

IRISH COASTAL WAVE AND WATER LEVEL MODELLING STUDY 2018

Phase 3 - Dundalk Extension

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1 INTRODUCTION

This report presents the work undertaken and the findings of the extension to Phase 3 of the Irish Coastal Wave and Water Level Modelling Study (ICWWS) 2018 at Dundalk. The work is an extension to the Phase 3 study undertaken for Dundalk during 2018, whereby combinations of wave climate and water levels were derived for the Dundalk shoreline/defence line. Full details of the Dundalk Phase 3 study can be found in the ICWWS 2018 Phase 3 Dundalk report (Reference 1).

Dundalk was identified by the OPW as a new coastal Flood Relief Scheme (FRS) location requiring a detailed assessment of wave climate and water level estimations to enable future wave overtopping analysis to be conducted, and it was thus included as a Phase 3 study area as part of the ICWWS. The outputs of this study and its extension will inform the evaluation of the risk associated with wave overtopping, any resulting coastal flooding (both now and in the future) and the detailed design of measures to mitigate and manage any such identified coastal flood risk.

As part of the 2018 Phase 3 study, combinations of present day wave climate (heights, periods and directions) and water levels for AEPs of 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% were derived for the Dundalk shoreline/defence line. A similar approach was undertaken to determine the corresponding wave climate and water levels for four future scenarios accounting for different projected sea level rise allowances. Spectral significant wave heights, peak spectral wave periods and mean wave directions for each AEP and water level at a series of shoreline/defence line locations comprised the key outputs of this study.

This extension has built upon the work previously undertaken for Phase 3, whereby a further set of simulations have been undertaken, with the purpose of deriving one additional joint probability wave and water level combination for each of the six estimation locations identified for Dundalk for the present day and two future scenarios.

2 METHODOLOGY

The methodology for this extension mirrored the work undertaken as part of Phase 3 of the ICWWS at Dundalk and is detailed in the Phase 3 report (Reference 1). A numerical model was used to transform offshore combined waves of known AEP to near the shoreline or defence line. The relevant offshore wave climate conditions were combined with present day water levels using a joint probability analysis. These combinations were then used to provide the input to the wave transformation model.

Six wave and water level combinations were produced for the Dundalk Phase 3 study, and three critical directions (90°, 120° and 150°) resulted in the most arduous conditions along the various sections of coastline. This extension involved the simulation of one additional joint probability wave and water level combination for each of the three critical directions for a range of AEPs (50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1%) for the present day. Further simulations were also undertaken for the Mid Range Future Scenario (MRFS) and High End Future Scenario (HEFS), including the 10%, 0.5% and 0.1% AEPs. For each AEP, the additional joint probability combination utilised the highest water level produced through the joint probability analysis, and associated wave and wind data.

2.1 Statistical Analysis

RPS utilised hindcast data from the UK Met Office WAVEWATCH III wave model in order to determine appropriate wave and wind data for use in the detailed computational modelling for Dundalk. Extreme Value Analysis (EVA) was undertaken on these datasets during Phase 3, as outlined in the Phase 3 report (Reference 1).

Extreme water level data was taken from the Irish Coastal Protection Strategy Study (ICPSS) in line with the Dundalk Phase 3 study, as discussed in the Phase 3 report.

The results of the joint probability analysis of wave/ wind conditions with extreme water level undertaken during the Phase 3 study were used to facilitate the current extension. One joint probability combination of inshore wave conditions and extreme water levels was used to develop boundary conditions and drive the hydrodynamic model for each critical direction and for each AEP. This combination was chosen to reflect the wave/wind conditions at the highest extreme water level produced from the joint probability analysis for each AEP. The extreme water levels selected are shown in Table 2.1 to Mean Sea Level (MSL) datum. The corresponding offshore wave boundary and wind data for each boundary and critical direction were used to develop the boundary files for the modelling system. Note, the additional combination is a supplement to the existing six combinations of inshore wave and water level conditions derived under Phase 3 of the ICWWS 2018.

Table 2.1: Selected AEP Extreme water levels

AEP	Water Level (m to MSL)
50%	3.22
20%	3.34
10%	3.44
5%	3.53
2%	3.66
1%	3.75
0.5%	3.85
0.1%	4.07

2.2 Model Simulations

The wave transformation modelