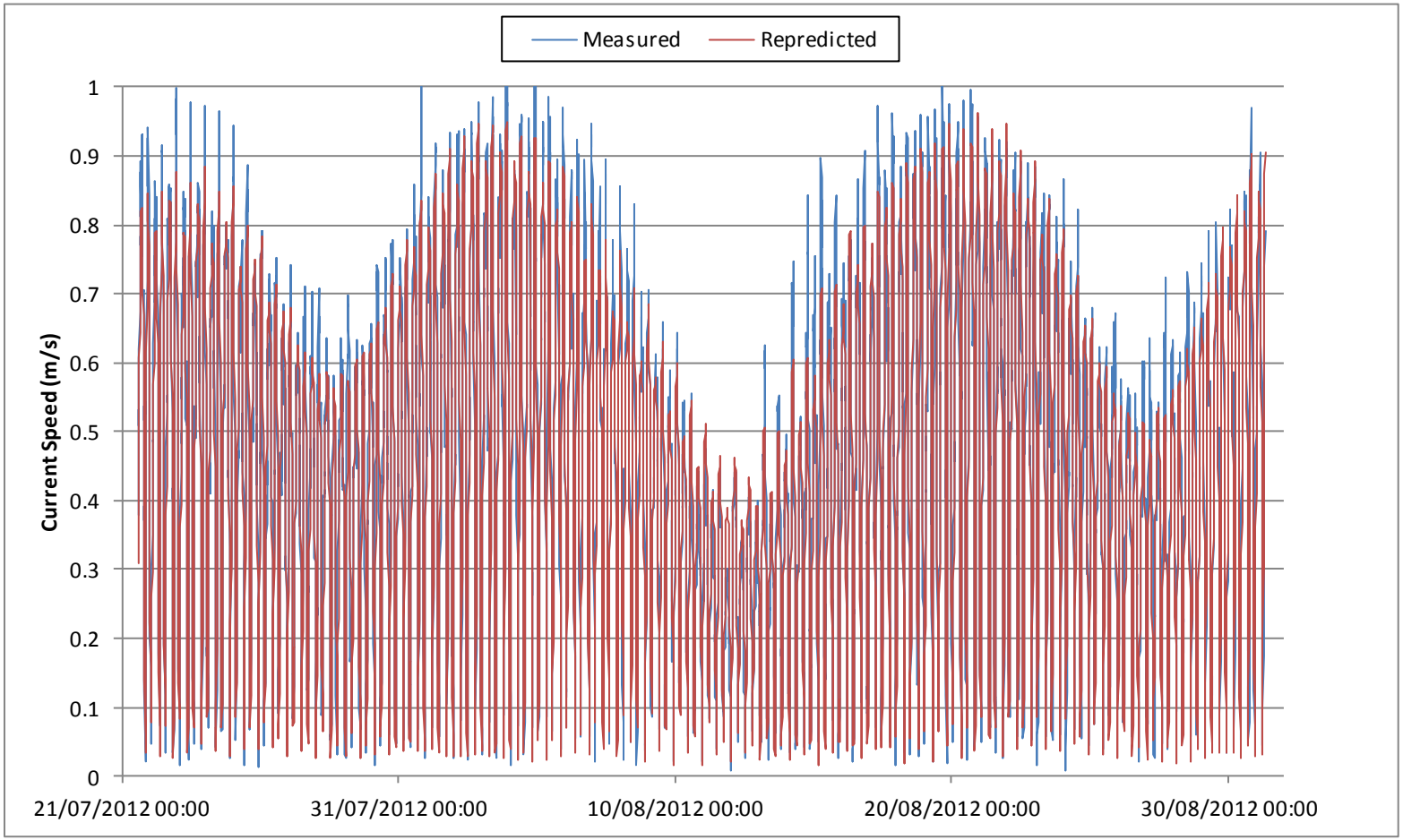


Figure B- 12: Smart Coast Site 1 Measured and Re-predicted Current Direction

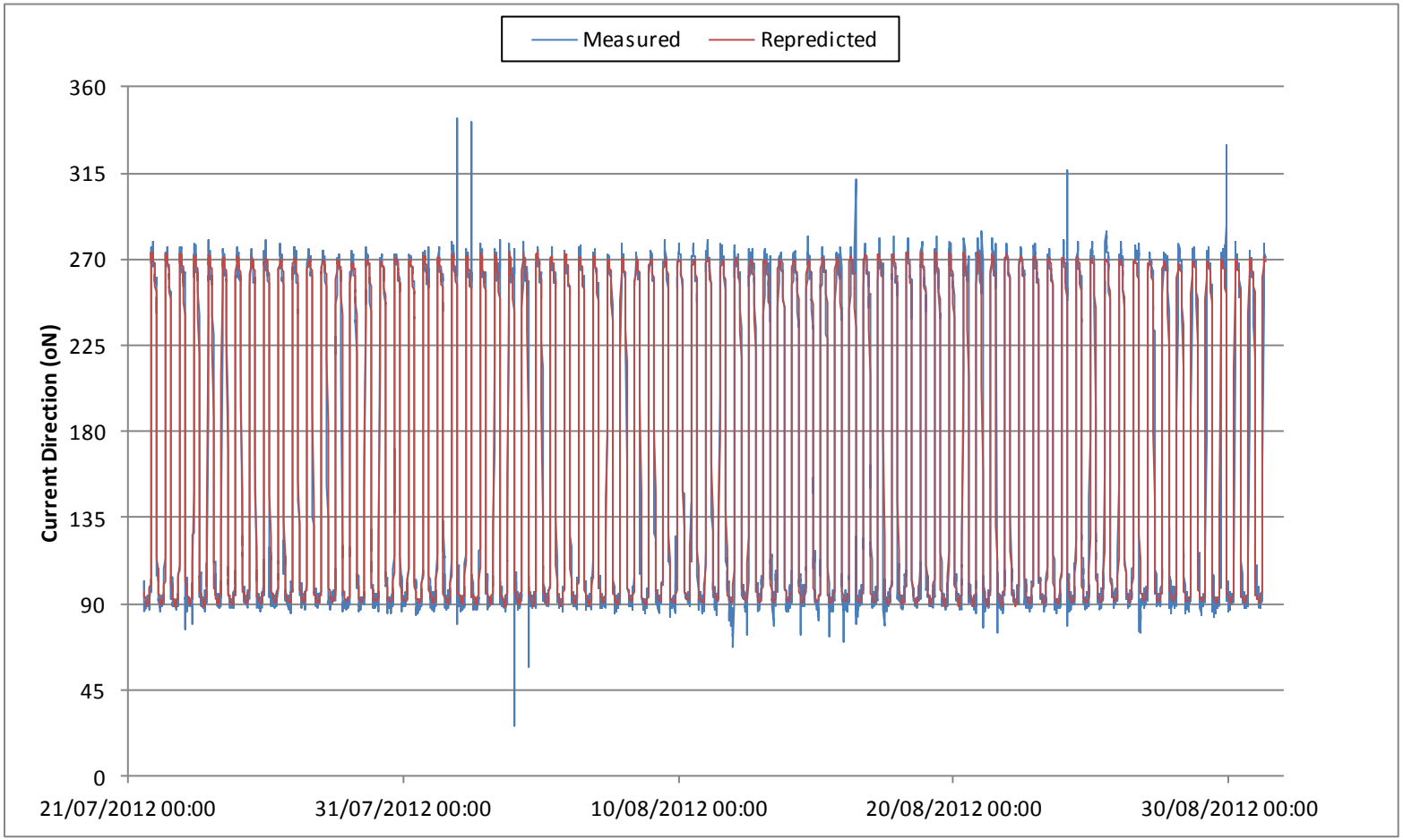


Figure B- 13: Smart Coast Site 2 Measured and Re-predicted Tidal Elevation

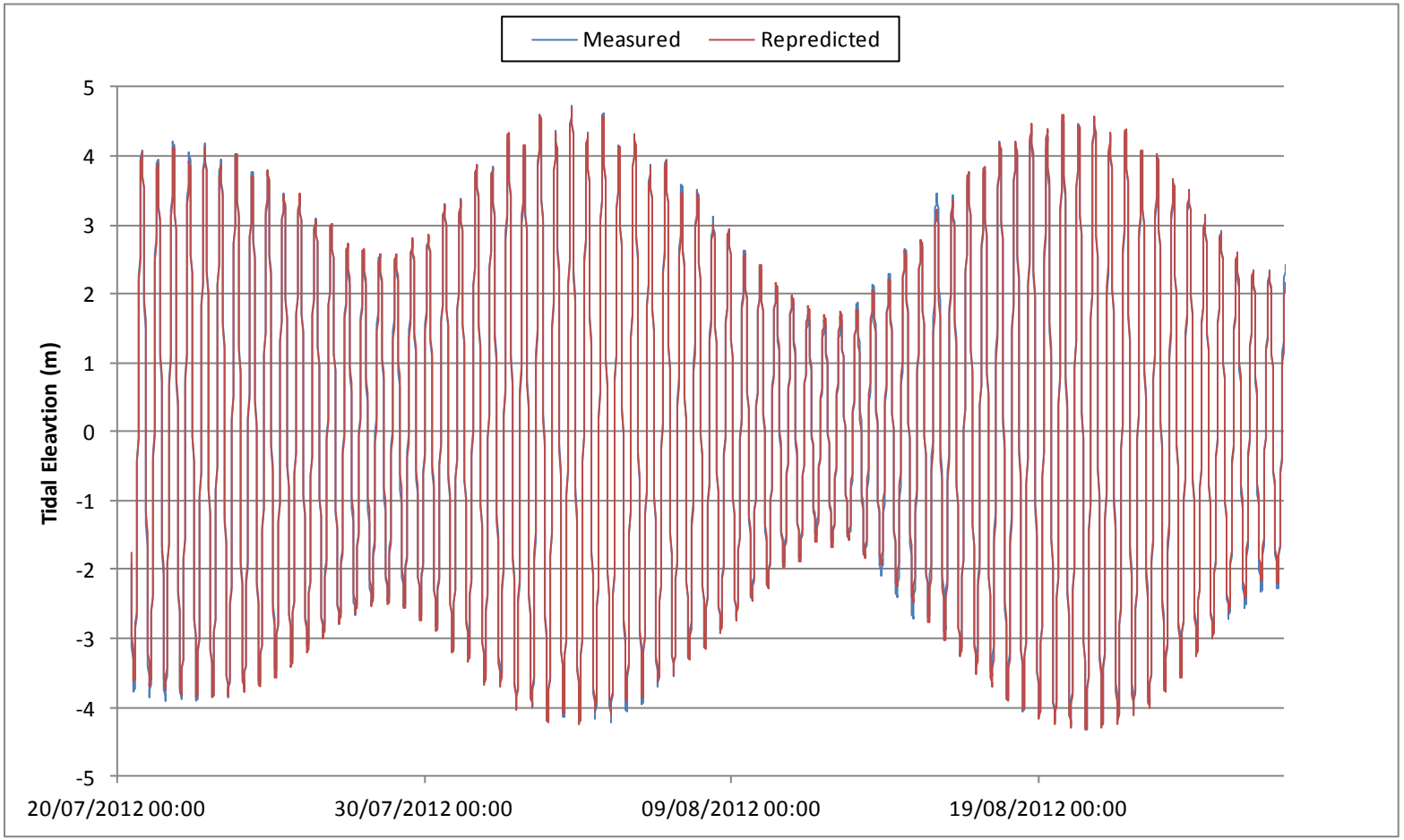


Figure B- 14: Smart Coast Site 2 Measured and Re-predicted Current Speed

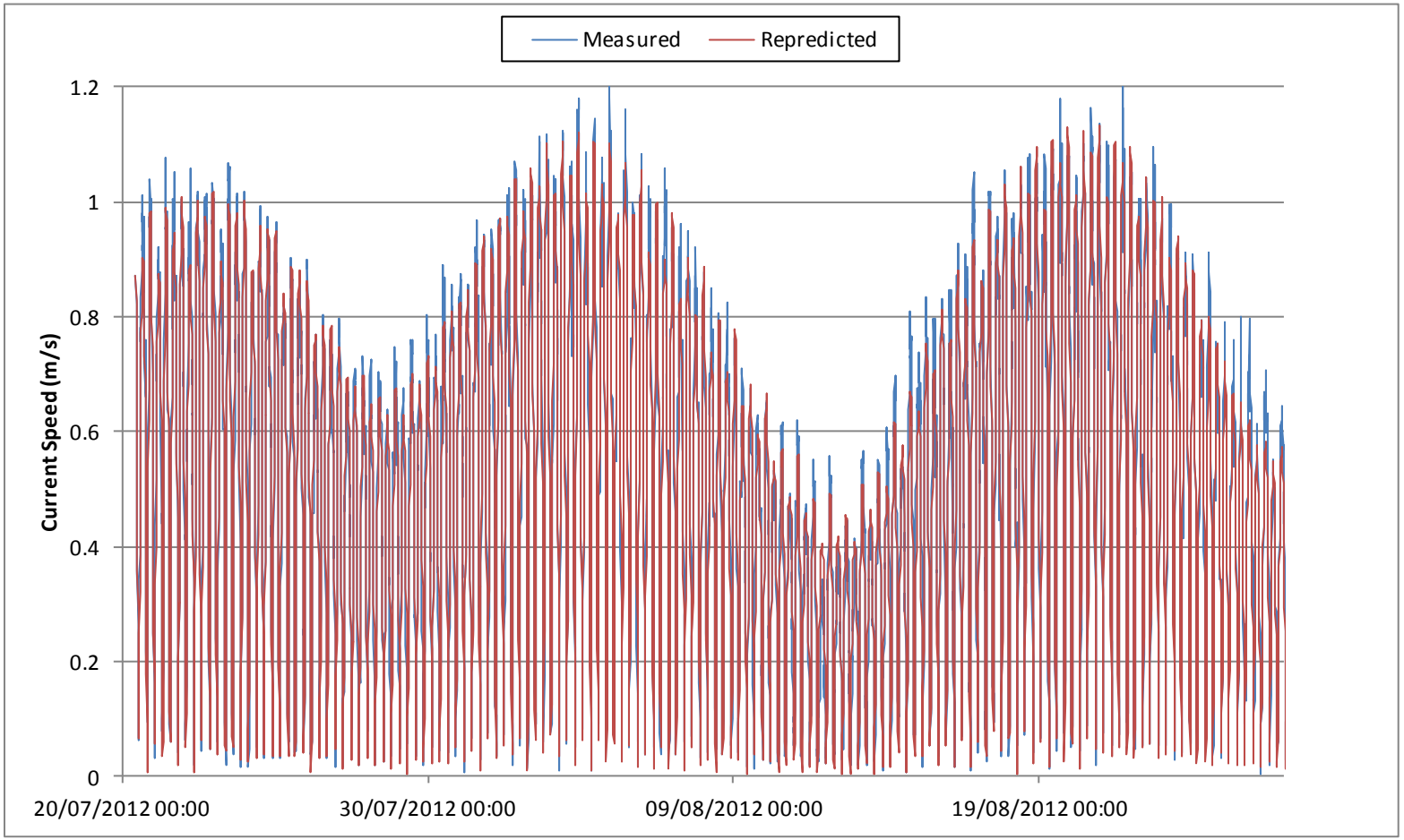


Figure B- 15: Smart Coast Site 2 Measured and Re-predicted Current Direction

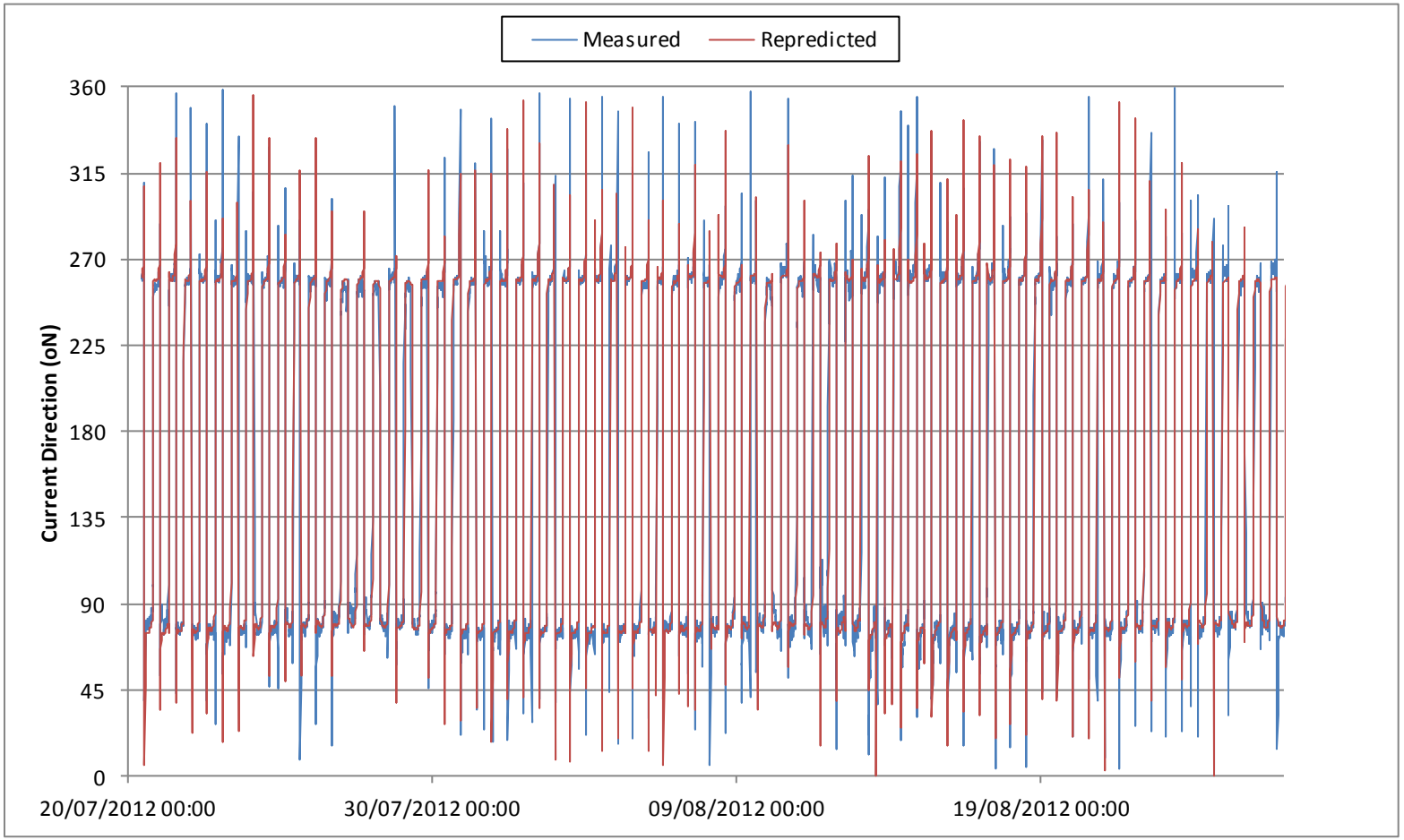


Figure B- 16: Smart Coast Site 3 Measured and Re-predicted Tidal Elevation

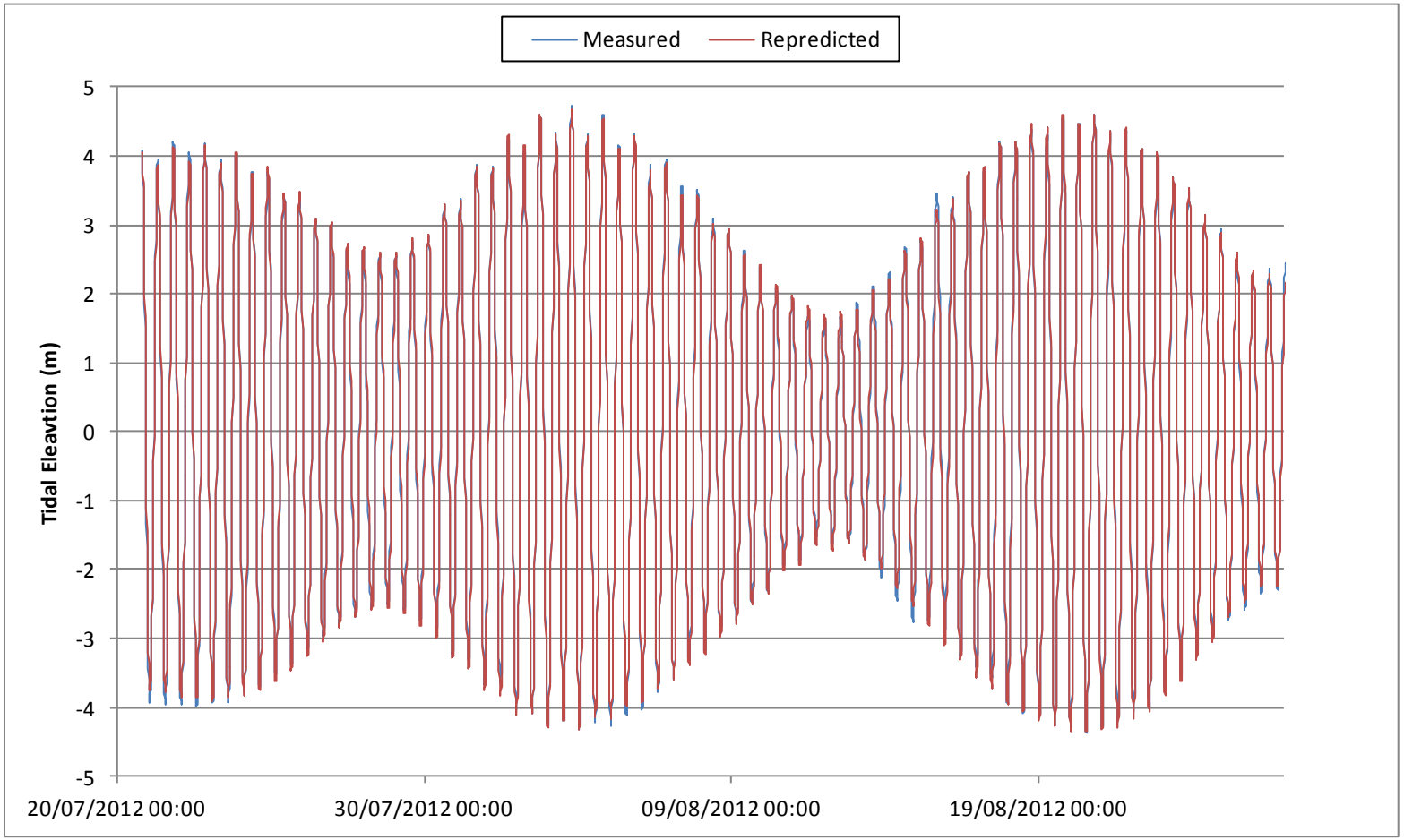


Figure B- 17: Smart Coast Site 3 Measured and Re-predicted Current Speed

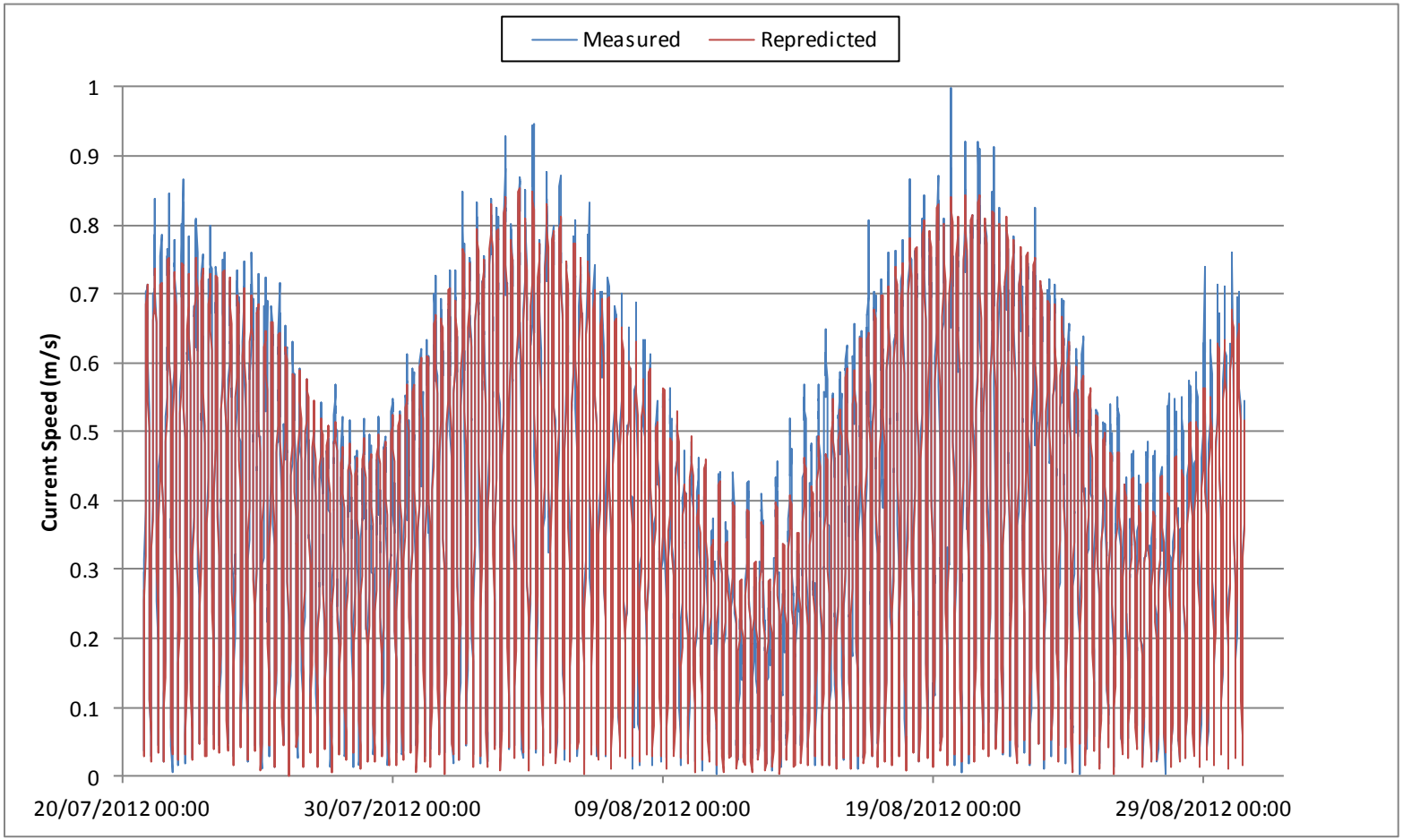


Figure B- 18: Smart Coast Site 3 Measured and Re-predicted Current Direction

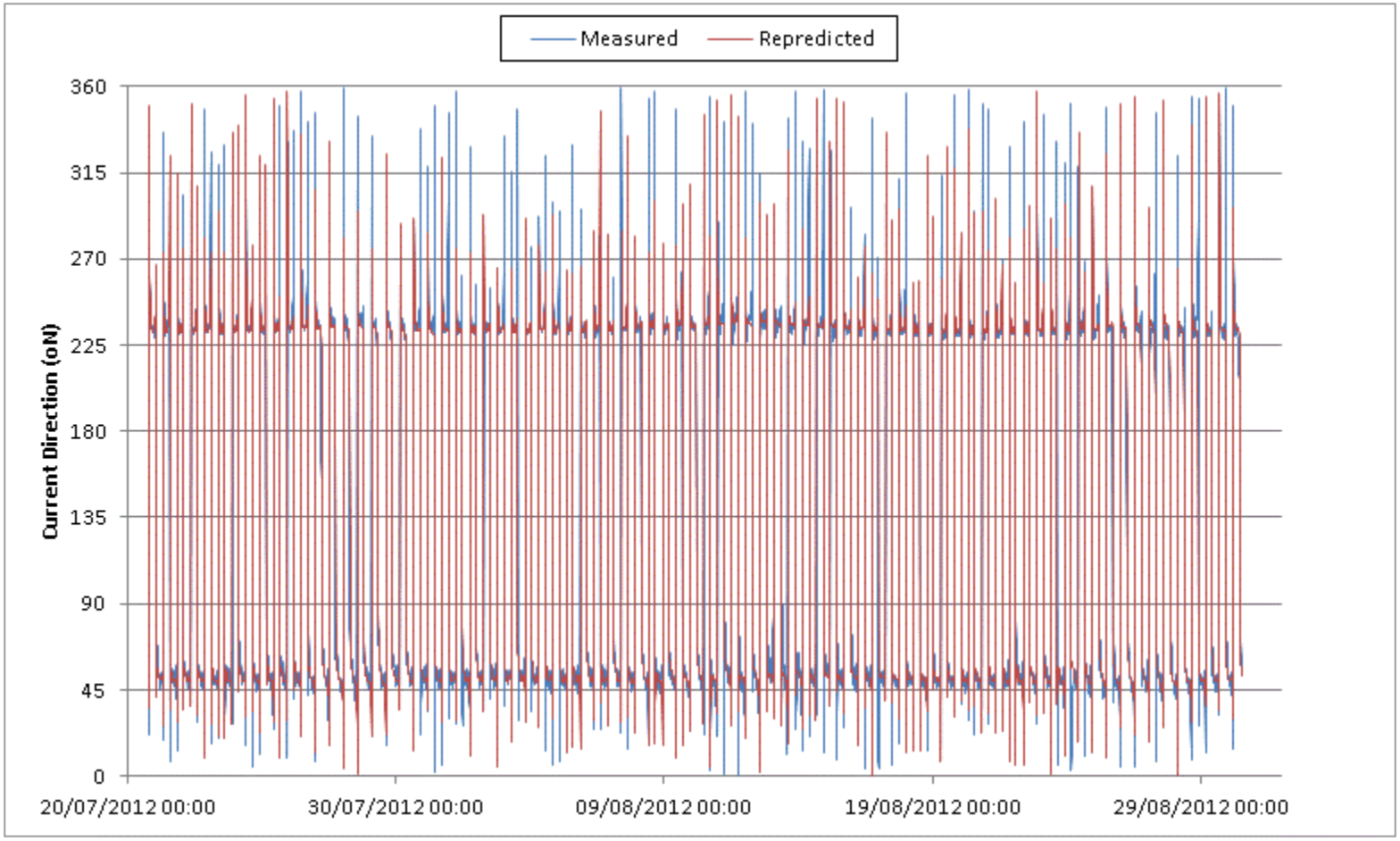


Figure B- 19: Smart Coast Site 4 Measured and Re-predicted Tidal Elevation

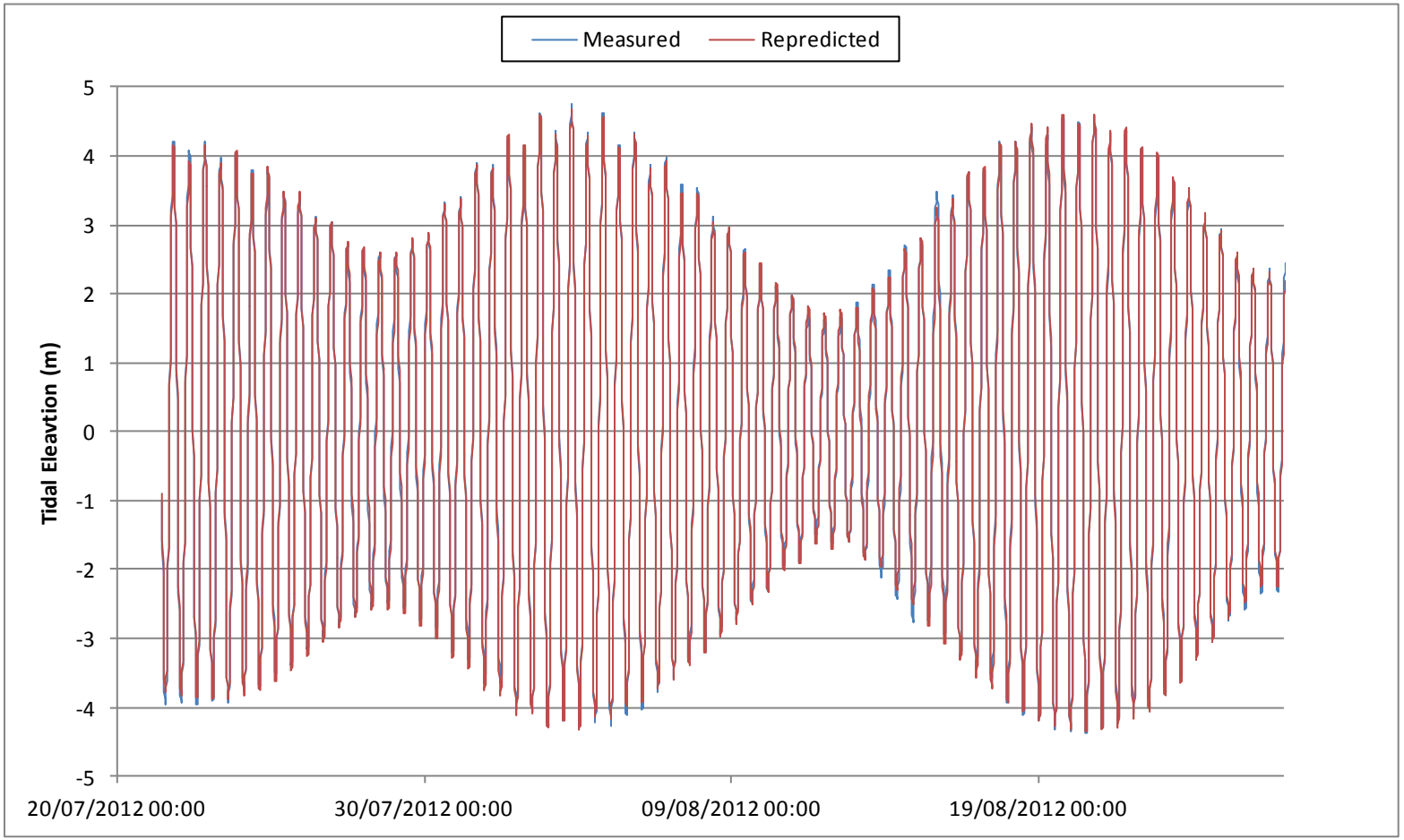


Figure B- 20: Smart Coast Site 4 Measured and Re-predicted Current Speed

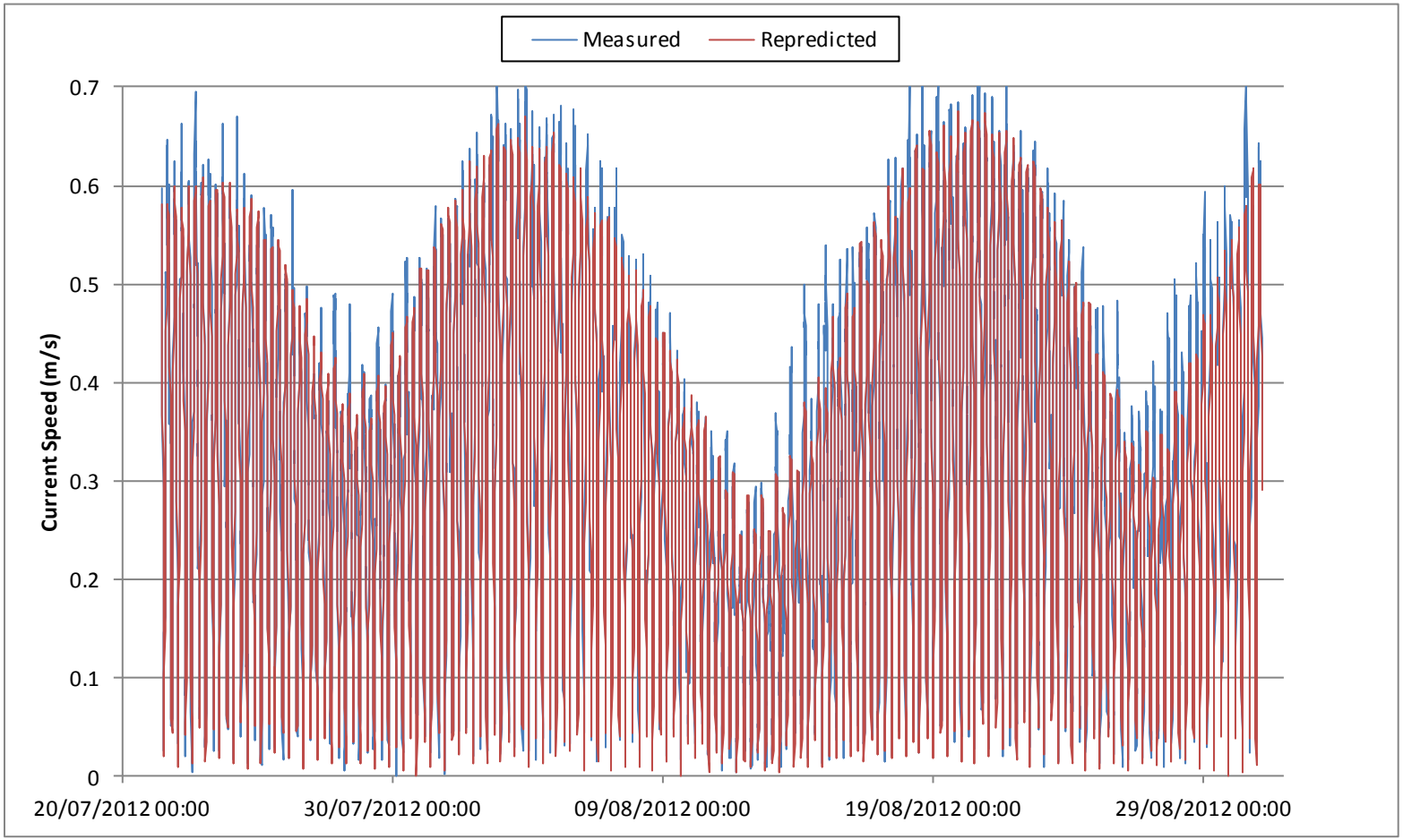


Figure B- 21: Smart Coast Site 4 Measured and Re-predicted Current Direction

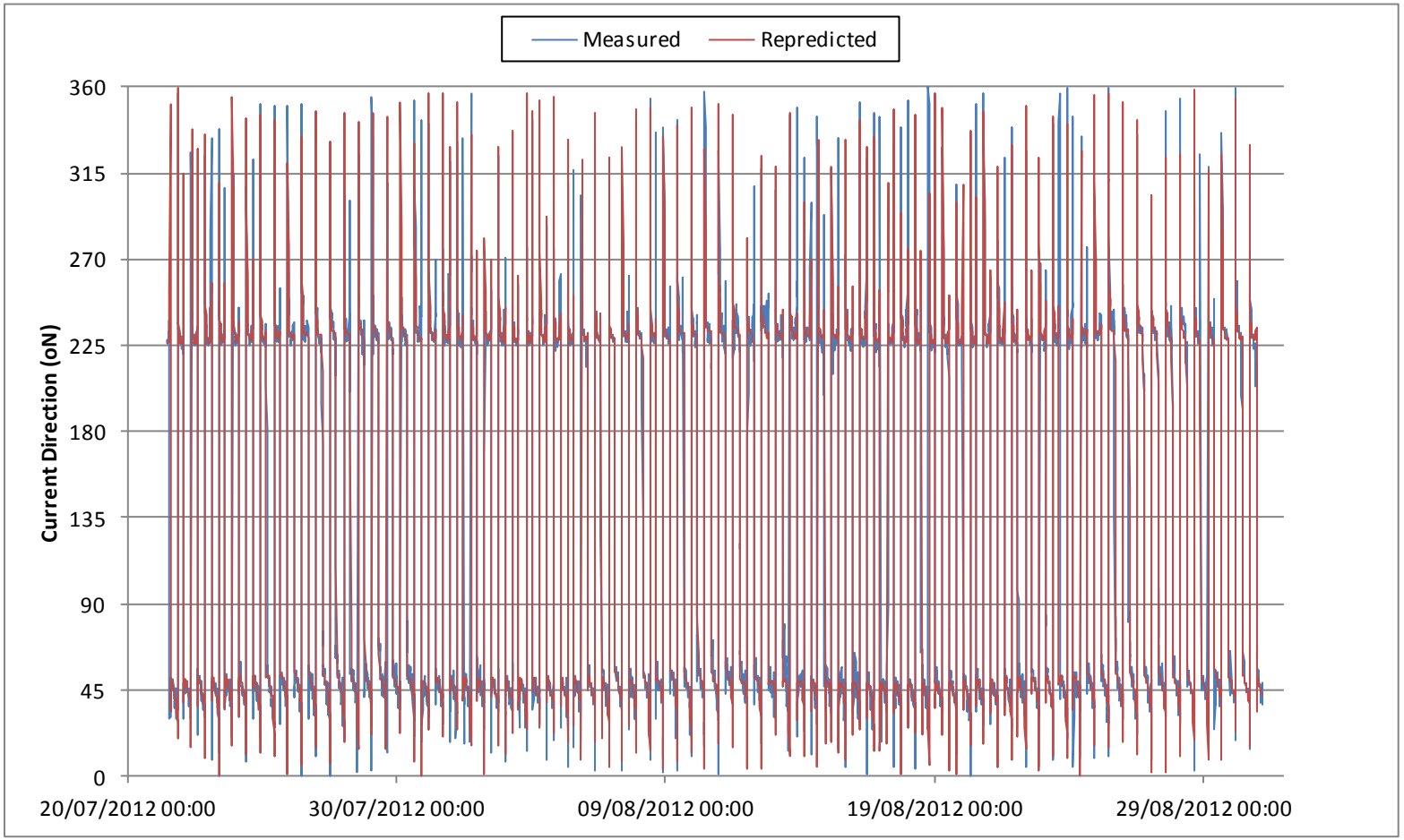


Figure B- 22: Smart Coast Site 5 Measured and Re-predicted Tidal Elevation

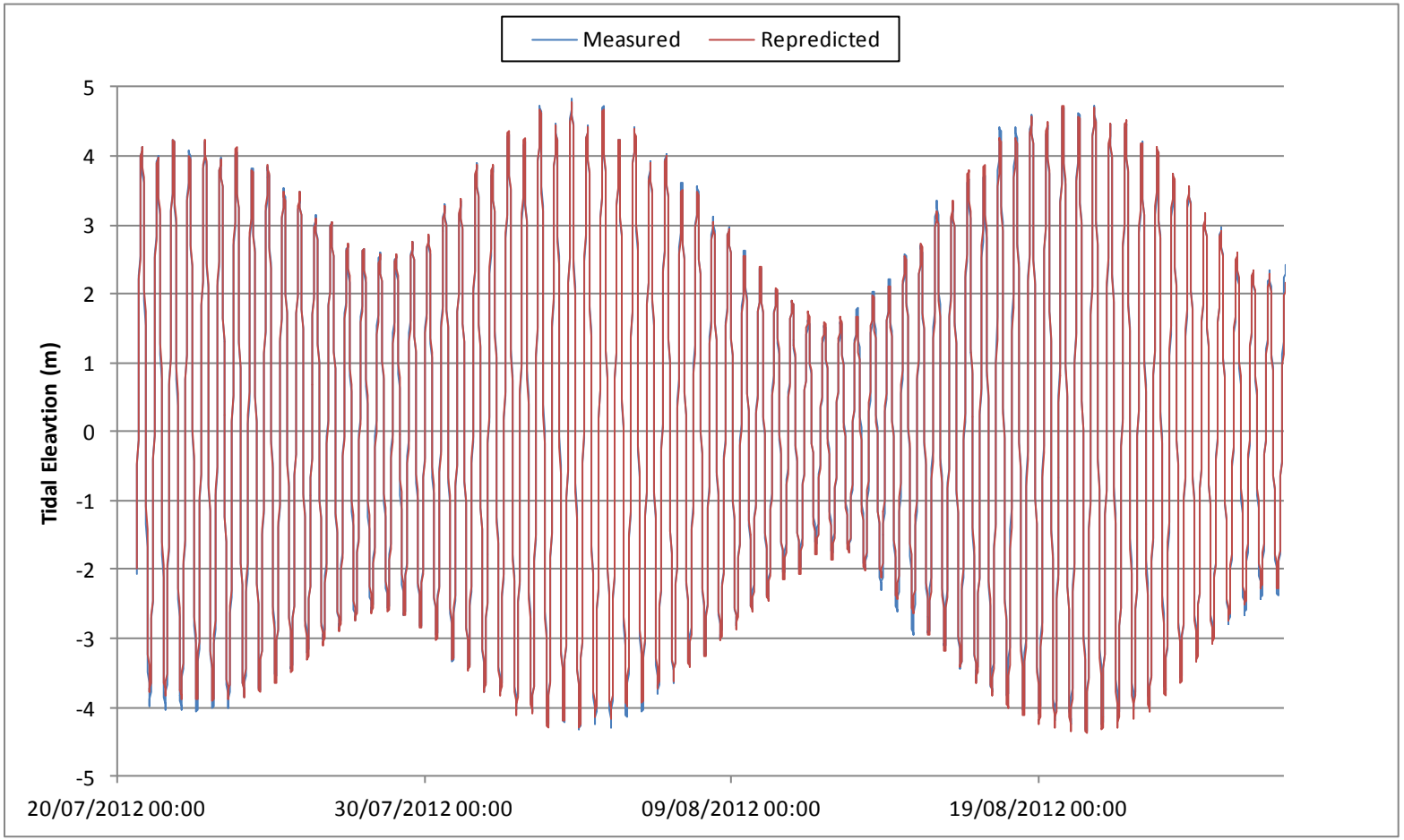


Figure B- 23: Smart Coast Site 5 Measured and Re-predicted Current Speed

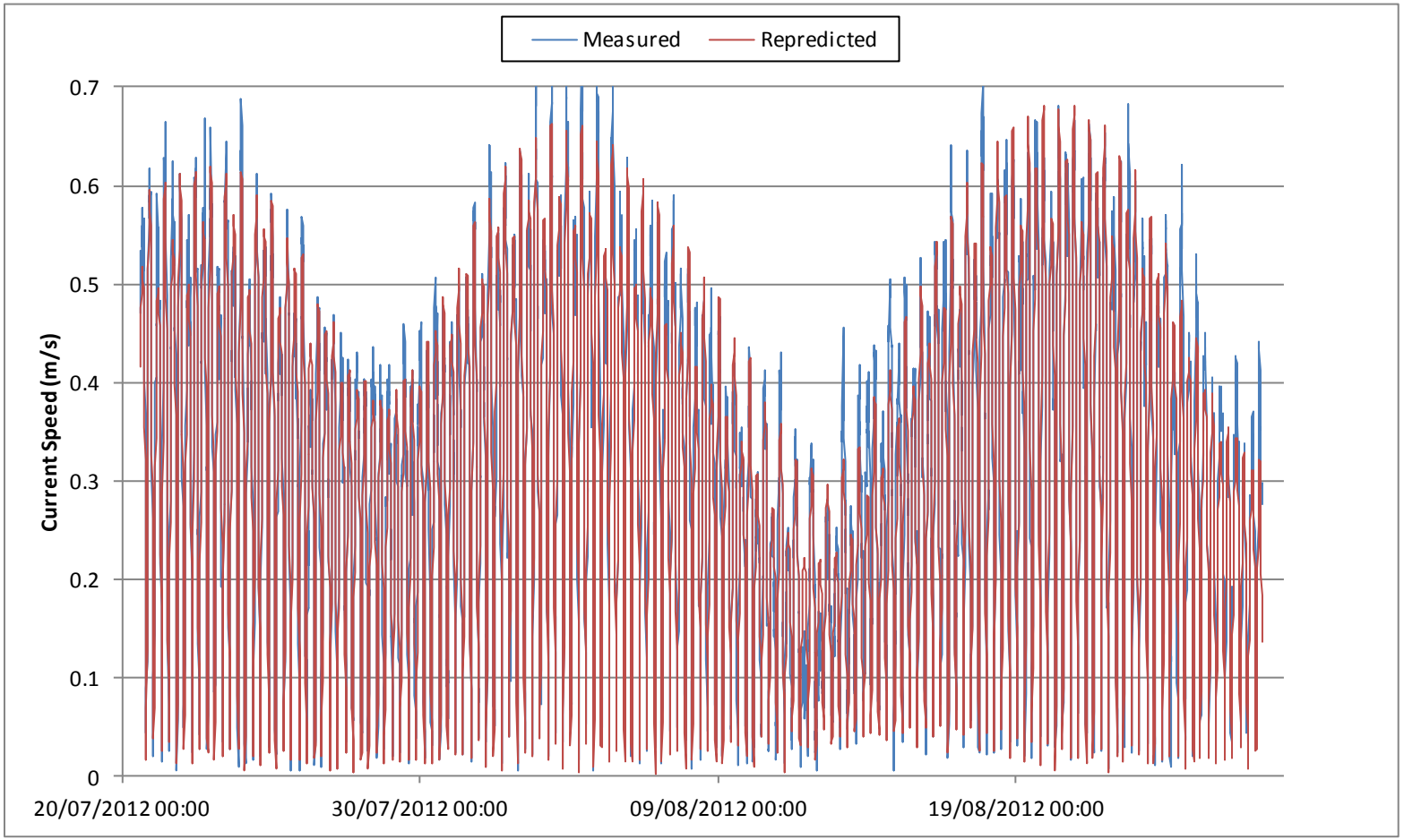
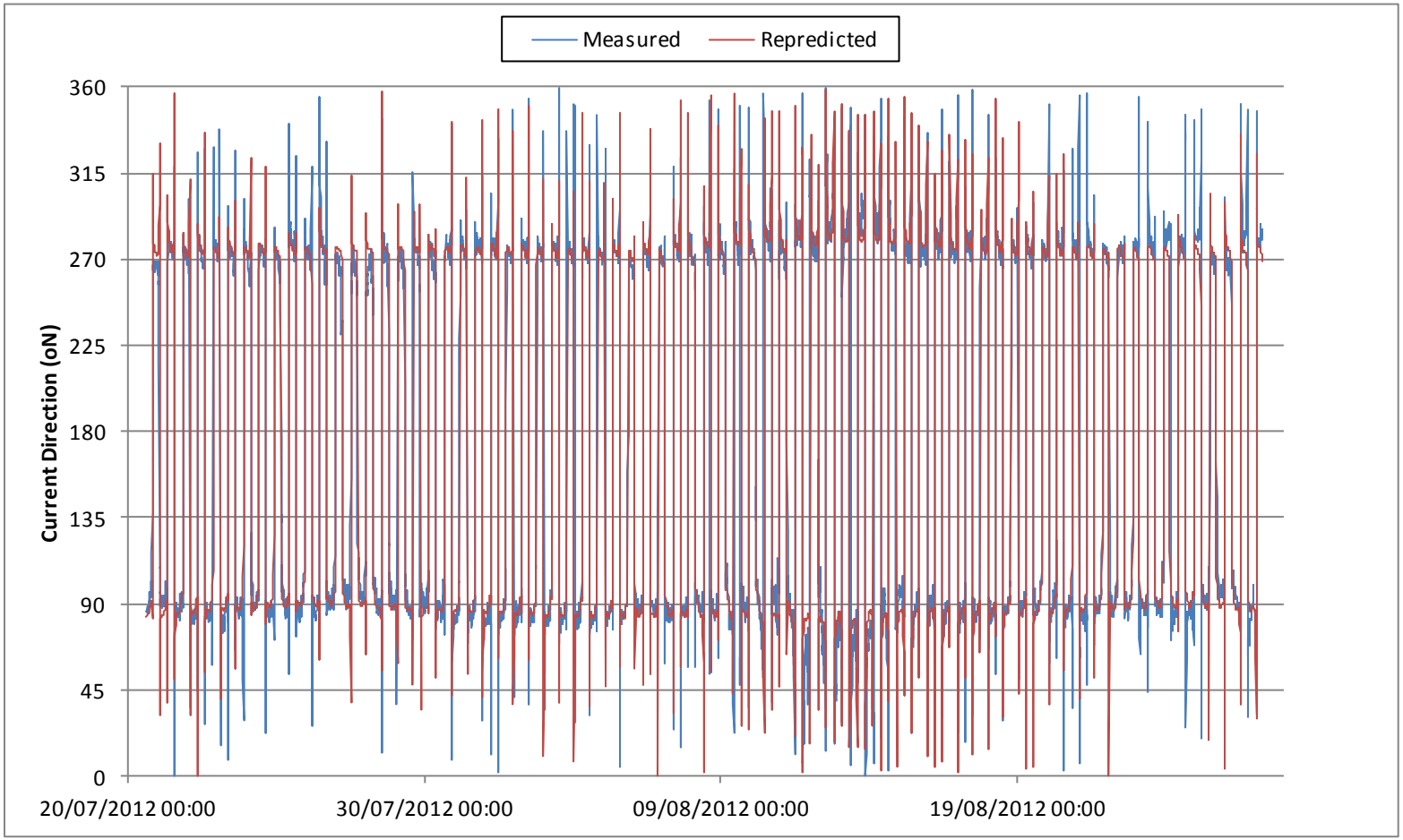


Figure B- 24: Smart Coast Site 5 Measured and Re-predicted Current Direction



Appendix C Tabular Validation Comparisons

TABLES

Table C- 1: Tidal elevation validation comparison– Port Talbot

	Raw Data				Re-predicted Data			
Phase Shift	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)
-15 min	-0.03	-0.3%	5.00	0.24	-0.01	-0.2%	7.50	0.19
-14 min	-0.03	-0.3%	6.00	0.23	-0.01	-0.2%	8.50	0.18
-13 min	-0.03	-0.3%	7.00	0.23	-0.01	-0.2%	9.50	0.18
-12 min	-0.03	-0.3%	8.00	0.22	-0.02	-0.2%	10.50	0.17
-11 min	-0.03	-0.3%	9.00	0.22	-0.02	-0.2%	11.50	0.17
-10 min	-0.03	-0.3%	10.00	0.22	-0.02	-0.2%	12.50	0.17
-9 min	-0.03	-0.3%	11.00	0.23	-0.02	-0.2%	13.50	0.18
-8 min	-0.03	-0.3%	12.00	0.23	-0.02	-0.2%	14.50	0.18
-7 min	-0.03	-0.3%	13.00	0.24	-0.02	-0.2%	15.50	0.19
-6 min	-0.03	-0.3%	14.00	0.25	-0.02	-0.2%	16.50	0.20
-5 min	-0.03	-0.3%	15.00	0.26	-0.02	-0.2%	17.50	0.22
-4 min	-0.03	-0.3%	16.00	0.27	-0.02	-0.2%	18.50	0.23
-3 min	-0.03	-0.3%	17.00	0.28	-0.02	-0.2%	19.50	0.25
-2 min	-0.03	-0.3%	18.00	0.29	-0.02	-0.2%	20.50	0.26
-1 min	-0.03	-0.3%	19.00	0.31	-0.02	-0.2%	21.50	0.28
0 min	-0.03	-0.4%	20.00	0.32	-0.02	-0.2%	22.50	0.30
1 min	-0.03	-0.4%	21.00	0.34	-0.02	-0.2%	23.50	0.31
2 min	-0.03	-0.4%	22.00	0.35	-0.02	-0.2%	24.50	0.33
3 min	-0.03	-0.4%	23.00	0.37	-0.02	-0.2%	25.50	0.35
4 min	-0.03	-0.4%	24.00	0.39	-0.02	-0.2%	26.50	0.37
5 min	-0.03	-0.4%	25.00	0.40	-0.02	-0.2%	27.50	0.38
6 min	-0.03	-0.4%	26.00	0.42	-0.02	-0.2%	28.50	0.40
7 min	-0.03	-0.4%	27.00	0.44	-0.02	-0.2%	29.50	0.42
8 min	-0.03	-0.4%	28.00	0.46	-0.02	-0.2%	30.50	0.44
9 min	-0.03	-0.4%	29.00	0.48	-0.02	-0.2%	31.50	0.46
10 min	-0.03	-0.4%	30.00	0.50	-0.02	-0.2%	32.50	0.48
11 min	-0.03	-0.4%	31.00	0.51	-0.02	-0.3%	33.50	0.50
12 min	-0.03	-0.4%	32.00	0.53	-0.02	-0.3%	34.50	0.52
13 min	-0.03	-0.4%	33.00	0.55	-0.02	-0.3%	35.50	0.54
14 min	-0.03	-0.4%	34.00	0.57	-0.02	-0.3%	36.50	0.56
15 min	-0.03	-0.4%	35.00	0.59	-0.02	-0.3%	37.50	0.58

Table C- 2: Tidal elevation validation comparison – Swansea

	Raw Data				Re-predicted Data			
Phase Shift	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)
-15 min	-0.03	-0.4%	0.00	0.16	-0.03	-0.3%	7.50	0.13
-14 min	-0.03	-0.4%	1.00	0.15	-0.03	-0.3%	8.50	0.12
-13 min	-0.03	-0.4%	2.00	0.15	-0.03	-0.3%	9.50	0.12
-12 min	-0.03	-0.4%	3.00	0.15	-0.03	-0.3%	10.50	0.12
-11 min	-0.03	-0.4%	4.00	0.15	-0.03	-0.3%	11.50	0.12
-10 min	-0.04	-0.4%	5.00	0.15	-0.03	-0.4%	12.50	0.13
-9 min	-0.04	-0.4%	6.00	0.16	-0.03	-0.4%	13.50	0.14
-8 min	-0.04	-0.4%	7.00	0.17	-0.03	-0.4%	14.50	0.15
-7 min	-0.04	-0.4%	8.00	0.18	-0.03	-0.4%	15.50	0.17
-6 min	-0.04	-0.4%	9.00	0.20	-0.03	-0.4%	16.50	0.18
-5 min	-0.04	-0.4%	10.00	0.21	-0.03	-0.4%	17.50	0.20
-4 min	-0.04	-0.4%	11.00	0.23	-0.03	-0.4%	18.50	0.22
-3 min	-0.04	-0.4%	12.00	0.24	-0.03	-0.4%	19.50	0.24
-2 min	-0.04	-0.4%	13.00	0.26	-0.03	-0.4%	20.50	0.25
-1 min	-0.04	-0.4%	14.00	0.28	-0.03	-0.4%	21.50	0.27
0 min	-0.04	-0.4%	15.00	0.30	-0.03	-0.4%	22.50	0.29
1 min	-0.04	-0.4%	16.00	0.31	-0.03	-0.4%	23.50	0.31
2 min	-0.04	-0.4%	17.00	0.33	-0.03	-0.4%	24.50	0.33
3 min	-0.04	-0.5%	18.00	0.35	-0.03	-0.4%	25.50	0.35
4 min	-0.04	-0.5%	19.00	0.37	-0.03	-0.4%	26.50	0.37
5 min	-0.04	-0.5%	20.00	0.39	-0.03	-0.4%	27.50	0.39
6 min	-0.04	-0.5%	21.00	0.41	-0.03	-0.4%	28.50	0.41
7 min	-0.04	-0.5%	22.00	0.43	-0.03	-0.4%	29.50	0.43
8 min	-0.04	-0.5%	23.00	0.45	-0.03	-0.4%	30.50	0.45
9 min	-0.04	-0.5%	24.00	0.47	-0.03	-0.4%	31.50	0.47
10 min	-0.04	-0.5%	25.00	0.49	-0.03	-0.4%	32.50	0.49
11 min	-0.04	-0.5%	26.00	0.51	-0.03	-0.4%	33.50	0.51
12 min	-0.04	-0.5%	27.00	0.53	-0.04	-0.4%	34.50	0.53
13 min	-0.04	-0.5%	28.00	0.55	-0.04	-0.4%	35.50	0.55
14 min	-0.04	-0.5%	29.00	0.57	-0.04	-0.4%	36.50	0.57
15 min	-0.04	-0.5%	30.00	0.59	-0.04	-0.4%	37.50	0.60

Table C- 3: Tidal elevation validation comparison – Mumbles

	Raw Data				Re-predicted Data			
Phase Shift	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)
-15 min	-0.09	-1.1%	-15.00	0.22	0.02	0.2%	7.50	0.22
-14 min	-0.09	-1.1%	-14.00	0.20	0.02	0.2%	8.50	0.21
-13 min	-0.09	-1.1%	-13.00	0.20	0.02	0.2%	9.50	0.20
-12 min	-0.09	-1.1%	-12.00	0.19	0.02	0.2%	10.50	0.20
-11 min	-0.09	-1.1%	-11.00	0.18	0.01	0.2%	11.50	0.19
-10 min	-0.10	-1.1%	-10.00	0.18	0.01	0.2%	12.50	0.19
-9 min	-0.10	-1.1%	-9.00	0.18	0.01	0.2%	13.50	0.19
-8 min	-0.10	-1.2%	-8.00	0.18	0.01	0.2%	14.50	0.19
-7 min	-0.10	-1.2%	-7.00	0.18	0.01	0.2%	15.50	0.19
-6 min	-0.10	-1.2%	-6.00	0.19	0.01	0.2%	16.50	0.20
-5 min	-0.10	-1.2%	-5.00	0.20	0.01	0.2%	17.50	0.21
-4 min	-0.10	-1.2%	-4.00	0.21	0.01	0.2%	18.50	0.22
-3 min	-0.10	-1.2%	-3.00	0.22	0.01	0.2%	19.50	0.23
-2 min	-0.10	-1.2%	-2.00	0.23	0.01	0.2%	20.50	0.24
-1 min	-0.10	-1.2%	-1.00	0.25	0.01	0.1%	21.50	0.25
0 min	-0.10	-1.2%	0.00	0.26	0.01	0.1%	22.50	0.27
1 min	-0.10	-1.2%	1.00	0.28	0.01	0.1%	23.50	0.28
2 min	-0.10	-1.2%	2.00	0.30	0.01	0.1%	24.50	0.30
3 min	-0.10	-1.2%	3.00	0.31	0.01	0.1%	25.50	0.31
4 min	-0.10	-1.2%	4.00	0.33	0.01	0.1%	26.50	0.33
5 min	-0.10	-1.2%	5.00	0.35	0.01	0.1%	27.50	0.35
6 min	-0.10	-1.2%	6.00	0.36	0.01	0.1%	28.50	0.37
7 min	-0.10	-1.2%	7.00	0.38	0.01	0.1%	29.50	0.38
8 min	-0.10	-1.2%	8.00	0.40	0.01	0.1%	30.50	0.40
9 min	-0.10	-1.2%	9.00	0.42	0.01	0.1%	31.50	0.42
10 min	-0.10	-1.2%	10.00	0.44	0.01	0.1%	32.50	0.44
11 min	-0.10	-1.2%	11.00	0.46	0.01	0.1%	33.50	0.46
12 min	-0.10	-1.2%	12.00	0.48	0.01	0.1%	34.50	0.48
13 min	-0.10	-1.2%	13.00	0.50	0.01	0.1%	35.50	0.50
14 min	-0.10	-1.2%	14.00	0.52	0.01	0.1%	36.50	0.52
15 min	-0.10	-1.2%	15.00	0.54	0.01	0.1%	37.50	0.54

Table C- 4: Tidal elevation validation comparison – AWAC Site 1

	Raw Data				Adjusted Data			
Phase Shift	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)
-15 min	0.02	0.2%	-10.00	0.20	0.02	0.2%	-10.00	0.20
-14 min	0.02	0.2%	-9.00	0.18	0.02	0.2%	-9.00	0.18
-13 min	0.02	0.2%	-8.00	0.17	0.02	0.2%	-8.00	0.17
-12 min	0.02	0.2%	-7.00	0.16	0.02	0.2%	-7.00	0.16
-11 min	0.02	0.2%	-6.00	0.15	0.02	0.2%	-6.00	0.15
-10 min	0.02	0.2%	-5.00	0.14	0.02	0.2%	-5.00	0.14
-9 min	0.02	0.2%	-4.00	0.14	0.02	0.2%	-4.00	0.14
-8 min	0.02	0.2%	-3.00	0.14	0.02	0.2%	-3.00	0.14
-7 min	0.02	0.2%	-2.00	0.15	0.02	0.2%	-2.00	0.15
-6 min	0.02	0.2%	-1.00	0.15	0.02	0.2%	-1.00	0.15
-5 min	0.02	0.2%	0.00	0.16	0.02	0.2%	0.00	0.16
-4 min	0.02	0.2%	1.00	0.17	0.02	0.2%	1.00	0.17
-3 min	0.02	0.2%	2.00	0.18	0.02	0.2%	2.00	0.18
-2 min	0.02	0.2%	3.00	0.20	0.02	0.2%	3.00	0.20
-1 min	0.01	0.2%	4.00	0.21	0.01	0.2%	4.00	0.21
0 min	0.01	0.2%	5.00	0.23	0.01	0.2%	5.00	0.23
1 min	0.01	0.2%	6.00	0.25	0.01	0.2%	6.00	0.25
2 min	0.01	0.2%	7.00	0.26	0.01	0.2%	7.00	0.26
3 min	0.01	0.2%	8.00	0.28	0.01	0.2%	8.00	0.28
4 min	0.01	0.2%	9.00	0.30	0.01	0.2%	9.00	0.30
5 min	0.01	0.2%	10.00	0.32	0.01	0.2%	10.00	0.32
6 min	0.01	0.2%	11.00	0.34	0.01	0.2%	11.00	0.34
7 min	0.01	0.2%	12.00	0.36	0.01	0.2%	12.00	0.36
8 min	0.01	0.2%	13.00	0.38	0.01	0.2%	13.00	0.38
9 min	0.01	0.2%	14.00	0.40	0.01	0.2%	14.00	0.40
10 min	0.01	0.2%	15.00	0.42	0.01	0.2%	15.00	0.42
11 min	0.01	0.1%	16.00	0.44	0.01	0.1%	16.00	0.44
12 min	0.01	0.1%	17.00	0.46	0.01	0.1%	17.00	0.46
13 min	0.01	0.1%	18.00	0.48	0.01	0.1%	18.00	0.48
14 min	0.01	0.1%	19.00	0.50	0.01	0.1%	19.00	0.50
15 min	0.01	0.1%	20.00	0.52	0.01	0.1%	20.00	0.52

Table C- 5: Tidal elevation validation comparison – AWAC Site 2

	Raw Data				Re-predicted Data			
Phase Shift	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)
-15 min	0.03	0.4%	-10.00	0.18	0.00	0.0%	-7.50	0.18
-14 min	0.03	0.4%	-9.00	0.16	0.00	0.0%	-6.50	0.17
-13 min	0.03	0.4%	-8.00	0.15	0.00	0.0%	-5.50	0.16
-12 min	0.03	0.4%	-7.00	0.14	0.00	0.0%	-4.50	0.15
-11 min	0.03	0.3%	-6.00	0.13	0.00	0.0%	-3.50	0.15
-10 min	0.03	0.3%	-5.00	0.12	0.00	0.0%	-2.50	0.15
-9 min	0.03	0.3%	-4.00	0.12	0.00	0.0%	-1.50	0.15
-8 min	0.03	0.3%	-3.00	0.12	0.00	0.0%	-0.50	0.15
-7 min	0.03	0.3%	-2.00	0.13	0.00	0.0%	0.50	0.16
-6 min	0.03	0.3%	-1.00	0.14	0.00	0.0%	1.50	0.17
-5 min	0.03	0.3%	0.00	0.15	0.00	0.0%	2.50	0.18
-4 min	0.03	0.3%	1.00	0.16	0.00	0.0%	3.50	0.19
-3 min	0.03	0.3%	2.00	0.17	0.00	0.0%	4.50	0.21
-2 min	0.03	0.3%	3.00	0.19	0.00	0.0%	5.50	0.22
-1 min	0.03	0.3%	4.00	0.21	0.00	0.0%	6.50	0.24
0 min	0.03	0.3%	5.00	0.22	0.00	0.0%	7.50	0.25
1 min	0.03	0.3%	6.00	0.24	0.00	0.0%	8.50	0.27
2 min	0.03	0.3%	7.00	0.26	0.00	0.0%	9.50	0.29
3 min	0.03	0.3%	8.00	0.28	0.00	0.0%	10.50	0.31
4 min	0.03	0.3%	9.00	0.30	0.00	0.0%	11.50	0.33
5 min	0.03	0.3%	10.00	0.32	0.00	0.0%	12.50	0.35
6 min	0.03	0.3%	11.00	0.34	0.00	0.0%	13.50	0.36
7 min	0.03	0.3%	12.00	0.36	0.00	0.0%	14.50	0.38
8 min	0.03	0.3%	13.00	0.38	0.00	-0.1%	15.50	0.40
9 min	0.02	0.3%	14.00	0.40	0.00	-0.1%	16.50	0.42
10 min	0.02	0.3%	15.00	0.42	0.00	-0.1%	17.50	0.44
11 min	0.02	0.3%	16.00	0.44	-0.01	-0.1%	18.50	0.46
12 min	0.02	0.3%	17.00	0.46	-0.01	-0.1%	19.50	0.48
13 min	0.02	0.3%	18.00	0.48	-0.01	-0.1%	20.50	0.50
14 min	0.02	0.3%	19.00	0.50	-0.01	-0.1%	21.50	0.52
15 min	0.02	0.3%	20.00	0.52	-0.01	-0.1%	22.50	0.54

Table C- 6: Tidal elevation validation comparison – Smart Coast Site 1

	Raw Data				Re-predicted Data			
Phase Shift	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)
-15 min	0.01	0.1%	-5.00	0.35	-0.04	-0.4%	-10.00	0.32
-14 min	0.01	0.1%	-4.00	0.34	-0.04	-0.4%	-9.00	0.31
-13 min	0.01	0.1%	-3.00	0.32	-0.04	-0.4%	-8.00	0.29
-12 min	0.01	0.1%	-2.00	0.31	-0.04	-0.4%	-7.00	0.28
-11 min	0.01	0.1%	-1.00	0.29	-0.04	-0.4%	-6.00	0.26
-10 min	0.01	0.1%	0.00	0.28	-0.04	-0.4%	-5.00	0.25
-9 min	0.01	0.1%	1.00	0.27	-0.04	-0.4%	-4.00	0.24
-8 min	0.01	0.1%	2.00	0.26	-0.04	-0.4%	-3.00	0.23
-7 min	0.01	0.1%	3.00	0.25	-0.04	-0.4%	-2.00	0.23
-6 min	0.01	0.1%	4.00	0.24	-0.04	-0.4%	-1.00	0.22
-5 min	0.01	0.1%	5.00	0.24	-0.04	-0.4%	0.00	0.22
-4 min	0.01	0.1%	6.00	0.24	-0.04	-0.4%	1.00	0.22
-3 min	0.01	0.1%	7.00	0.24	-0.04	-0.4%	2.00	0.22
-2 min	0.01	0.1%	8.00	0.24	-0.04	-0.4%	3.00	0.22
-1 min	0.01	0.1%	9.00	0.24	-0.04	-0.4%	4.00	0.23
0 min	0.01	0.1%	10.00	0.25	-0.04	-0.4%	5.00	0.24
1 min	0.01	0.1%	11.00	0.25	-0.04	-0.4%	6.00	0.25
2 min	0.01	0.1%	12.00	0.26	-0.04	-0.4%	7.00	0.26
3 min	0.01	0.1%	13.00	0.27	-0.04	-0.4%	8.00	0.27
4 min	0.01	0.1%	14.00	0.28	-0.04	-0.4%	9.00	0.28
5 min	0.01	0.1%	15.00	0.30	-0.04	-0.4%	10.00	0.30
6 min	0.01	0.1%	16.00	0.31	-0.04	-0.4%	11.00	0.31
7 min	0.01	0.1%	17.00	0.33	-0.04	-0.4%	12.00	0.33
8 min	0.01	0.1%	18.00	0.34	-0.04	-0.4%	13.00	0.35
9 min	0.01	0.1%	19.00	0.36	-0.04	-0.4%	14.00	0.36
10 min	0.01	0.1%	20.00	0.38	-0.04	-0.4%	15.00	0.38
11 min	0.01	0.1%	21.00	0.39	-0.04	-0.4%	16.00	0.40
12 min	0.01	0.1%	22.00	0.41	-0.04	-0.4%	17.00	0.42
13 min	0.01	0.1%	23.00	0.43	-0.04	-0.4%	18.00	0.44
14 min	0.01	0.1%	24.00	0.45	-0.04	-0.4%	19.00	0.46
15 min	0.01	0.1%	25.00	0.47	-0.04	-0.4%	20.00	0.48

Table C- 7: Tidal elevation validation comparison – Smart Coast Site 2

	Raw Data				Re-predicted Data			
Phase Shift	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)
-15 min	0.02	0.2%	-5.00	0.34	0.02	0.2%	-10.00	0.33
-14 min	0.02	0.2%	-4.00	0.32	0.02	0.2%	-9.00	0.31
-13 min	0.02	0.2%	-3.00	0.31	0.02	0.2%	-8.00	0.29
-12 min	0.02	0.2%	-2.00	0.29	0.02	0.2%	-7.00	0.28
-11 min	0.02	0.2%	-1.00	0.27	0.02	0.2%	-6.00	0.26
-10 min	0.02	0.2%	0.00	0.26	0.02	0.2%	-5.00	0.25
-9 min	0.02	0.2%	1.00	0.25	0.02	0.2%	-4.00	0.23
-8 min	0.02	0.2%	2.00	0.23	0.02	0.2%	-3.00	0.22
-7 min	0.02	0.2%	3.00	0.22	0.02	0.2%	-2.00	0.21
-6 min	0.02	0.2%	4.00	0.22	0.02	0.2%	-1.00	0.20
-5 min	0.02	0.2%	5.00	0.21	0.02	0.2%	0.00	0.19
-4 min	0.02	0.2%	6.00	0.20	0.02	0.2%	1.00	0.19
-3 min	0.02	0.2%	7.00	0.20	0.02	0.2%	2.00	0.19
-2 min	0.02	0.2%	8.00	0.20	0.02	0.2%	3.00	0.19
-1 min	0.02	0.2%	9.00	0.20	0.02	0.2%	4.00	0.19
0 min	0.02	0.2%	10.00	0.21	0.02	0.2%	5.00	0.20
1 min	0.02	0.2%	11.00	0.22	0.02	0.2%	6.00	0.20
2 min	0.02	0.2%	12.00	0.23	0.02	0.2%	7.00	0.21
3 min	0.02	0.2%	13.00	0.24	0.02	0.2%	8.00	0.23
4 min	0.02	0.2%	14.00	0.25	0.02	0.2%	9.00	0.24
5 min	0.02	0.2%	15.00	0.26	0.02	0.2%	10.00	0.25
6 min	0.02	0.2%	16.00	0.28	0.02	0.2%	11.00	0.27
7 min	0.02	0.2%	17.00	0.29	0.02	0.2%	12.00	0.29
8 min	0.02	0.2%	18.00	0.31	0.02	0.2%	13.00	0.30
9 min	0.02	0.2%	19.00	0.33	0.02	0.2%	14.00	0.32
10 min	0.02	0.2%	20.00	0.34	0.02	0.2%	15.00	0.34
11 min	0.02	0.2%	21.00	0.36	0.02	0.2%	16.00	0.36
12 min	0.02	0.2%	22.00	0.38	0.02	0.2%	17.00	0.38
13 min	0.02	0.2%	23.00	0.40	0.02	0.2%	18.00	0.40
14 min	0.02	0.2%	24.00	0.42	0.02	0.2%	19.00	0.42
15 min	0.02	0.2%	25.00	0.44	0.02	0.2%	20.00	0.44

Table C- 8: Tidal elevation validation comparison – Smart Coast Site 3

	Raw Data				Re-predicted Data			
Phase Shift	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)
-15 min	0.00	0.1%	-10.00	0.31	-0.01	-0.1%	-10.00	0.28
-14 min	0.00	0.1%	-9.00	0.29	-0.01	-0.1%	-9.00	0.27
-13 min	0.00	0.1%	-8.00	0.28	-0.01	-0.1%	-8.00	0.25
-12 min	0.00	0.1%	-7.00	0.26	-0.01	-0.1%	-7.00	0.23
-11 min	0.00	0.1%	-6.00	0.25	-0.01	-0.1%	-6.00	0.22
-10 min	0.00	0.1%	-5.00	0.23	-0.01	-0.1%	-5.00	0.21
-9 min	0.00	0.1%	-4.00	0.22	-0.01	-0.1%	-4.00	0.19
-8 min	0.00	0.1%	-3.00	0.21	-0.01	-0.1%	-3.00	0.18
-7 min	0.00	0.1%	-2.00	0.20	-0.01	-0.1%	-2.00	0.18
-6 min	0.00	0.1%	-1.00	0.19	-0.01	-0.1%	-1.00	0.17
-5 min	0.00	0.1%	0.00	0.19	-0.01	-0.1%	0.00	0.17
-4 min	0.00	0.1%	1.00	0.19	-0.01	-0.1%	1.00	0.17
-3 min	0.00	0.1%	2.00	0.19	-0.01	-0.1%	2.00	0.17
-2 min	0.00	0.1%	3.00	0.19	-0.01	-0.1%	3.00	0.18
-1 min	0.00	0.0%	4.00	0.20	-0.01	-0.1%	4.00	0.19
0 min	0.00	0.0%	5.00	0.21	-0.01	-0.1%	5.00	0.20
1 min	0.00	0.0%	6.00	0.22	-0.01	-0.1%	6.00	0.21
2 min	0.00	0.0%	7.00	0.23	-0.01	-0.1%	7.00	0.23
3 min	0.00	0.0%	8.00	0.24	-0.01	-0.1%	8.00	0.24
4 min	0.00	0.0%	9.00	0.26	-0.01	-0.1%	9.00	0.26
5 min	0.00	0.0%	10.00	0.27	-0.01	-0.1%	10.00	0.28
6 min	0.00	0.0%	11.00	0.29	-0.01	-0.1%	11.00	0.29
7 min	0.00	0.0%	12.00	0.31	-0.01	-0.1%	12.00	0.31
8 min	0.00	0.0%	13.00	0.32	-0.01	-0.1%	13.00	0.33
9 min	0.00	0.0%	14.00	0.34	-0.01	-0.1%	14.00	0.35
10 min	0.00	0.0%	15.00	0.36	-0.01	-0.1%	15.00	0.37
11 min	0.00	0.0%	16.00	0.38	-0.01	-0.1%	16.00	0.39
12 min	0.00	0.0%	17.00	0.40	-0.01	-0.1%	17.00	0.41
13 min	0.00	0.0%	18.00	0.42	-0.01	-0.1%	18.00	0.43
14 min	0.00	0.0%	19.00	0.44	-0.01	-0.1%	19.00	0.45
15 min	0.00	0.0%	20.00	0.46	-0.01	-0.1%	20.00	0.47

Table C- 9: Tidal elevation validation comparison – Smart Coast Site 4

	Raw Data				Re-predicted Data			
Phase Shift	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)
-15 min	0.02	0.3%	-15.00	0.30	0.00	0.0%	-10.00	0.27
-14 min	0.02	0.3%	-14.00	0.28	0.00	0.0%	-9.00	0.25
-13 min	0.02	0.3%	-13.00	0.27	0.00	0.0%	-8.00	0.24
-12 min	0.02	0.3%	-12.00	0.25	0.00	0.0%	-7.00	0.22
-11 min	0.02	0.3%	-11.00	0.24	0.00	0.0%	-6.00	0.21
-10 min	0.02	0.3%	-10.00	0.22	0.00	0.0%	-5.00	0.20
-9 min	0.02	0.3%	-9.00	0.21	0.00	0.0%	-4.00	0.19
-8 min	0.02	0.3%	-8.00	0.20	0.00	0.0%	-3.00	0.18
-7 min	0.02	0.3%	-7.00	0.19	0.00	0.0%	-2.00	0.17
-6 min	0.02	0.3%	-6.00	0.19	0.00	0.0%	-1.00	0.17
-5 min	0.02	0.3%	-5.00	0.19	0.00	0.0%	0.00	0.17
-4 min	0.02	0.3%	-4.00	0.19	0.00	0.0%	1.00	0.17
-3 min	0.02	0.3%	-3.00	0.19	0.00	0.0%	2.00	0.17
-2 min	0.02	0.3%	-2.00	0.19	0.00	0.0%	3.00	0.18
-1 min	0.02	0.3%	-1.00	0.20	0.00	0.0%	4.00	0.19
0 min	0.02	0.3%	0.00	0.21	0.00	0.0%	5.00	0.21
1 min	0.02	0.3%	1.00	0.22	0.00	0.0%	6.00	0.22
2 min	0.02	0.3%	2.00	0.23	0.00	0.0%	7.00	0.23
3 min	0.02	0.3%	3.00	0.25	0.00	0.0%	8.00	0.25
4 min	0.02	0.3%	4.00	0.26	0.00	0.0%	9.00	0.27
5 min	0.02	0.3%	5.00	0.28	0.00	0.0%	10.00	0.29
6 min	0.02	0.3%	6.00	0.30	0.00	0.0%	11.00	0.30
7 min	0.02	0.3%	7.00	0.32	0.00	0.0%	12.00	0.32
8 min	0.02	0.2%	8.00	0.33	0.00	0.0%	13.00	0.34
9 min	0.02	0.2%	9.00	0.35	0.00	0.0%	14.00	0.36
10 min	0.02	0.2%	10.00	0.37	0.00	0.0%	15.00	0.38
11 min	0.02	0.2%	11.00	0.39	0.00	0.0%	16.00	0.40
12 min	0.02	0.2%	12.00	0.41	0.00	0.0%	17.00	0.42
13 min	0.02	0.2%	13.00	0.43	0.00	0.0%	18.00	0.44
14 min	0.02	0.2%	14.00	0.45	0.00	0.0%	19.00	0.46
15 min	0.02	0.2%	15.00	0.47	0.00	0.0%	20.00	0.48

Table C- 10: Tidal elevation validation comparison – Smart Coast Site 5

	Raw Data				Re-predicted Data			
Phase Shift	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)	Mean WL Diff (m)	Mean WL Diff (%)	Mean Phase Diff (mins)	RMS WL (m)
-15 min	0.00	0.1%	-15.00	0.31	0.01	0.1%	-10.00	0.30
-14 min	0.00	0.1%	-14.00	0.29	0.01	0.1%	-9.00	0.28
-13 min	0.00	0.1%	-13.00	0.27	0.01	0.1%	-8.00	0.26
-12 min	0.00	0.1%	-12.00	0.26	0.01	0.1%	-7.00	0.24
-11 min	0.00	0.1%	-11.00	0.24	0.01	0.1%	-6.00	0.23
-10 min	0.00	0.1%	-10.00	0.23	0.01	0.1%	-5.00	0.21
-9 min	0.00	0.1%	-9.00	0.21	0.01	0.1%	-4.00	0.20
-8 min	0.00	0.1%	-8.00	0.20	0.01	0.1%	-3.00	0.19
-7 min	0.00	0.1%	-7.00	0.19	0.01	0.1%	-2.00	0.18
-6 min	0.00	0.1%	-6.00	0.18	0.01	0.1%	-1.00	0.17
-5 min	0.00	0.1%	-5.00	0.18	0.01	0.1%	0.00	0.16
-4 min	0.00	0.0%	-4.00	0.18	0.01	0.1%	1.00	0.16
-3 min	0.00	0.0%	-3.00	0.18	0.01	0.1%	2.00	0.16
-2 min	0.00	0.0%	-2.00	0.18	0.01	0.1%	3.00	0.17
-1 min	0.00	0.0%	-1.00	0.19	0.01	0.1%	4.00	0.17
0 min	0.00	0.0%	0.00	0.20	0.01	0.1%	5.00	0.18
1 min	0.00	0.0%	1.00	0.21	0.01	0.1%	6.00	0.19
2 min	0.00	0.0%	2.00	0.22	0.01	0.1%	7.00	0.21
3 min	0.00	0.0%	3.00	0.23	0.01	0.1%	8.00	0.22
4 min	0.00	0.0%	4.00	0.25	0.01	0.1%	9.00	0.24
5 min	0.00	0.0%	5.00	0.26	0.01	0.1%	10.00	0.26
6 min	0.00	0.0%	6.00	0.28	0.01	0.1%	11.00	0.27
7 min	0.00	0.0%	7.00	0.30	0.01	0.1%	12.00	0.29
8 min	0.00	0.0%	8.00	0.32	0.01	0.1%	13.00	0.31
9 min	0.00	0.0%	9.00	0.34	0.01	0.1%	14.00	0.33
10 min	0.00	0.0%	10.00	0.35	0.01	0.1%	15.00	0.35
11 min	0.00	0.0%	11.00	0.37	0.01	0.1%	16.00	0.37
12 min	0.00	0.0%	12.00	0.39	0.01	0.1%	17.00	0.39
13 min	0.00	0.0%	13.00	0.41	0.01	0.1%	18.00	0.41
14 min	0.00	0.0%	14.00	0.43	0.01	0.1%	19.00	0.43
15 min	0.00	0.0%	15.00	0.45	0.01	0.1%	20.00	0.45

Table C- 11: Current velocity validation comparison – AWAC Site 1

	Raw Data					Adjusted Data				
Phase Shift	Mean Speed Diff (m/s)	Mean Speed Diff (%)	Mean Dir Diff (°)	RMS Flow (m/s)	Scatter Index	Mean Speed Diff (m/s)	Mean Speed Diff (%)	Mean Dir Diff (°)	RMS Flow (m/s)	Scatter Index
-15 min	0.00	-0.6%	-25.04	0.07	0.65	0.01	3.4%	-5.00	0.05	0.35
-14 min	0.00	-0.6%	-24.70	0.07	0.65	0.01	3.4%	-4.85	0.05	0.35
-13 min	0.00	-0.6%	-24.26	0.07	0.65	0.01	3.5%	-4.95	0.05	0.35
-12 min	0.00	-0.6%	-24.33	0.07	0.65	0.01	3.5%	-4.94	0.05	0.35
-11 min	0.00	-0.6%	-23.93	0.07	0.65	0.01	3.5%	-4.90	0.05	0.35
-10 min	0.00	-0.6%	-23.41	0.07	0.65	0.01	3.5%	-3.98	0.05	0.35
-9 min	0.00	-0.6%	-22.93	0.07	0.65	0.01	3.5%	-3.81	0.05	0.35
-8 min	0.00	-0.6%	-22.80	0.07	0.65	0.01	3.5%	-3.58	0.05	0.35
-7 min	0.00	-0.6%	-22.66	0.07	0.65	0.01	3.5%	-3.55	0.05	0.35
-6 min	0.00	-0.6%	-22.36	0.07	0.65	0.01	3.5%	-3.36	0.05	0.35
-5 min	0.00	-0.6%	-21.99	0.07	0.65	0.01	3.5%	-2.24	0.05	0.35
-4 min	0.00	-0.6%	-21.36	0.07	0.65	0.01	3.5%	-2.01	0.05	0.35
-3 min	0.00	-0.6%	-21.03	0.07	0.65	0.01	3.5%	-2.01	0.05	0.35
-2 min	0.00	-0.6%	-21.29	0.07	0.65	0.01	3.6%	-2.19	0.05	0.35
-1 min	0.00	-0.6%	-21.10	0.07	0.65	0.01	3.6%	-2.15	0.05	0.35
0 min	0.00	-0.6%	-20.56	0.07	0.65	0.01	3.6%	-0.92	0.05	0.35
1 min	0.00	-0.6%	-19.99	0.07	0.65	0.01	3.6%	-0.67	0.05	0.35
2 min	0.00	-0.5%	-19.89	0.07	0.65	0.01	3.6%	-0.64	0.05	0.35
3 min	0.00	-0.5%	-19.54	0.07	0.65	0.01	3.6%	-0.40	0.05	0.35
4 min	0.00	-0.5%	-19.65	0.07	0.65	0.01	3.6%	-0.39	0.05	0.35
5 min	0.00	-0.5%	-19.54	0.07	0.65	0.01	3.6%	0.07	0.05	0.35
6 min	0.00	-0.5%	-19.21	0.07	0.65	0.01	3.7%	0.27	0.05	0.35
7 min	0.00	-0.5%	-19.07	0.07	0.65	0.01	3.7%	-0.10	0.05	0.35
8 min	0.00	-0.5%	-19.10	0.07	0.65	0.01	3.7%	-0.05	0.05	0.35
9 min	0.00	-0.5%	-18.49	0.07	0.65	0.01	3.7%	0.21	0.05	0.35
10 min	0.00	-0.6%	-18.15	0.07	0.65	0.01	3.7%	1.35	0.05	0.35
11 min	0.00	-0.5%	-17.72	0.07	0.65	0.01	3.6%	1.57	0.05	0.35
12 min	0.00	-0.5%	-17.57	0.07	0.65	0.01	3.6%	1.61	0.05	0.35
13 min	0.00	-0.5%	-17.19	0.07	0.65	0.01	3.6%	1.87	0.05	0.35
14 min	0.00	-0.5%	-17.35	0.07	0.65	0.01	3.6%	1.71	0.05	0.35
15 min	0.00	-0.6%	-17.02	0.07	0.65	0.01	3.6%	2.44	0.05	0.35

Table C- 12: Current velocity validation comparison – AWAC Site 2

	Raw Data					Re-predicted Data				
Phase Shift	**Mean Speed Diff (m/s)**	**Mean Speed Diff (%)**	**Mean Dir Diff (°)**	**RMS Flow (m/s)**	**Scatter Index**	**Mean Speed Diff (m/s)**	**Mean Speed Diff (%)**	**Mean Dir Diff (°)**	**RMS Flow (m/s)**	**Scatter Index**
-15 min	0.02	4.3%	-4.50	0.05	0.27	0.02	3.4%	-2.61	0.03	0.16
-14 min	0.02	4.3%	-4.18	0.05	0.27	0.02	3.4%	-2.49	0.03	0.16
-13 min	0.02	4.3%	-3.87	0.05	0.27	0.02	3.5%	-2.16	0.03	0.16
-12 min	0.02	4.3%	-3.92	0.05	0.27	0.02	3.5%	-1.83	0.03	0.16
-11 min	0.02	4.3%	-3.55	0.05	0.27	0.02	3.5%	-1.43	0.03	0.16
-10 min	0.02	4.3%	-3.45	0.05	0.27	0.02	3.5%	-1.16	0.03	0.16
-9 min	0.02	4.3%	-3.28	0.05	0.27	0.02	3.5%	-1.13	0.03	0.16
-8 min	0.02	4.3%	-3.10	0.05	0.27	0.02	3.5%	-0.85	0.03	0.16
-7 min	0.02	4.3%	-2.95	0.05	0.27	0.02	3.5%	-0.88	0.03	0.16
-6 min	0.02	4.3%	-2.72	0.05	0.27	0.02	3.5%	-0.42	0.03	0.16
-5 min	0.02	4.3%	-2.51	0.05	0.27	0.02	3.5%	0.04	0.03	0.16
-4 min	0.02	4.3%	-2.10	0.05	0.27	0.02	3.5%	-0.04	0.03	0.16
-3 min	0.02	4.3%	-1.70	0.05	0.27	0.02	3.5%	0.38	0.03	0.16
-2 min	0.02	4.3%	-2.10	0.05	0.27	0.02	3.5%	-0.04	0.03	0.16
-1 min	0.02	4.3%	-1.88	0.05	0.27	0.02	3.5%	-0.20	0.03	0.16
0 min	0.02	4.3%	-1.68	0.05	0.27	0.02	3.5%	-0.32	0.03	0.16
1 min	0.02	4.3%	-1.89	0.05	0.27	0.02	3.5%	0.09	0.03	0.16
2 min	0.02	4.3%	-1.68	0.05	0.27	0.02	3.5%	0.24	0.03	0.16
3 min	0.02	4.4%	-1.22	0.05	0.27	0.02	3.5%	0.68	0.03	0.16
4 min	0.02	4.4%	-0.74	0.05	0.27	0.02	3.5%	1.12	0.03	0.16
5 min	0.02	4.4%	-0.47	0.05	0.27	0.02	3.5%	1.02	0.03	0.16
6 min	0.02	4.4%	-0.42	0.05	0.27	0.02	3.5%	1.16	0.03	0.16
7 min	0.02	4.4%	0.04	0.05	0.27	0.02	3.5%	1.34	0.03	0.16
8 min	0.02	4.4%	-0.54	0.05	0.27	0.02	3.5%	1.51	0.03	0.16
9 min	0.02	4.4%	-0.48	0.05	0.27	0.02	3.5%	2.01	0.03	0.16
10 min	0.02	4.3%	-0.42	0.05	0.27	0.02	3.5%	2.51	0.03	0.16
11 min	0.02	4.4%	-0.99	0.05	0.27	0.02	3.5%	2.47	0.03	0.16
12 min	0.02	4.4%	-0.93	0.05	0.27	0.02	3.5%	2.95	0.03	0.16
13 min	0.02	4.4%	-0.87	0.05	0.27	0.02	3.5%	2.36	0.03	0.16
14 min	0.02	4.4%	-0.60	0.05	0.27	0.02	3.5%	2.04	0.03	0.16
15 min	0.02	4.4%	-0.75	0.05	0.27	0.02	3.5%	1.98	0.03	0.16

Table C- 13: Current velocity validation comparison – Smart Coast Site 1

	Raw Data					Re-predicted Data				
Phase Shift	**Mean Speed Diff (m/s)**	**Mean Speed Diff (%)**	**Mean Dir Diff (°)**	**RMS Flow (m/s)**	**Scatter Index**	**Mean Speed Diff (m/s)**	**Mean Speed Diff (%)**	**Mean Dir Diff (°)**	**RMS Flow (m/s)**	**Scatter Index**
-15 min	-0.03	-3.3%	-8.55	0.06	0.12	-0.04	-4.1%	-8.29	0.06	0.12
-14 min	-0.03	-3.3%	-8.54	0.06	0.12	-0.04	-4.1%	-8.29	0.06	0.12
-13 min	-0.03	-3.3%	-8.53	0.06	0.12	-0.04	-4.1%	-8.28	0.06	0.12
-12 min	-0.03	-3.3%	-8.53	0.06	0.12	-0.04	-4.1%	-8.27	0.06	0.12
-11 min	-0.03	-3.3%	-8.52	0.06	0.12	-0.04	-4.1%	-8.26	0.06	0.12
-10 min	-0.03	-3.3%	-8.50	0.06	0.12	-0.04	-4.1%	-8.25	0.06	0.12
-9 min	-0.03	-3.3%	-8.50	0.06	0.12	-0.04	-4.1%	-8.24	0.06	0.12
-8 min	-0.03	-3.3%	-8.49	0.06	0.12	-0.04	-4.1%	-8.23	0.06	0.12
-7 min	-0.03	-3.3%	-8.48	0.06	0.12	-0.04	-4.1%	-8.22	0.06	0.12
-6 min	-0.03	-3.3%	-8.47	0.06	0.12	-0.04	-4.1%	-8.21	0.06	0.12
-5 min	-0.03	-3.3%	-8.46	0.06	0.12	-0.04	-4.1%	-8.20	0.06	0.12
-4 min	-0.03	-3.3%	-8.45	0.06	0.12	-0.04	-4.1%	-8.19	0.06	0.12
-3 min	-0.03	-3.3%	-8.44	0.06	0.12	-0.04	-4.1%	-8.19	0.06	0.12
-2 min	-0.03	-3.3%	-8.43	0.06	0.12	-0.04	-4.1%	-8.18	0.06	0.12
-1 min	-0.03	-3.3%	-8.42	0.06	0.12	-0.04	-4.1%	-8.17	0.06	0.12
0 min	-0.03	-3.3%	-8.41	0.06	0.12	-0.04	-4.1%	-8.16	0.06	0.12
1 min	-0.03	-3.3%	-8.40	0.06	0.12	-0.04	-4.1%	-8.15	0.06	0.12
2 min	-0.03	-3.3%	-8.40	0.06	0.12	-0.04	-4.1%	-8.14	0.06	0.12
3 min	-0.03	-3.3%	-8.39	0.06	0.12	-0.04	-4.1%	-8.13	0.06	0.12
4 min	-0.03	-3.3%	-8.38	0.06	0.12	-0.04	-4.1%	-8.12	0.06	0.12
5 min	-0.03	-3.3%	-8.37	0.06	0.12	-0.04	-4.1%	-8.11	0.06	0.12
6 min	-0.03	-3.3%	-8.36	0.06	0.12	-0.04	-4.1%	-8.10	0.06	0.12
7 min	-0.03	-3.3%	-8.35	0.06	0.12	-0.04	-4.1%	-8.09	0.06	0.12
8 min	-0.03	-3.3%	-8.34	0.06	0.12	-0.04	-4.1%	-8.09	0.06	0.12
9 min	-0.03	-3.3%	-8.33	0.06	0.12	-0.04	-4.1%	-8.08	0.06	0.12
10 min	-0.03	-3.3%	-8.32	0.06	0.12	-0.04	-4.1%	-8.06	0.06	0.12
11 min	-0.03	-3.3%	-8.31	0.06	0.12	-0.04	-4.1%	-8.06	0.06	0.12
12 min	-0.03	-3.3%	-8.30	0.06	0.12	-0.04	-4.1%	-8.05	0.06	0.12
13 min	-0.03	-3.3%	-8.29	0.06	0.12	-0.04	-4.1%	-8.04	0.06	0.12
14 min	-0.03	-3.3%	-8.28	0.06	0.12	-0.04	-4.1%	-8.03	0.06	0.12
15 min	-0.03	-3.3%	-8.27	0.06	0.12	-0.04	-4.1%	-8.02	0.06	0.12

Table C- 14: Current velocity validation comparison – Smart Coast Site 2

	Raw Data					Re-predicted Data				
Phase Shift	Mean Speed Diff (m/s)	Mean Speed Diff (%)	Mean Dir Diff (°)	RMS Flow (m/s)	Scatter Index	Mean Speed Diff (m/s)	Mean Speed Diff (%)	Mean Dir Diff (°)	RMS Flow (m/s)	Scatter Index
-15 min	0.02	2.0%	-4.38	0.10	0.18	0.02	1.9%	-3.39	0.06	0.10
-14 min	0.02	2.0%	-4.36	0.10	0.18	0.02	2.0%	-3.27	0.06	0.10
-13 min	0.02	2.0%	-4.39	0.10	0.18	0.02	2.0%	-3.21	0.06	0.10
-12 min	0.02	2.0%	-4.45	0.10	0.18	0.02	2.0%	-3.27	0.06	0.10
-11 min	0.02	2.0%	-4.52	0.10	0.18	0.02	2.0%	-3.31	0.06	0.10
-10 min	0.02	2.0%	-4.62	0.10	0.18	0.02	1.9%	-3.38	0.06	0.10
-9 min	0.02	2.0%	-4.68	0.10	0.18	0.02	2.0%	-3.45	0.06	0.10
-8 min	0.02	2.0%	-4.79	0.10	0.18	0.02	2.0%	-3.53	0.06	0.10
-7 min	0.02	2.0%	-4.85	0.10	0.18	0.02	2.0%	-3.58	0.06	0.10
-6 min	0.02	2.0%	-4.84	0.10	0.18	0.02	2.0%	-3.56	0.06	0.10
-5 min	0.02	2.0%	-4.75	0.10	0.18	0.02	1.9%	-3.49	0.06	0.10
-4 min	0.02	2.0%	-4.67	0.10	0.18	0.02	2.0%	-3.47	0.06	0.10
-3 min	0.02	2.0%	-4.72	0.10	0.18	0.02	2.0%	-3.48	0.06	0.10
-2 min	0.02	2.0%	-4.79	0.10	0.18	0.02	2.0%	-3.53	0.06	0.10
-1 min	0.02	2.0%	-4.87	0.10	0.18	0.02	2.0%	-3.60	0.06	0.10
0 min	0.02	2.0%	-4.96	0.10	0.18	0.02	1.9%	-3.70	0.06	0.10
1 min	0.02	2.0%	-5.05	0.10	0.18	0.02	2.0%	-3.78	0.06	0.10
2 min	0.02	2.0%	-5.18	0.10	0.18	0.02	2.0%	-3.87	0.06	0.10
3 min	0.02	2.0%	-5.27	0.10	0.18	0.02	2.0%	-3.94	0.06	0.10
4 min	0.02	2.0%	-5.27	0.10	0.18	0.02	2.0%	-3.93	0.06	0.10
5 min	0.02	2.0%	-5.18	0.10	0.18	0.02	1.9%	-3.83	0.06	0.10
6 min	0.02	2.0%	-5.14	0.10	0.18	0.02	2.0%	-3.73	0.06	0.10
7 min	0.02	2.0%	-5.16	0.10	0.18	0.02	2.0%	-3.72	0.06	0.10
8 min	0.02	2.0%	-5.23	0.10	0.18	0.02	2.0%	-3.79	0.06	0.10
9 min	0.02	2.0%	-5.33	0.10	0.18	0.02	2.0%	-3.88	0.06	0.10
10 min	0.02	2.0%	-5.48	0.10	0.18	0.02	1.9%	-4.00	0.06	0.10
11 min	0.02	2.0%	-5.57	0.10	0.18	0.02	2.0%	-4.09	0.06	0.10
12 min	0.02	2.0%	-5.65	0.10	0.18	0.02	2.0%	-4.20	0.06	0.10
13 min	0.02	2.0%	-5.73	0.10	0.18	0.02	2.0%	-4.29	0.06	0.10
14 min	0.02	2.0%	-5.73	0.10	0.18	0.02	2.0%	-4.30	0.06	0.10
15 min	0.02	2.0%	-5.65	0.10	0.18	0.02	1.9%	-4.23	0.06	0.10

Table C- 15: Current velocity validation comparison – Smart Coast Site 3

	Raw Data					Re-predicted Data				
Phase Shift	**Mean Speed Diff (m/s)**	**Mean Speed Diff (%)**	**Mean Dir Diff (°)**	**RMS Flow (m/s)**	**Scatter Index**	**Mean Speed Diff (m/s)**	**Mean Speed Diff (%)**	**Mean Dir Diff (°)**	**RMS Flow (m/s)**	**Scatter Index**
-15 min	0.00	-0.1%	-8.51	0.05	0.13	0.00	0.2%	-9.23	0.02	0.06
-14 min	0.00	-0.1%	-8.28	0.05	0.13	0.00	0.2%	-9.01	0.02	0.06
-13 min	0.00	-0.1%	-8.04	0.05	0.13	0.00	0.2%	-8.77	0.02	0.06
-12 min	0.00	-0.1%	-8.06	0.05	0.13	0.00	0.2%	-8.77	0.02	0.06
-11 min	0.00	-0.1%	-8.27	0.05	0.13	0.00	0.2%	-8.92	0.02	0.06
-10 min	0.00	-0.1%	-8.50	0.05	0.13	0.00	0.2%	-9.07	0.02	0.06
-9 min	0.00	-0.1%	-7.80	0.05	0.13	0.00	0.2%	-8.29	0.02	0.06
-8 min	0.00	-0.1%	-7.96	0.05	0.13	0.00	0.2%	-8.39	0.02	0.06
-7 min	0.00	-0.1%	-7.78	0.05	0.13	0.00	0.2%	-8.25	0.02	0.06
-6 min	0.00	-0.1%	-7.95	0.05	0.13	0.00	0.2%	-8.56	0.02	0.06
-5 min	0.00	-0.1%	-7.47	0.05	0.13	0.00	0.2%	-8.01	0.02	0.06
-4 min	0.00	-0.1%	-7.26	0.05	0.13	0.00	0.2%	-7.71	0.02	0.06
-3 min	0.00	-0.1%	-7.03	0.05	0.13	0.00	0.2%	-7.49	0.02	0.06
-2 min	0.00	-0.1%	-7.14	0.05	0.13	0.00	0.2%	-7.49	0.02	0.06
-1 min	0.00	-0.1%	-7.28	0.05	0.13	0.00	0.2%	-7.75	0.02	0.06
0 min	0.00	-0.1%	-7.56	0.05	0.13	0.00	0.2%	-8.02	0.02	0.06
1 min	0.00	-0.1%	-7.05	0.05	0.13	0.00	0.2%	-7.48	0.02	0.06
2 min	0.00	-0.1%	-7.12	0.05	0.13	0.00	0.2%	-7.55	0.02	0.06
3 min	0.00	-0.1%	-7.21	0.05	0.13	0.00	0.2%	-7.36	0.02	0.06
4 min	0.00	-0.1%	-7.28	0.05	0.13	0.00	0.2%	-7.55	0.02	0.06
5 min	0.00	-0.1%	-6.70	0.05	0.13	0.00	0.2%	-7.01	0.02	0.06
6 min	0.00	-0.1%	-6.40	0.05	0.13	0.00	0.2%	-6.63	0.02	0.06
7 min	0.00	-0.1%	-6.36	0.05	0.13	0.00	0.2%	-6.49	0.02	0.06
8 min	0.00	-0.1%	-6.37	0.05	0.13	0.00	0.2%	-6.53	0.02	0.06
9 min	0.00	-0.1%	-6.71	0.05	0.13	0.00	0.2%	-6.69	0.02	0.06
10 min	0.00	-0.1%	-7.07	0.05	0.13	0.00	0.2%	-7.03	0.02	0.06
11 min	0.00	-0.1%	-6.63	0.05	0.13	0.00	0.2%	-6.38	0.02	0.06
12 min	0.00	-0.1%	-6.62	0.05	0.13	0.00	0.2%	-6.51	0.02	0.06
13 min	0.00	-0.1%	-6.75	0.05	0.13	0.00	0.2%	-6.57	0.02	0.06
14 min	0.00	-0.1%	-6.86	0.05	0.13	0.00	0.2%	-6.82	0.02	0.06
15 min	0.00	-0.1%	-6.76	0.05	0.13	0.00	0.2%	-6.42	0.02	0.06

Table C- 16: Current velocity validation comparison – Smart Coast Site 4

	Raw Data					Re-predicted Data				
Phase Shift	**Mean Speed Diff (m/s)**	**Mean Speed Diff (%)**	**Mean Dir Diff (°)**	**RMS Flow (m/s)**	**Scatter Index**	**Mean Speed Diff (m/s)**	**Mean Speed Diff (%)**	**Mean Dir Diff (°)**	**RMS Flow (m/s)**	**Scatter Index**
-15 min	0.01	1.2%	-17.13	0.06	0.19	0.01	1.6%	-17.13	0.03	0.10
-14 min	0.01	1.2%	-17.27	0.06	0.19	0.01	1.6%	-17.23	0.03	0.10
-13 min	0.01	1.3%	-16.62	0.06	0.19	0.01	1.6%	-16.57	0.03	0.10
-12 min	0.01	1.3%	-16.67	0.06	0.19	0.01	1.6%	-16.59	0.03	0.10
-11 min	0.01	1.2%	-16.37	0.06	0.19	0.01	1.6%	-16.30	0.03	0.10
-10 min	0.01	1.2%	-16.29	0.06	0.19	0.01	1.6%	-16.19	0.03	0.10
-9 min	0.01	1.2%	-16.61	0.06	0.19	0.01	1.6%	-16.31	0.03	0.10
-8 min	0.01	1.3%	-17.06	0.06	0.19	0.01	1.6%	-16.30	0.03	0.10
-7 min	0.01	1.3%	-16.94	0.06	0.19	0.01	1.6%	-15.96	0.03	0.10
-6 min	0.01	1.3%	-16.58	0.06	0.19	0.01	1.6%	-15.64	0.03	0.10
-5 min	0.01	1.2%	-16.19	0.06	0.19	0.01	1.6%	-15.20	0.03	0.10
-4 min	0.01	1.3%	-16.24	0.06	0.19	0.01	1.6%	-15.09	0.03	0.10
-3 min	0.01	1.3%	-15.70	0.06	0.19	0.01	1.6%	-14.37	0.03	0.10
-2 min	0.01	1.3%	-15.64	0.06	0.19	0.01	1.6%	-14.43	0.03	0.10
-1 min	0.01	1.3%	-15.31	0.06	0.19	0.01	1.6%	-14.10	0.03	0.10
0 min	0.01	1.2%	-15.31	0.06	0.19	0.01	1.6%	-14.01	0.03	0.10
1 min	0.01	1.2%	-15.73	0.06	0.19	0.01	1.6%	-14.41	0.03	0.10
2 min	0.01	1.3%	-16.01	0.06	0.19	0.01	1.6%	-14.79	0.03	0.10
3 min	0.01	1.3%	-15.79	0.06	0.19	0.01	1.6%	-14.59	0.03	0.10
4 min	0.01	1.2%	-15.33	0.06	0.19	0.01	1.6%	-14.19	0.03	0.10
5 min	0.01	1.2%	-14.87	0.06	0.19	0.01	1.6%	-13.69	0.03	0.10
6 min	0.01	1.2%	-15.02	0.06	0.19	0.01	1.6%	-13.83	0.03	0.10
7 min	0.01	1.3%	-14.28	0.06	0.19	0.01	1.6%	-13.03	0.03	0.10
8 min	0.01	1.3%	-14.27	0.06	0.19	0.01	1.6%	-12.93	0.03	0.10
9 min	0.01	1.2%	-13.89	0.06	0.19	0.01	1.6%	-12.55	0.03	0.10
10 min	0.01	1.2%	-13.88	0.06	0.19	0.01	1.6%	-12.50	0.03	0.10
11 min	0.01	1.2%	-14.42	0.06	0.19	0.01	1.6%	-12.67	0.03	0.10
12 min	0.01	1.3%	-14.87	0.06	0.19	0.01	1.6%	-13.07	0.03	0.10
13 min	0.01	1.3%	-14.76	0.06	0.19	0.01	1.6%	-12.95	0.03	0.10
14 min	0.01	1.2%	-14.50	0.06	0.19	0.01	1.6%	-12.80	0.03	0.10
15 min	0.01	1.2%	-13.98	0.06	0.19	0.01	1.6%	-12.25	0.03	0.10

Table C- 17: Current velocity validation comparison – Smart Coast Site 5

	Raw Data					Re-predicted Data				
Phase Shift	**Mean Speed Diff (m/s)**	**Mean Speed Diff (%)**	**Mean Dir Diff (°)**	**RMS Flow (m/s)**	**Scatter Index**	**Mean Speed Diff (m/s)**	**Mean Speed Diff (%)**	**Mean Dir Diff (°)**	**RMS Flow (m/s)**	**Scatter Index**
-15 min	0.02	2.1%	-25.24	0.07	0.20	0.01	1.9%	-24.53	0.03	0.10
-14 min	0.02	2.1%	-25.12	0.07	0.20	0.01	1.9%	-24.44	0.03	0.10
-13 min	0.02	2.1%	-25.38	0.07	0.20	0.01	1.9%	-24.73	0.03	0.10
-12 min	0.02	2.1%	-25.08	0.07	0.20	0.01	1.9%	-24.46	0.03	0.10
-11 min	0.02	2.1%	-24.79	0.07	0.20	0.01	1.9%	-24.19	0.03	0.10
-10 min	0.02	2.1%	-24.87	0.07	0.20	0.01	1.9%	-24.30	0.03	0.10
-9 min	0.02	2.1%	-25.15	0.07	0.20	0.01	1.9%	-24.60	0.03	0.10
-8 min	0.02	2.1%	-25.18	0.07	0.20	0.01	1.9%	-24.51	0.03	0.10
-7 min	0.02	2.1%	-25.63	0.07	0.20	0.01	1.9%	-24.98	0.03	0.10
-6 min	0.02	2.1%	-25.60	0.07	0.20	0.01	1.9%	-24.50	0.03	0.10
-5 min	0.02	2.1%	-25.62	0.07	0.20	0.01	1.9%	-24.39	0.03	0.10
-4 min	0.02	2.1%	-25.62	0.07	0.20	0.01	1.9%	-24.28	0.03	0.10
-3 min	0.02	2.1%	-25.85	0.07	0.20	0.01	1.9%	-24.56	0.03	0.10
-2 min	0.02	2.1%	-25.51	0.07	0.20	0.01	1.9%	-24.29	0.03	0.10
-1 min	0.02	2.1%	-25.19	0.07	0.20	0.01	1.9%	-24.19	0.03	0.10
0 min	0.02	2.1%	-25.24	0.07	0.20	0.01	1.9%	-24.30	0.03	0.10
1 min	0.02	2.1%	-25.49	0.07	0.20	0.01	1.9%	-24.59	0.03	0.10
2 min	0.02	2.1%	-25.63	0.07	0.20	0.01	1.9%	-24.78	0.03	0.10
3 min	0.02	2.1%	-26.05	0.07	0.20	0.01	1.9%	-25.23	0.03	0.10
4 min	0.02	2.1%	-25.90	0.07	0.20	0.01	1.9%	-25.20	0.03	0.10
5 min	0.02	2.1%	-25.88	0.07	0.20	0.01	1.9%	-25.34	0.03	0.10
6 min	0.02	2.1%	-25.98	0.07	0.20	0.01	1.9%	-25.49	0.03	0.10
7 min	0.02	2.1%	-26.18	0.07	0.20	0.01	1.9%	-25.69	0.03	0.10
8 min	0.02	2.1%	-25.82	0.07	0.20	0.01	1.9%	-25.34	0.03	0.10
9 min	0.02	2.1%	-25.78	0.07	0.20	0.01	1.9%	-25.39	0.03	0.10
10 min	0.02	2.1%	-26.12	0.07	0.20	0.01	1.9%	-25.75	0.03	0.10
11 min	0.02	2.1%	-26.32	0.07	0.20	0.01	1.9%	-25.95	0.03	0.10
12 min	0.02	2.1%	-26.40	0.07	0.20	0.01	1.9%	-25.99	0.03	0.10
13 min	0.02	2.1%	-26.77	0.07	0.20	0.01	1.9%	-26.36	0.03	0.10
14 min	0.02	2.1%	-26.65	0.07	0.20	0.01	1.9%	-26.20	0.03	0.10
15 min	0.02	2.1%	-26.78	0.07	0.20	0.01	1.9%	-26.20	0.03	0.10

Appendix D Validation Time Series Comparisons

FIGURES

Figure D- 1: Tidal elevation validation comparison – Port Talbot

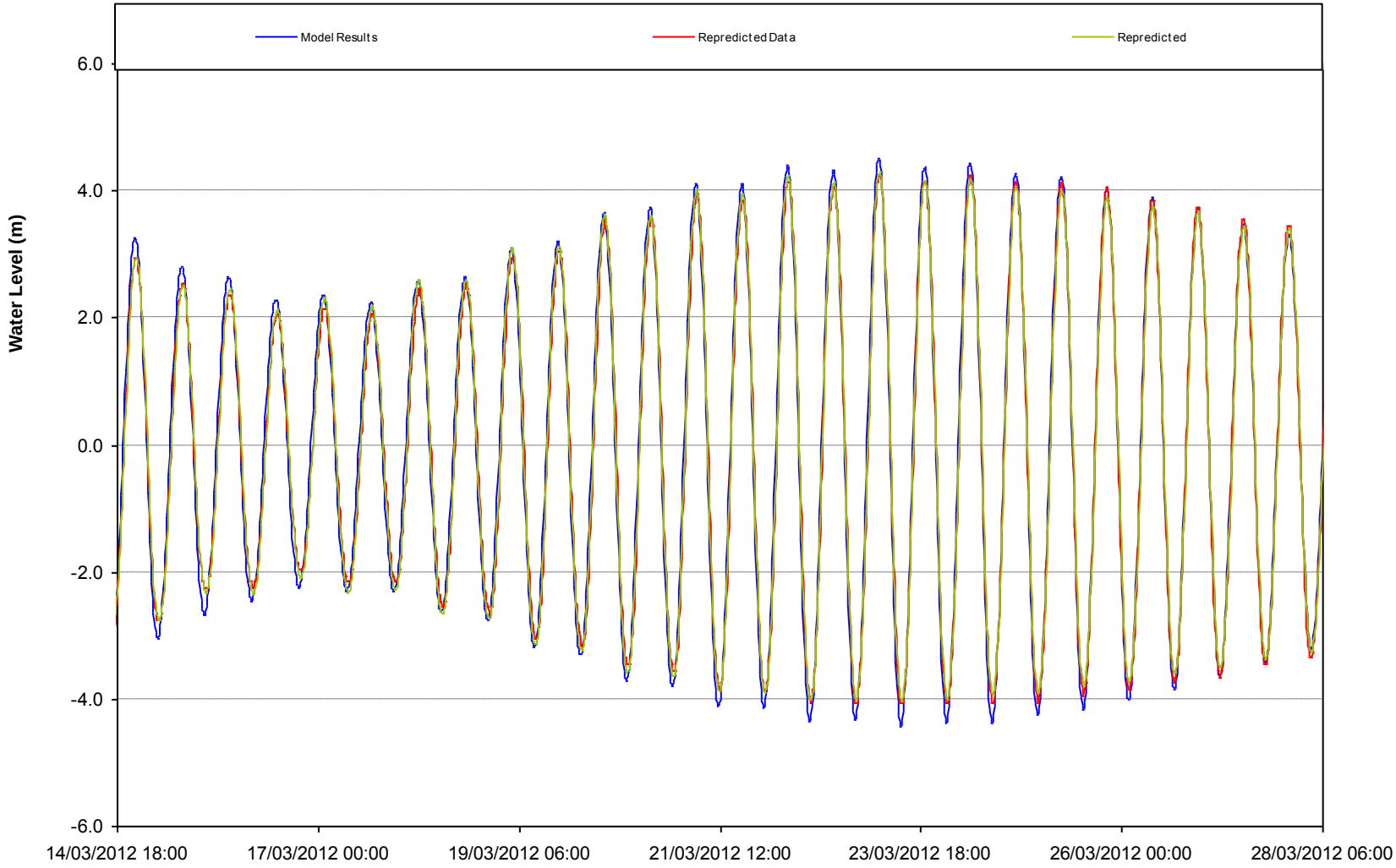


Figure D- 2: Tidal elevation validation comparison – Swansea

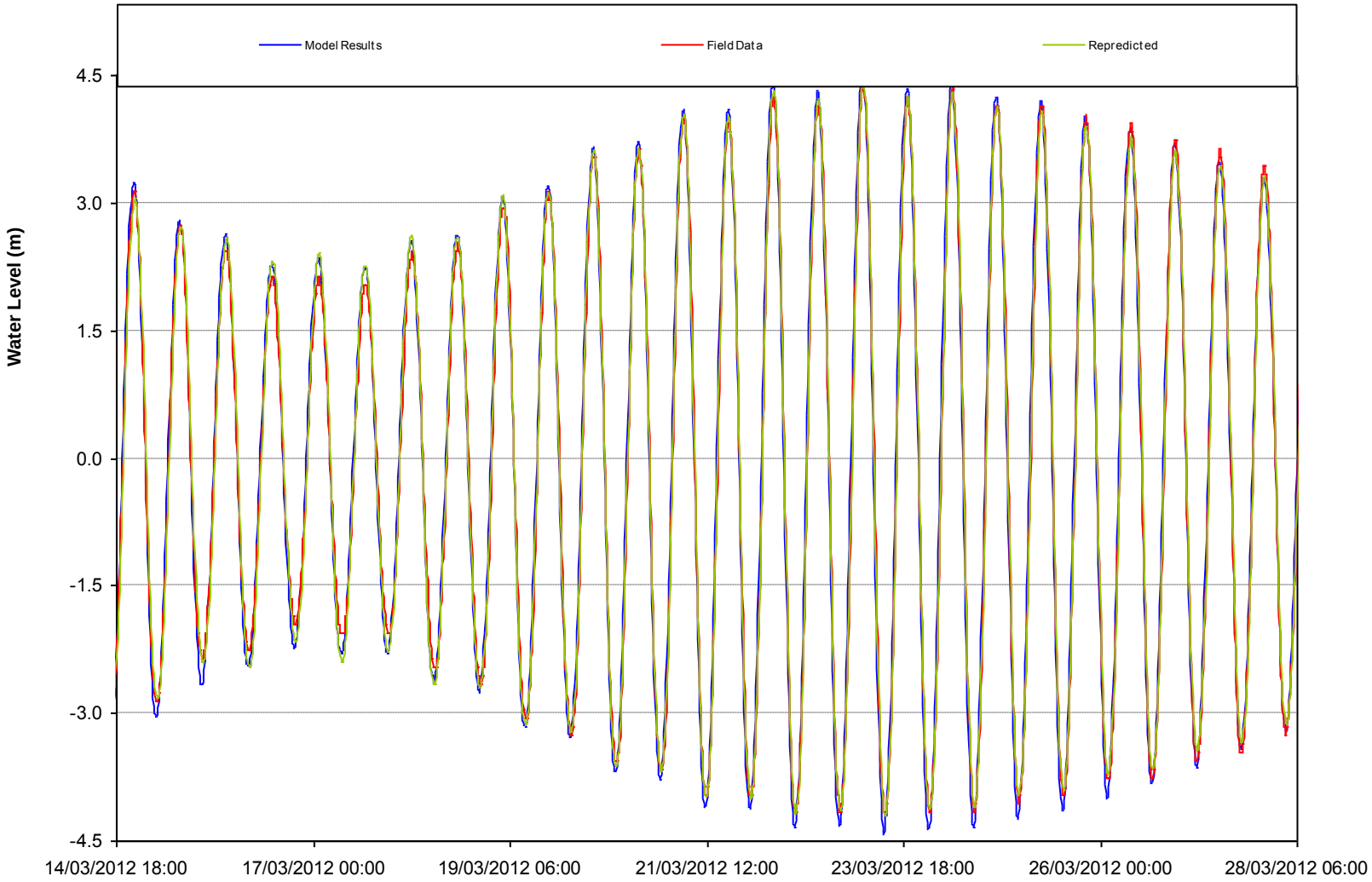


Figure D- 3: Tidal elevation validation comparison – Mumbles

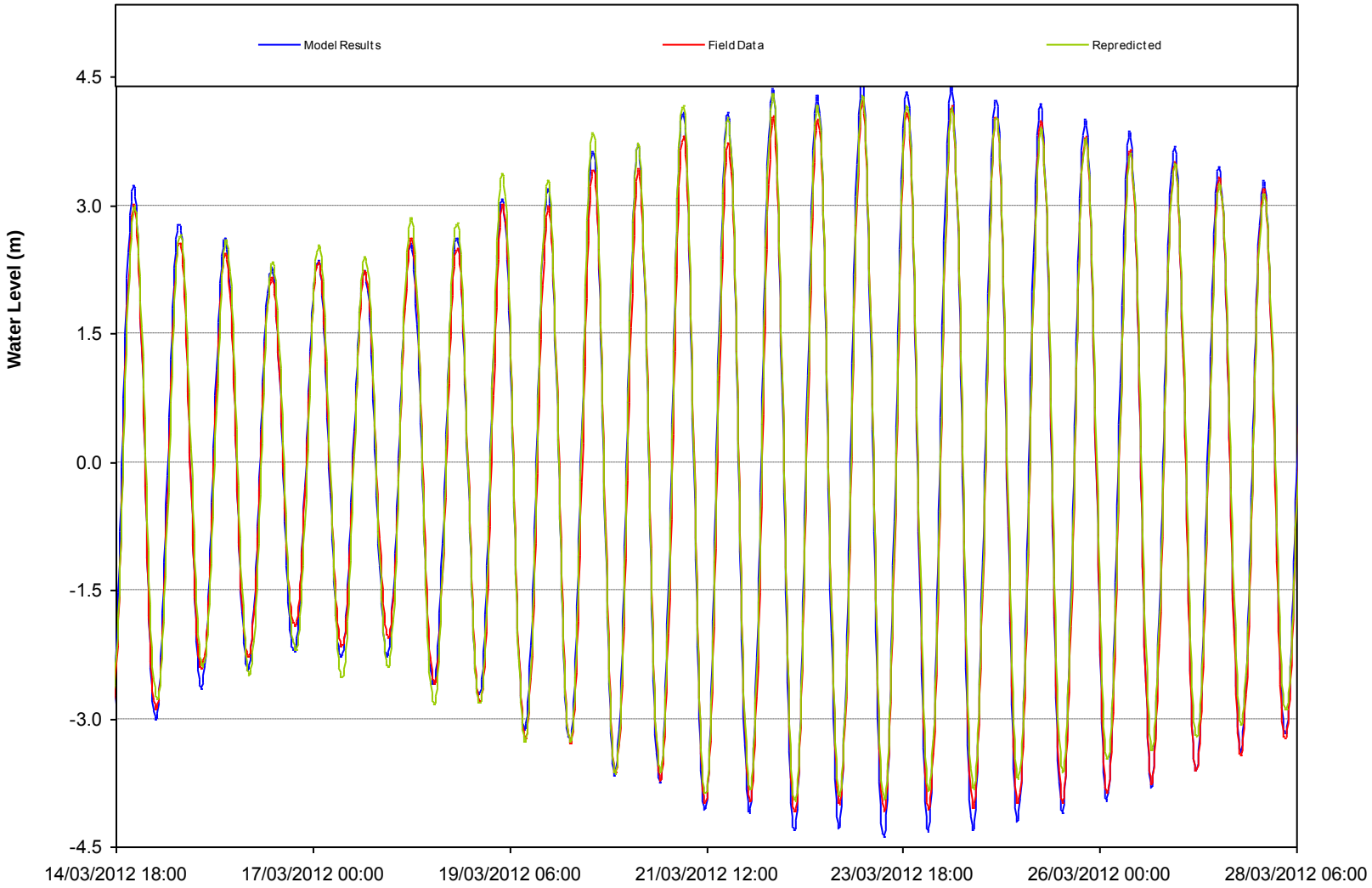


Figure D- 4: Tidal elevation validation comparison – AWAC Site 1

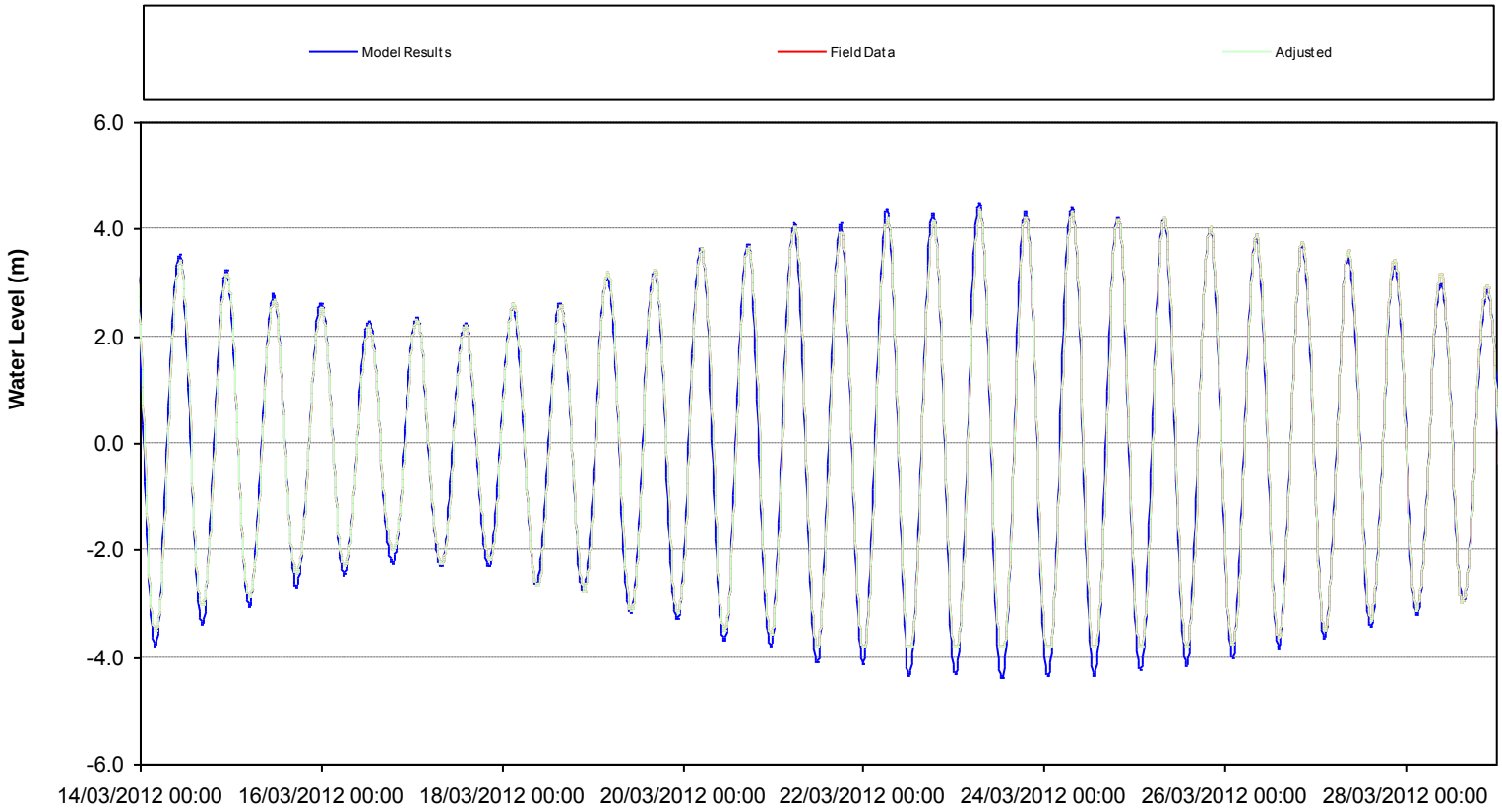


Figure D- 5: Tidal elevation validation comparison – AWAC Site 2

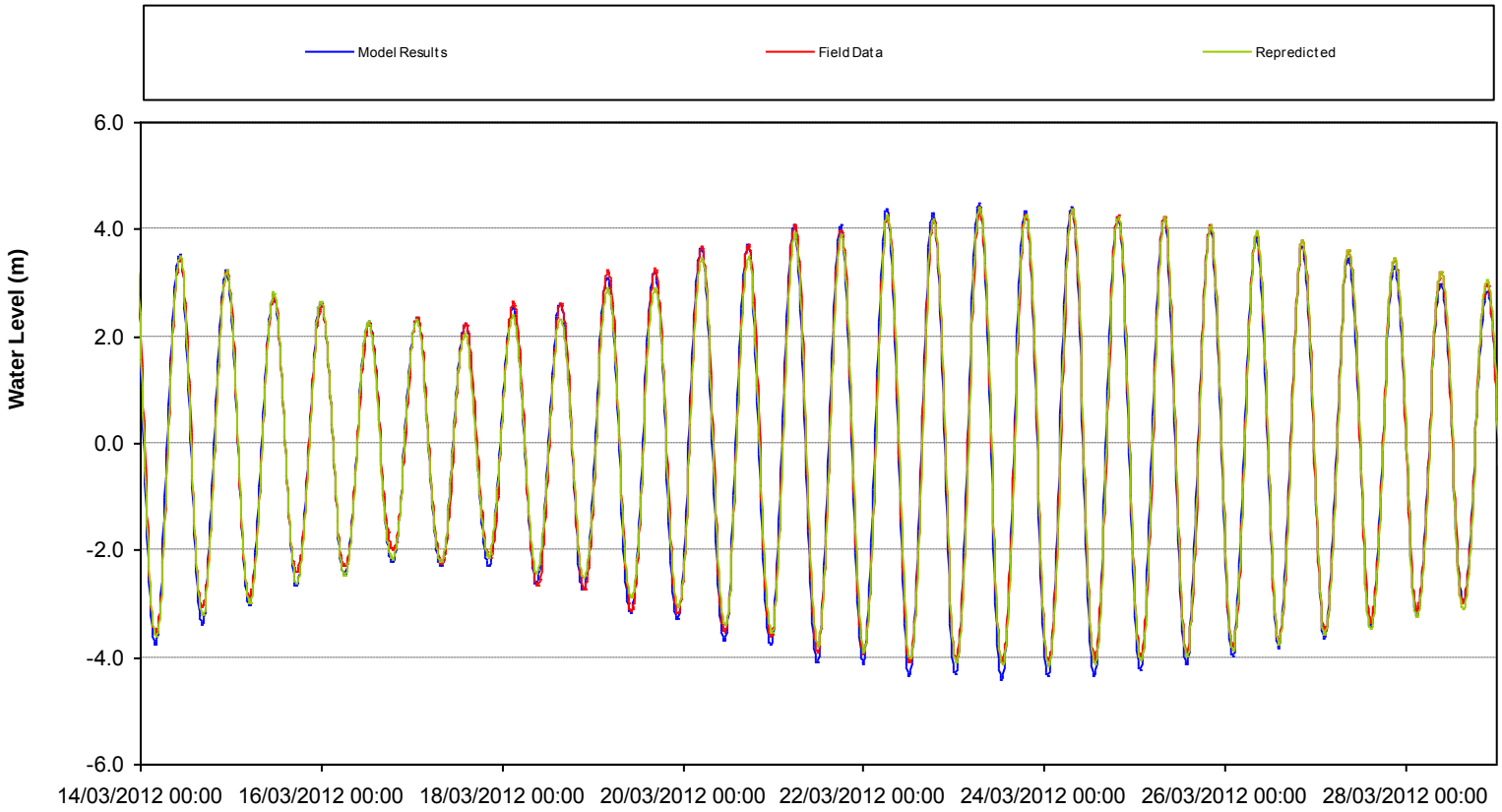


Figure D- 6: Tidal elevation validation comparison – Smart Coast Site 1

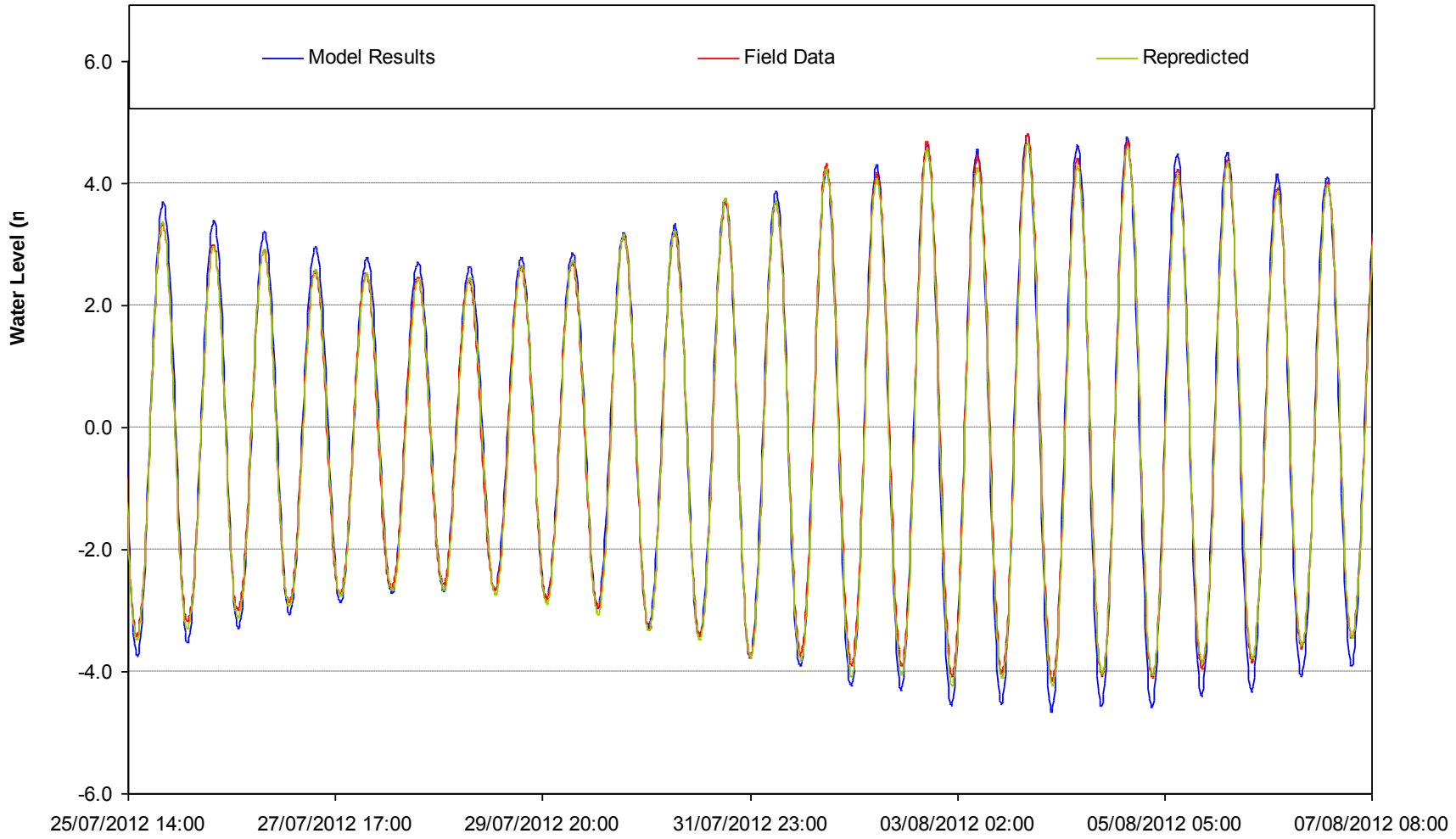


Figure D- 7: Tidal elevation validation comparison – Smart Coast Site 2

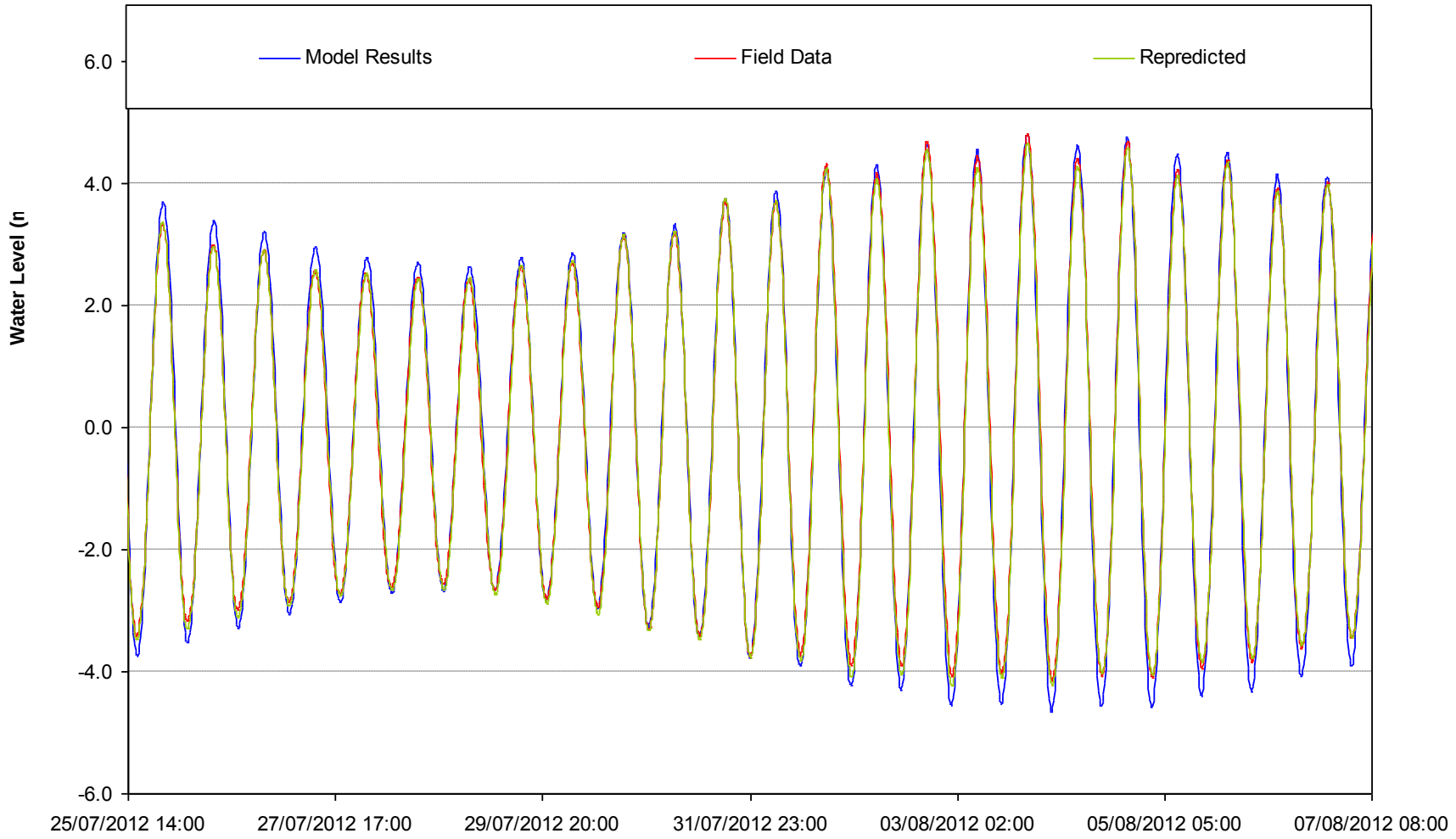


Figure D- 8: Tidal elevation validation comparison – Smart Coast Site 3

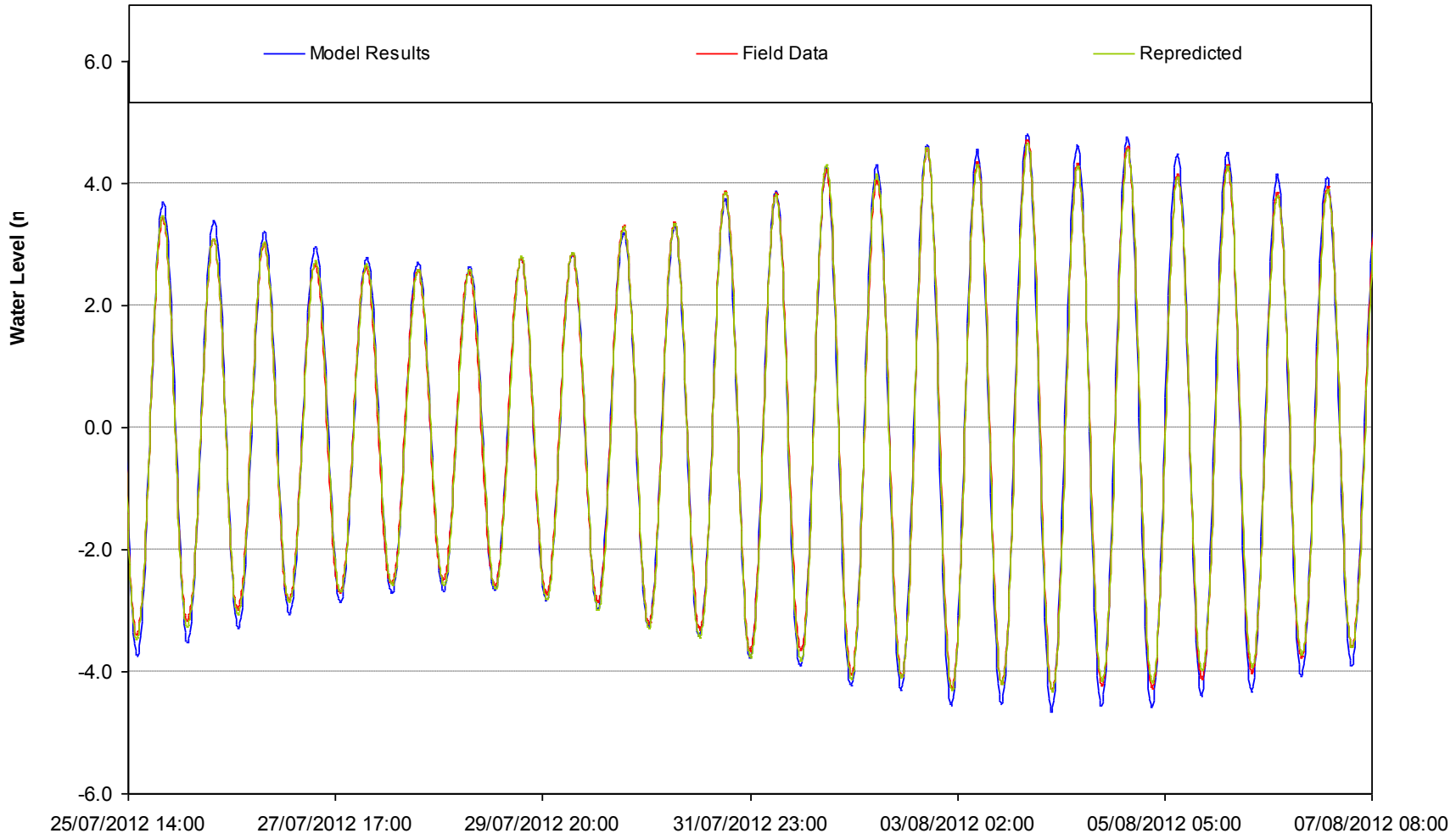


Figure D- 9: Tidal elevation validation comparison – Smart Coast Site 4

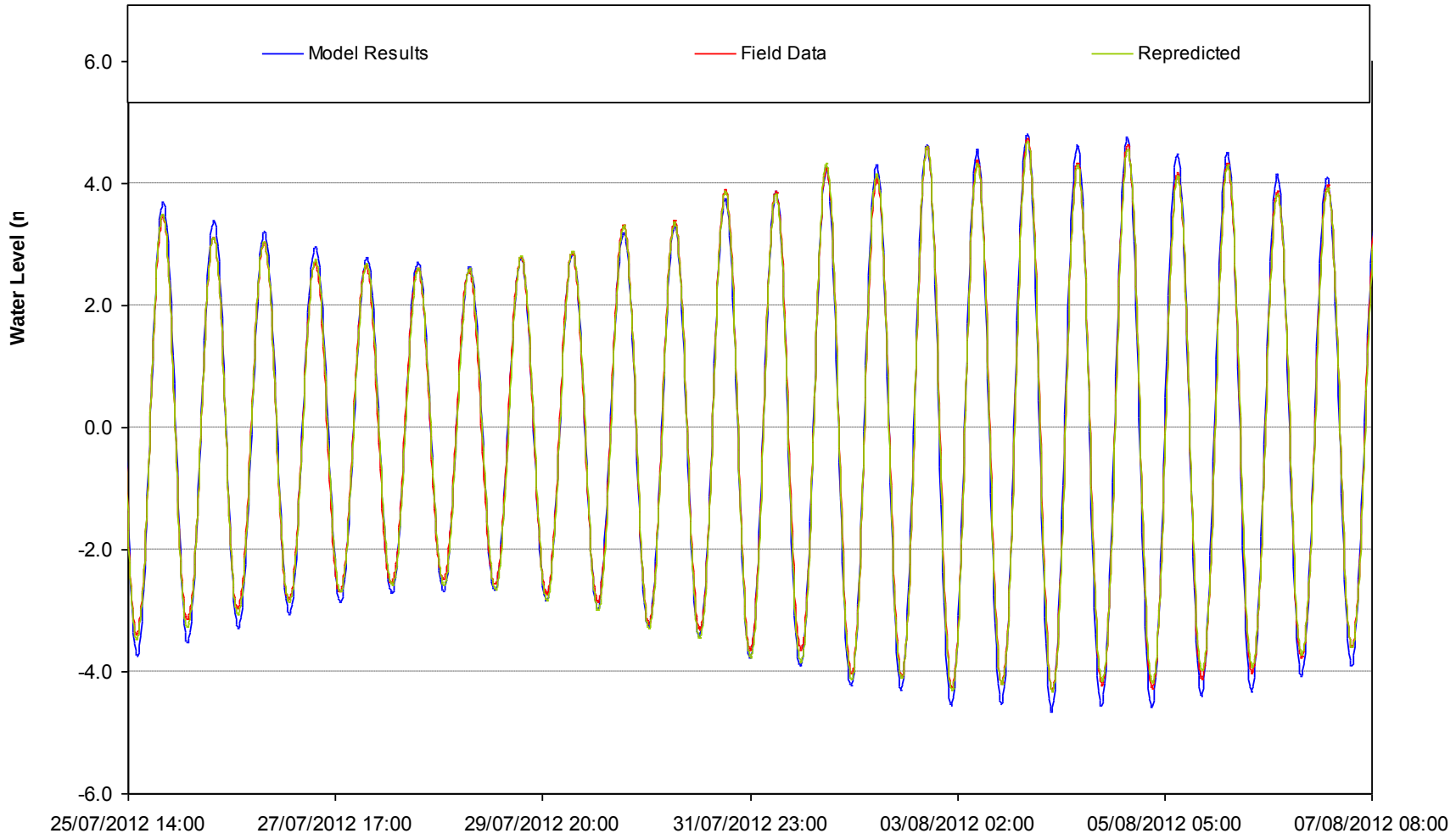


Figure D- 10: Tidal elevation validation comparison – Smart Coast Site 5

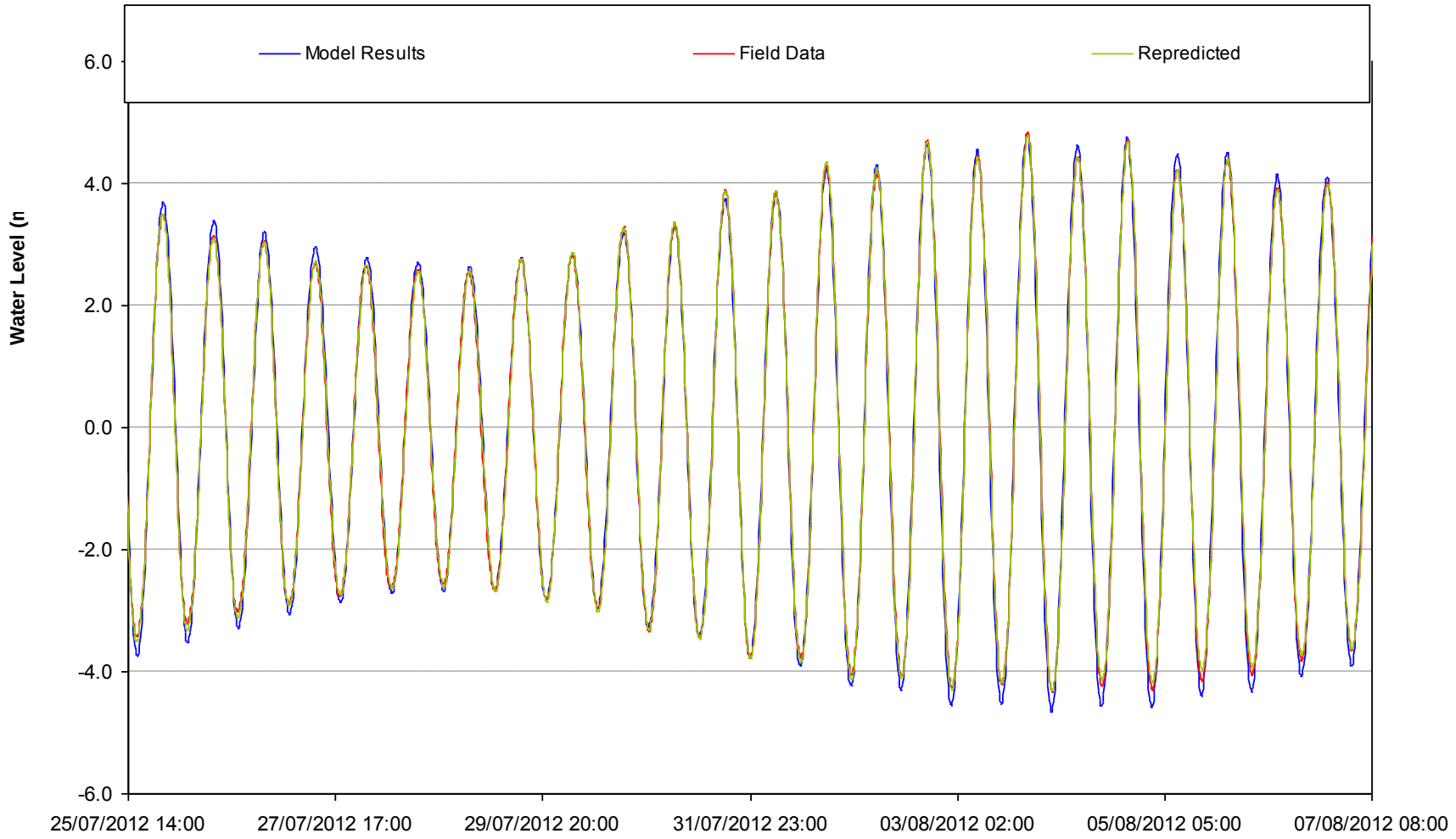


Figure D- 11: Current speed validation comparison – AWAC Site 1

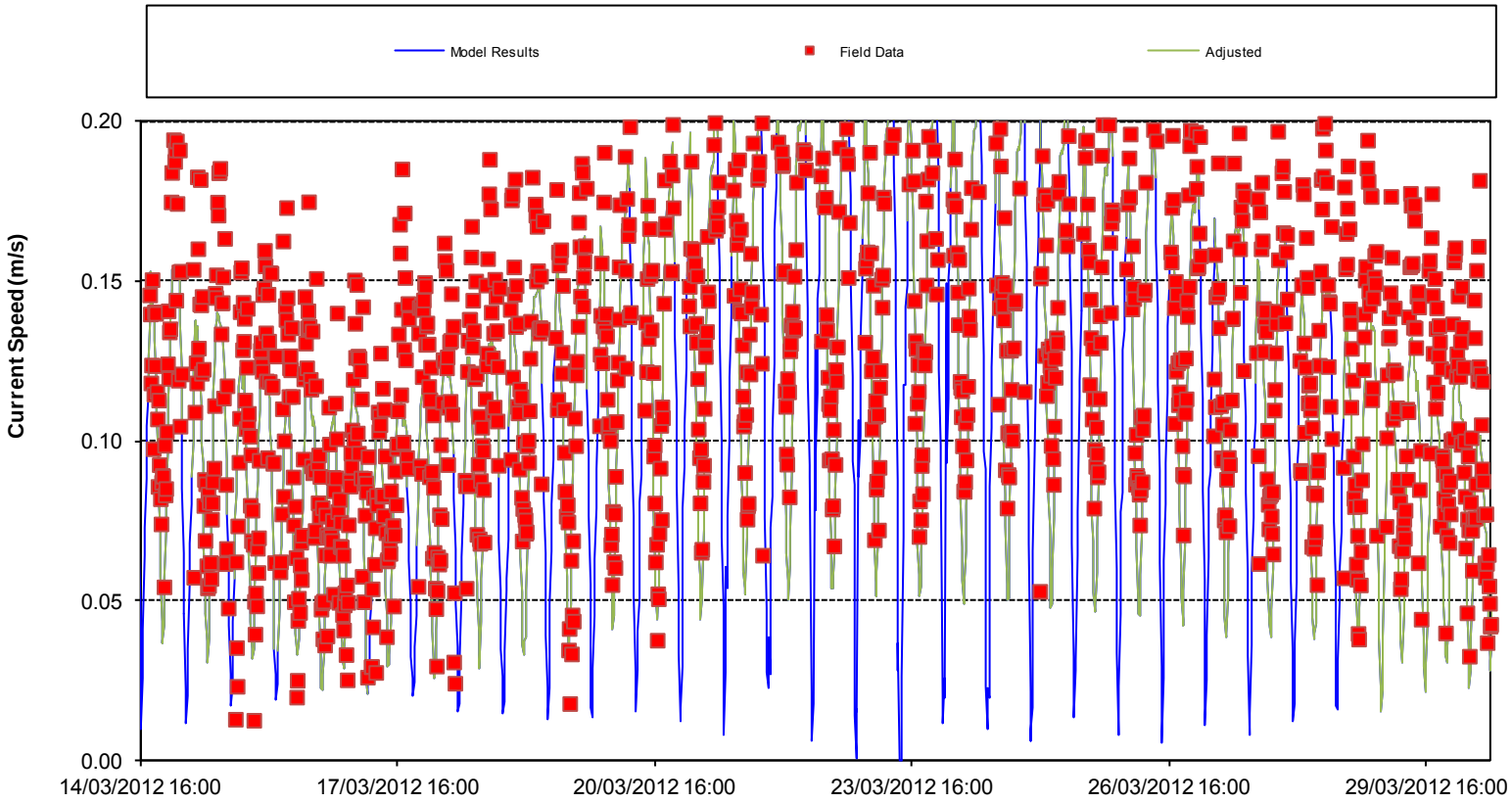


Figure D- 12: Current direction validation comparison – AWAC Site 1

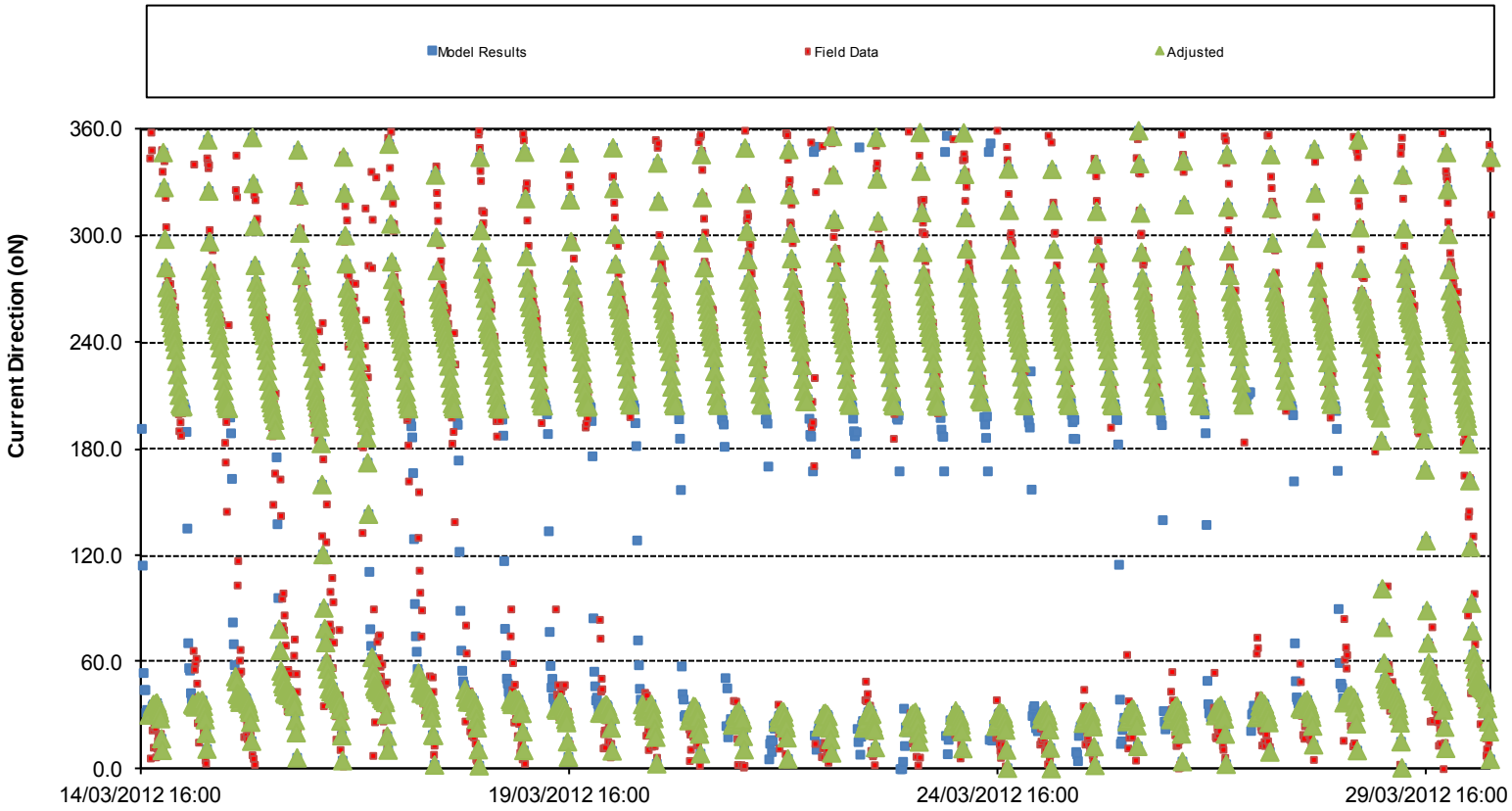


Figure D- 13: Current speed validation comparison – AWAC Site 2

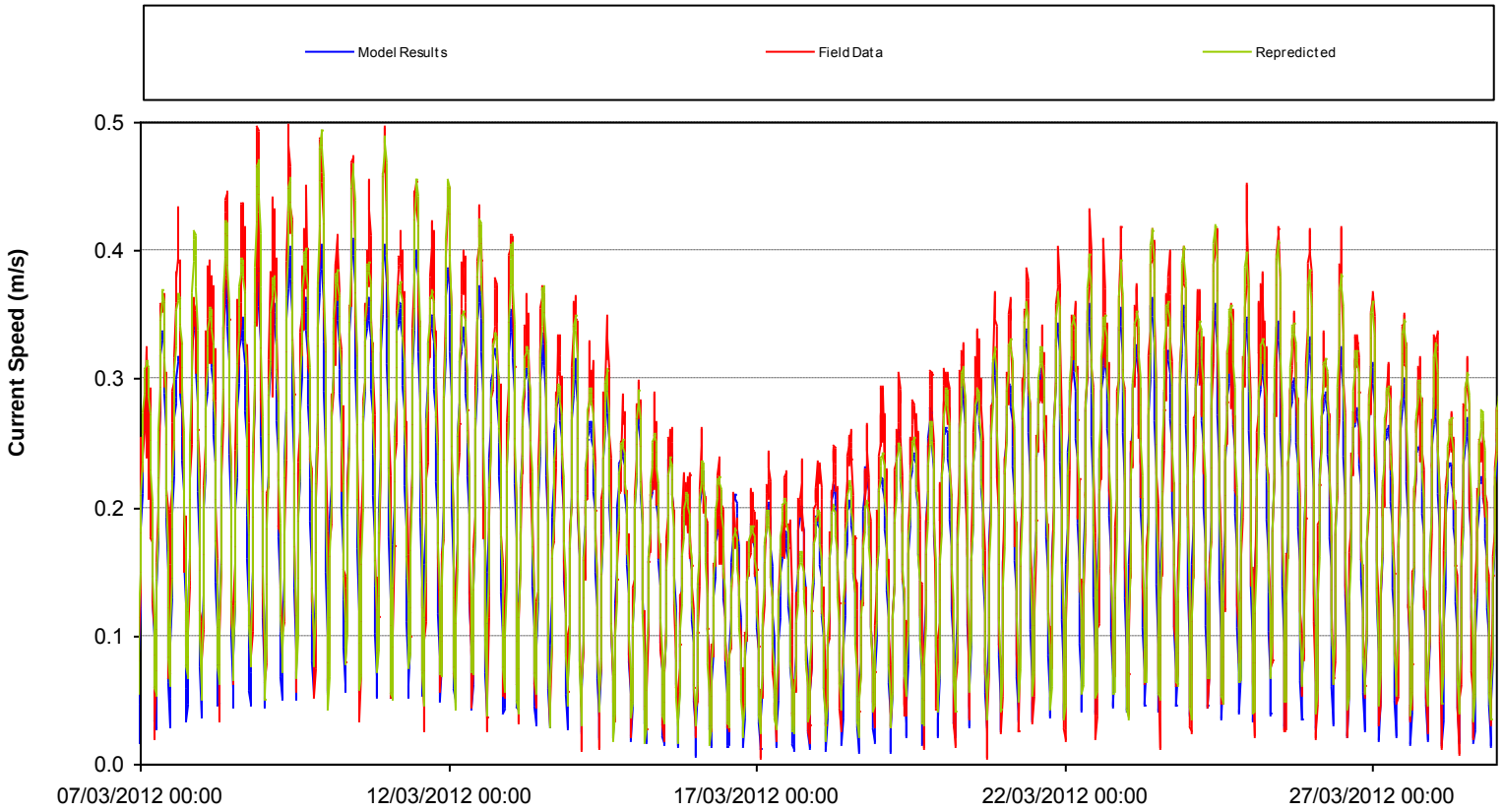


Figure D- 14: Current direction validation comparison – AWAC Site 2

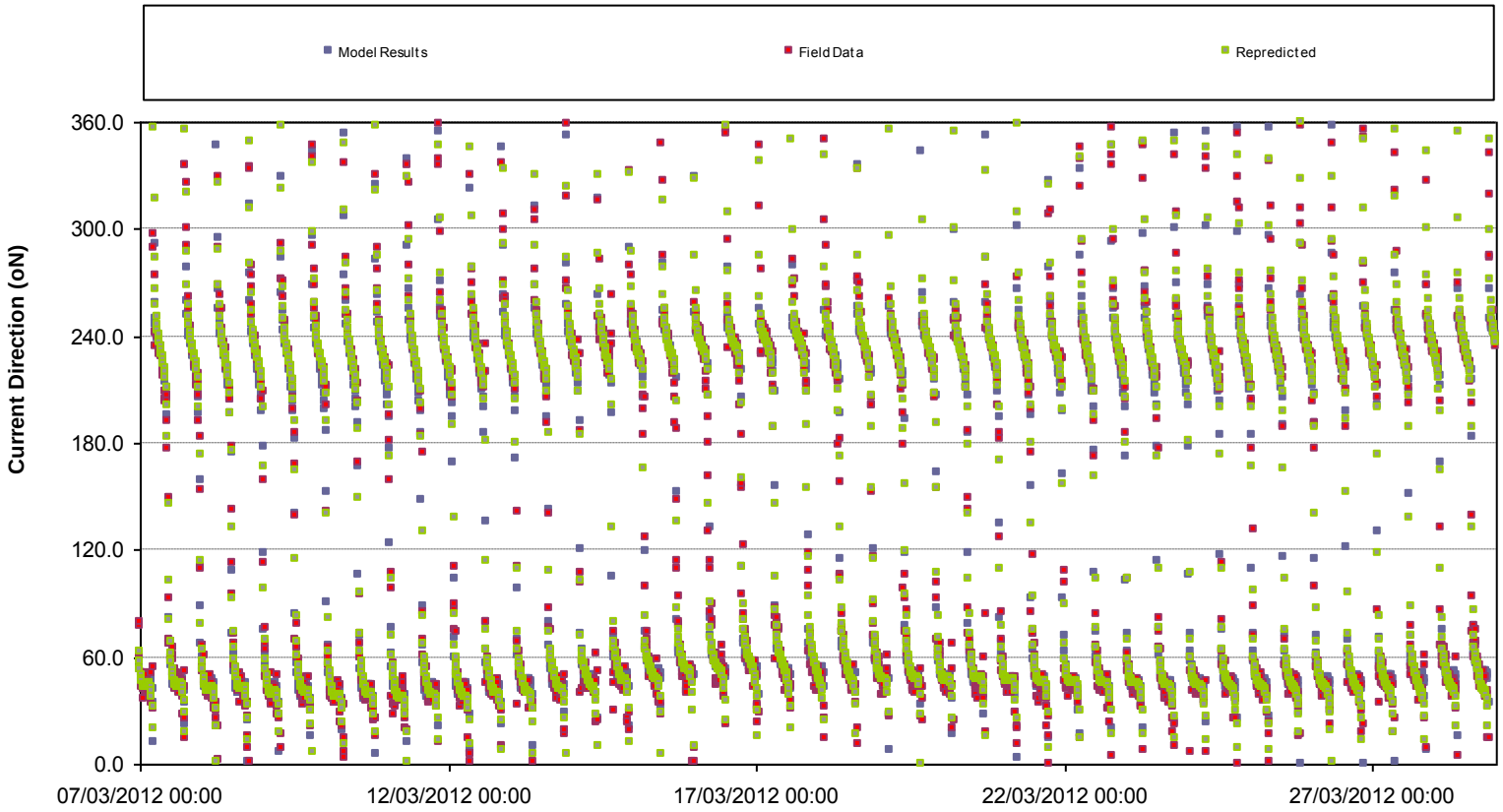


Figure D- 15: Current speed validation comparison – Smart Coast Site 1

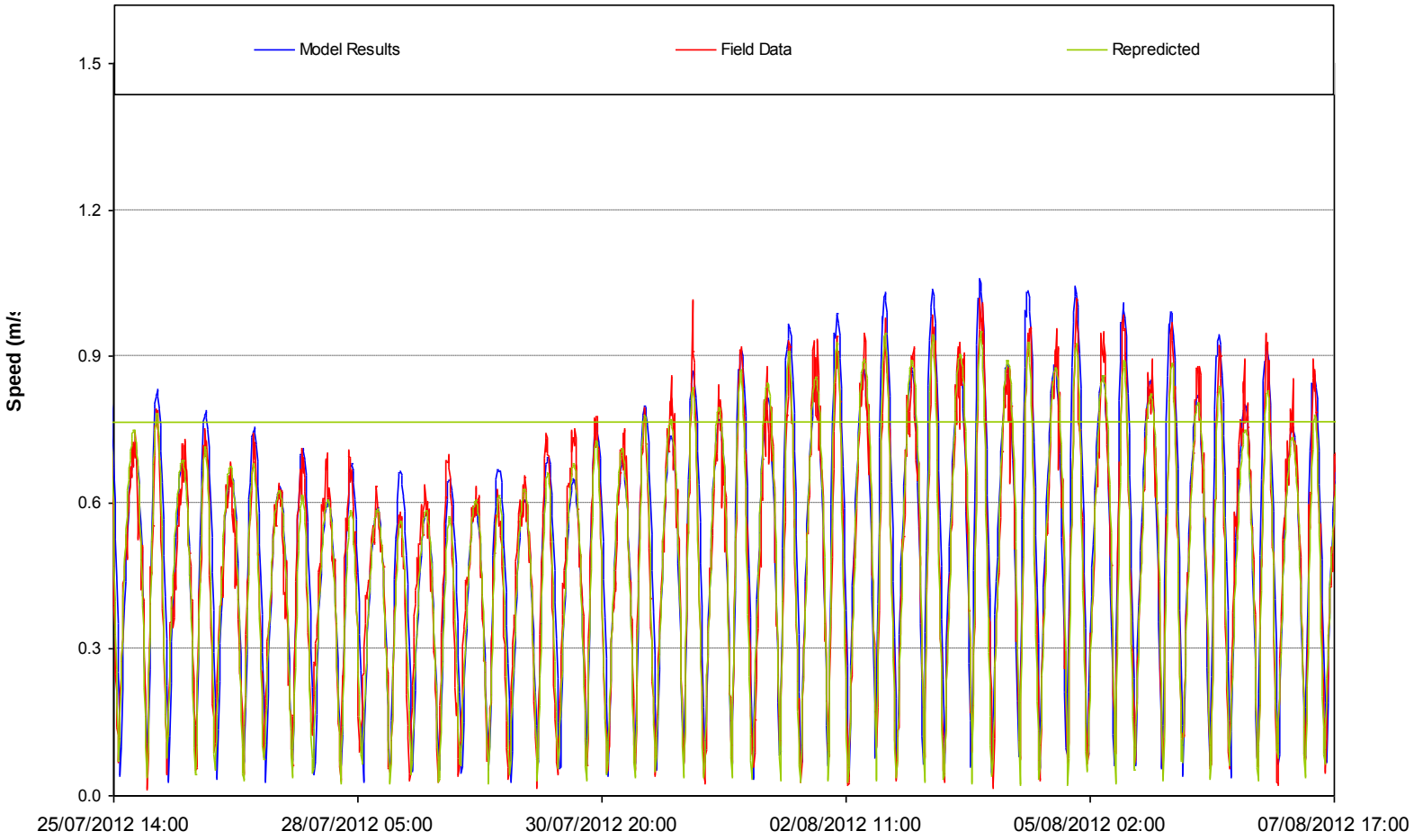


Figure D- 16: Current direction validation comparison – Smart Coast Site 1

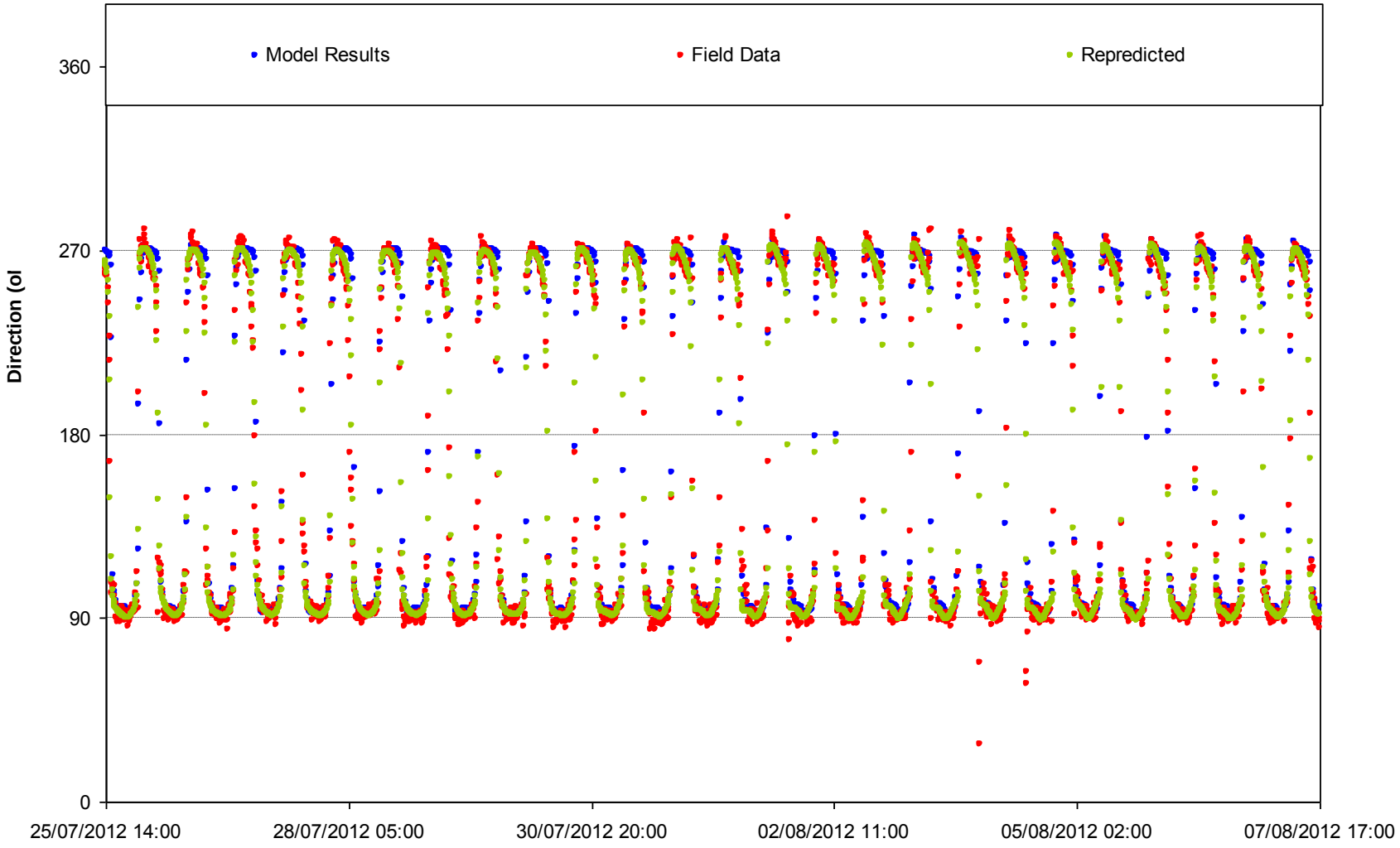


Figure D- 17: Current speed validation comparison – Smart Coast Site 2

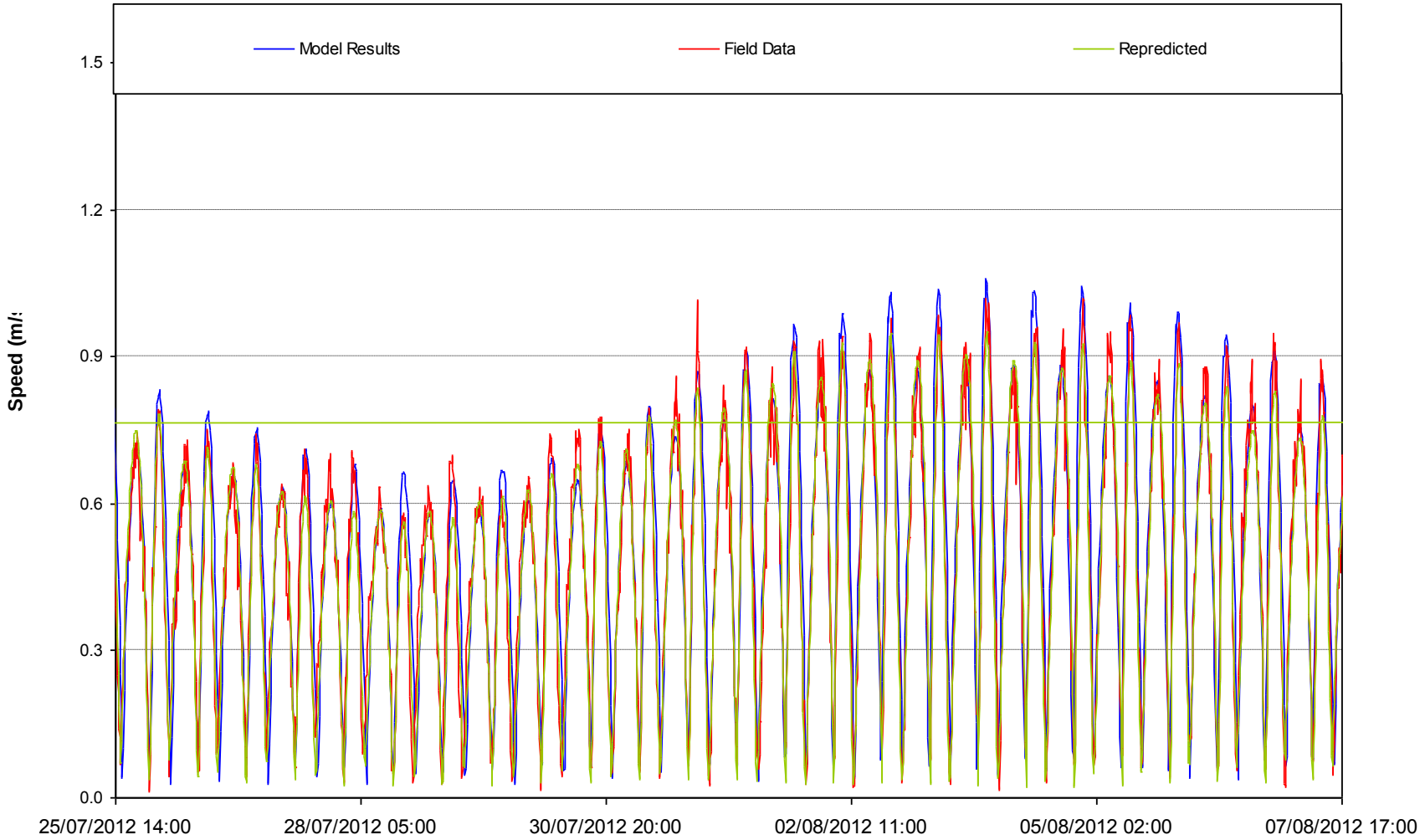


Figure D- 18: Current direction validation comparison – Smart Coast Site 2

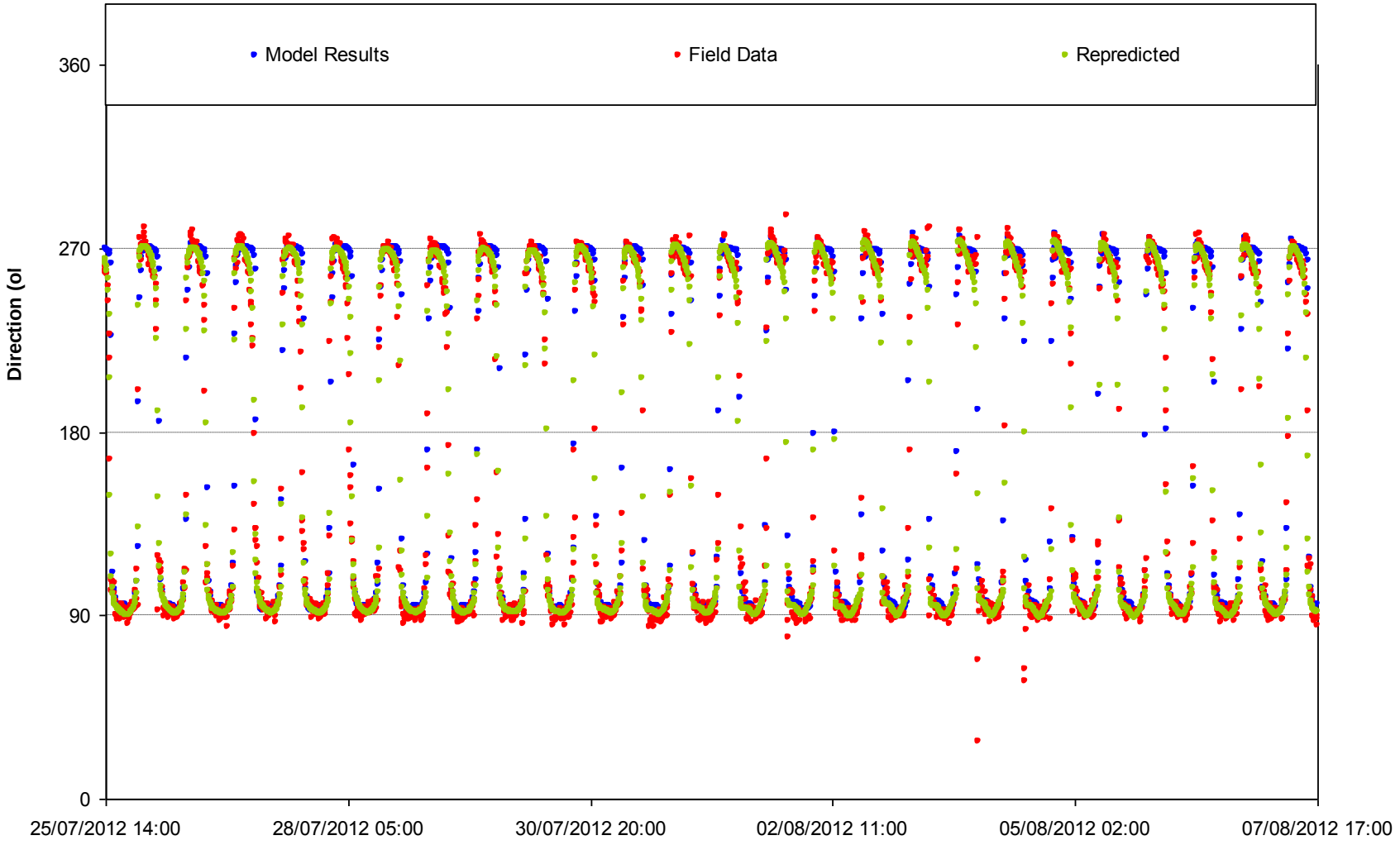


Figure D- 19: Current speed validation comparison – Smart Coast Site 3

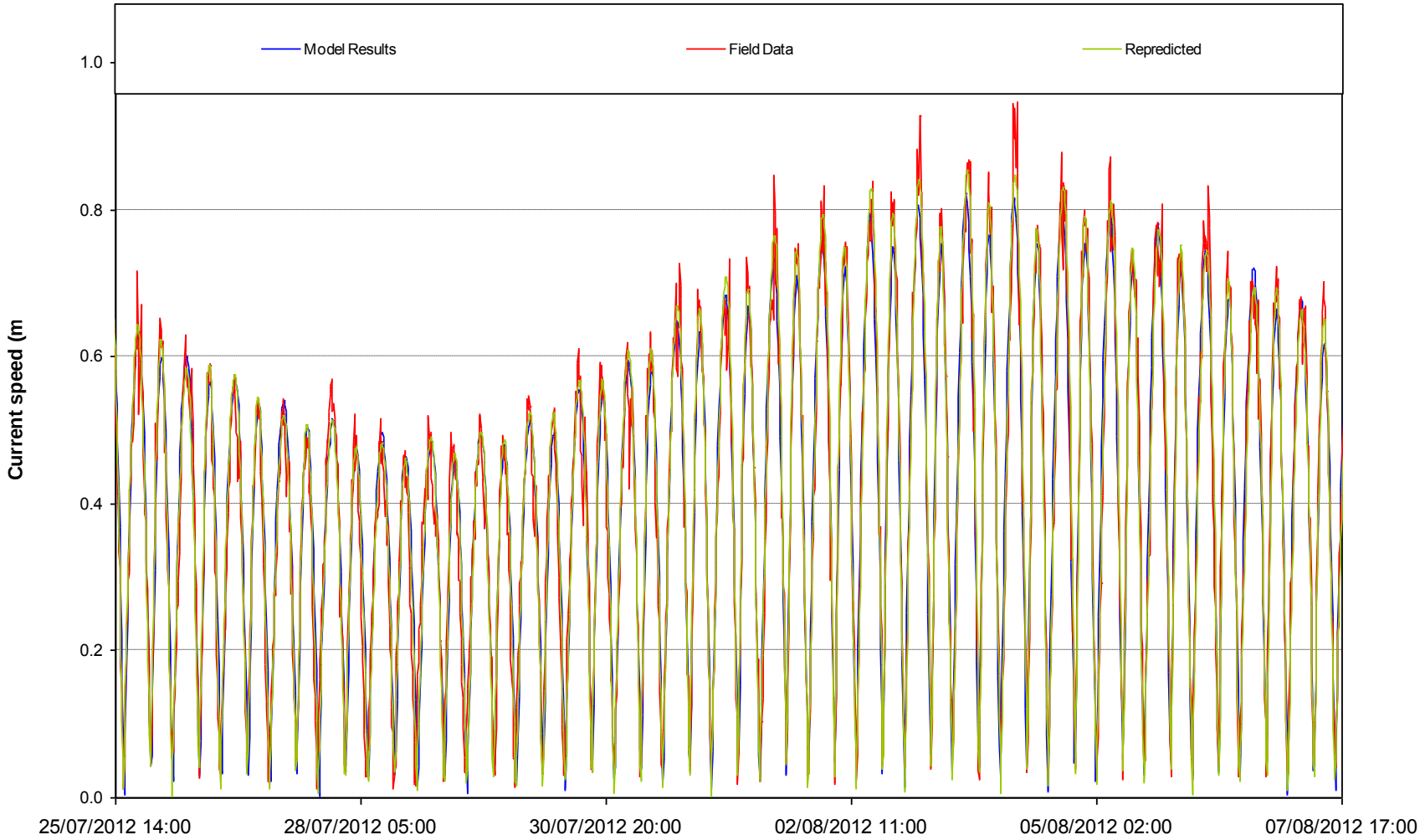


Figure D- 20: Current direction validation comparison – Smart Coast Site 3

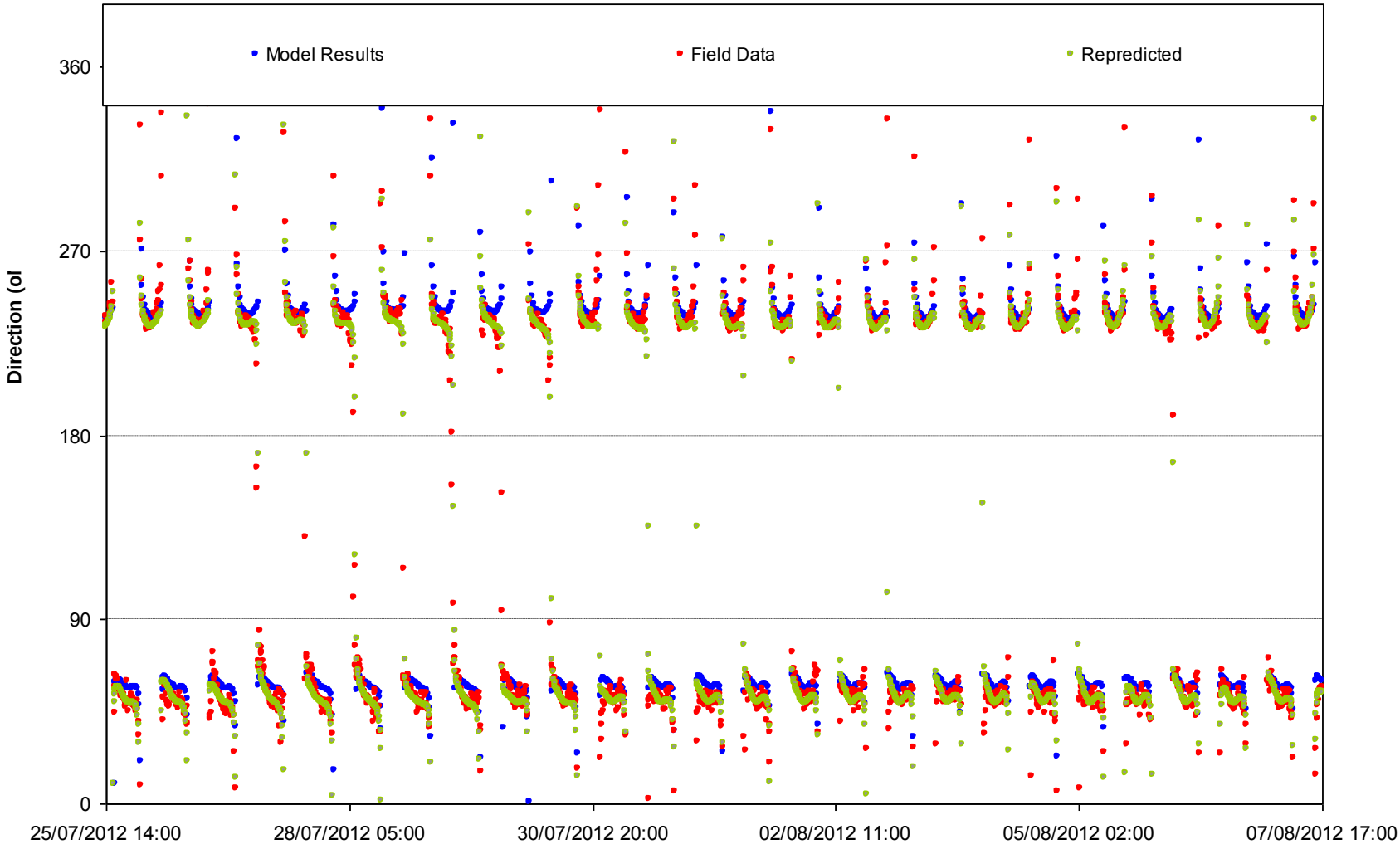


Figure D- 21: Current speed validation comparison – Smart Coast Site 4

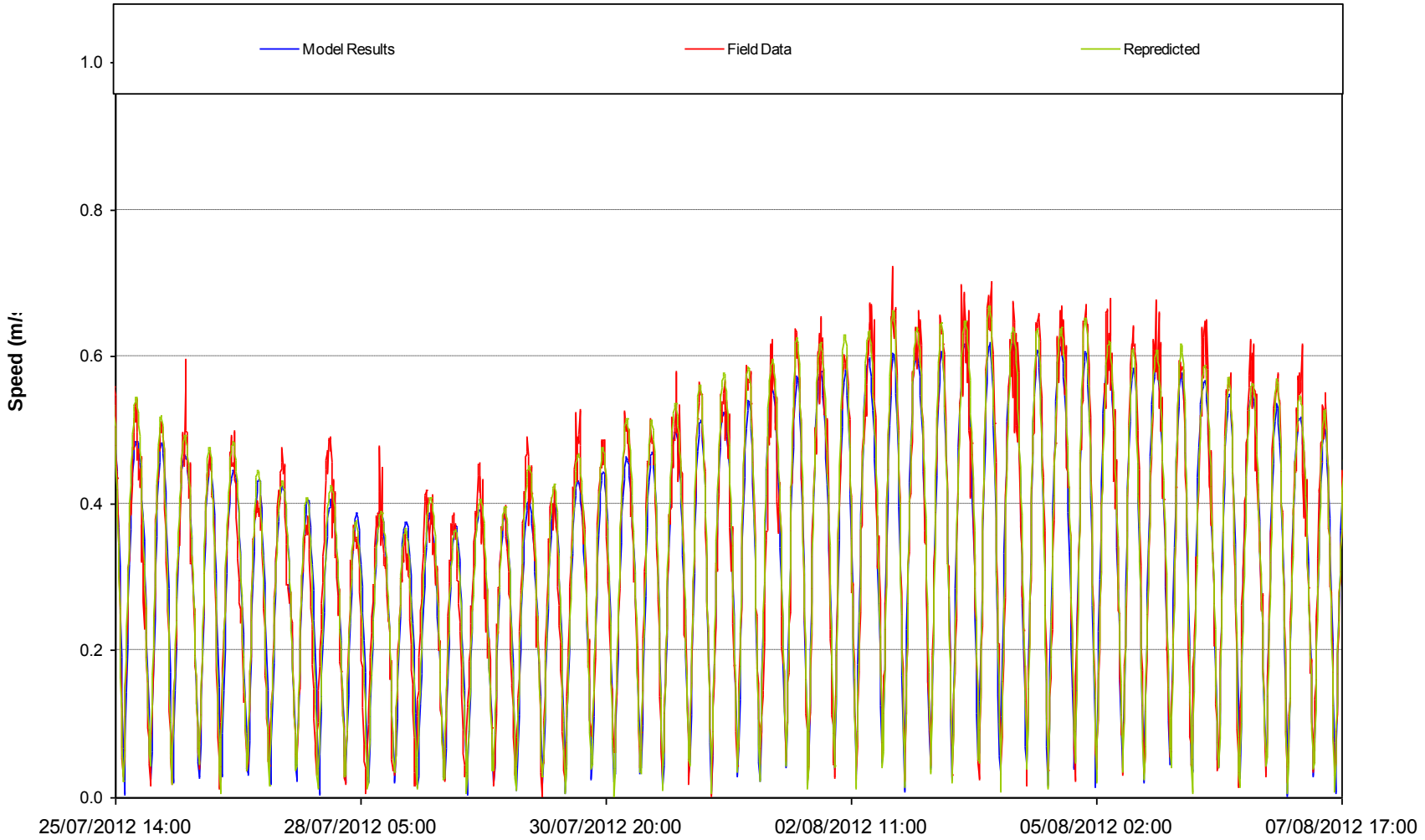


Figure D- 22:Current direction validation comparison – Smart Coast Site 4

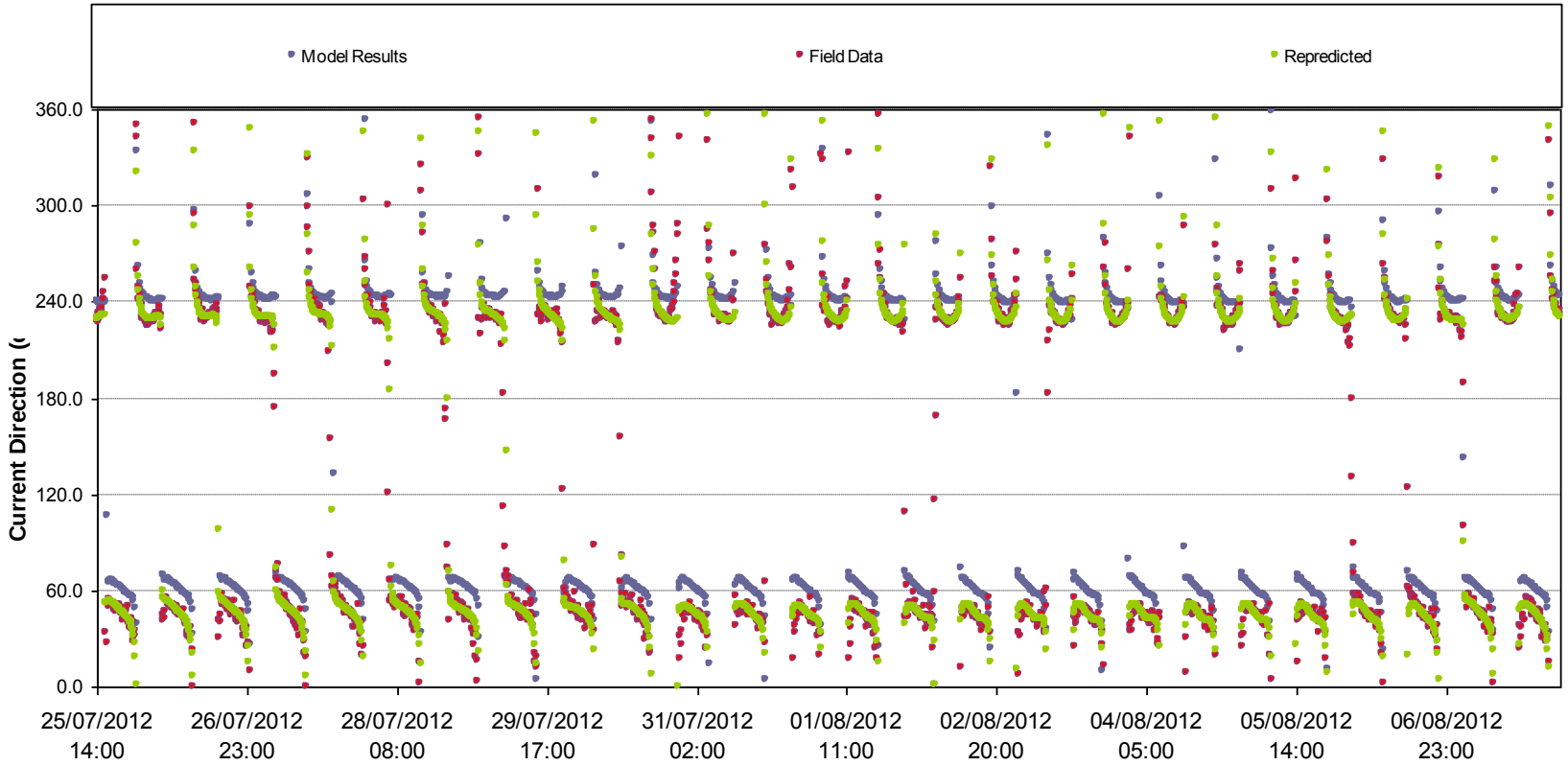


Figure D- 23:Current speed validation comparison – Smart Coast Site 5

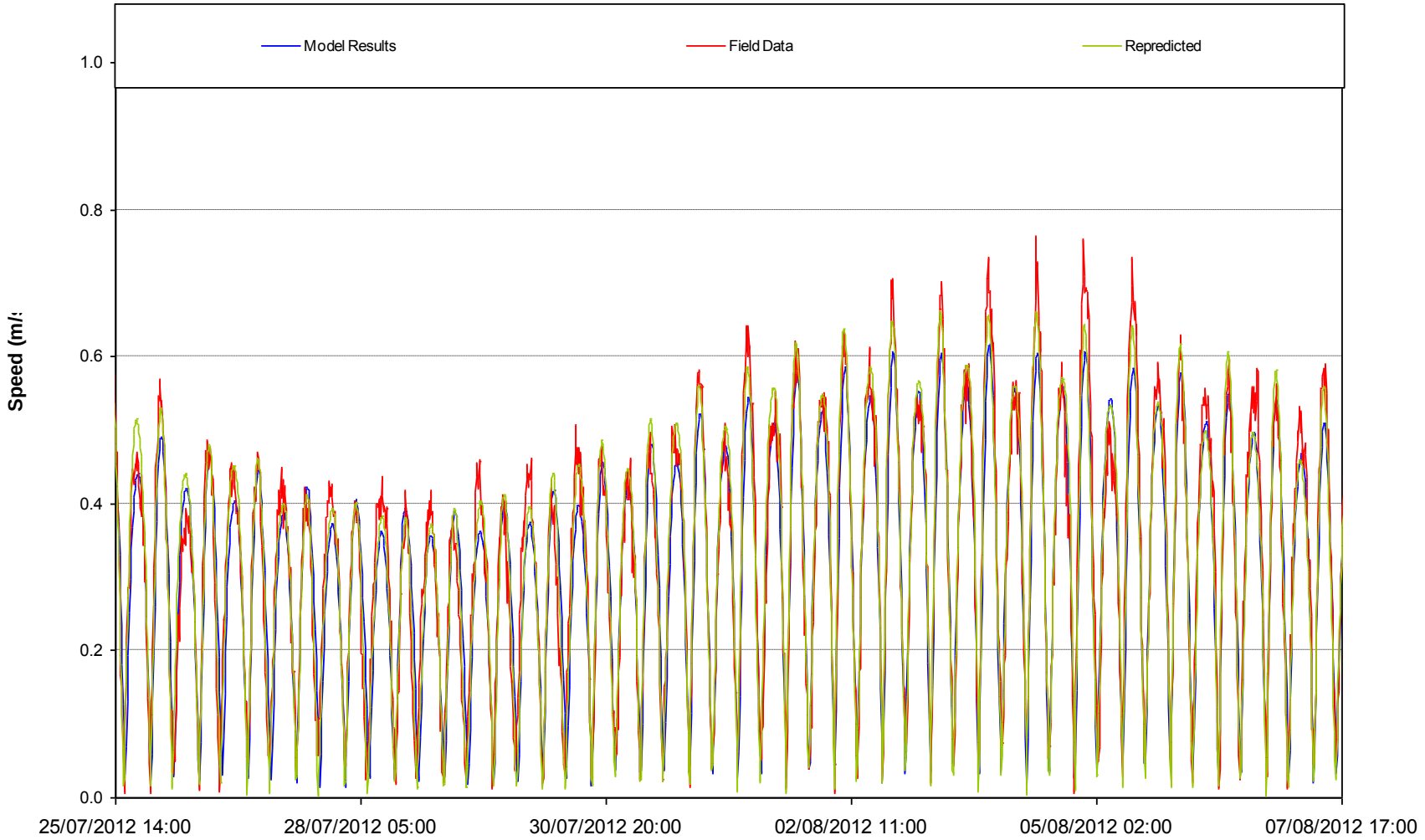


Figure D- 24:Current direction validation comparison – Smart Coast Site 5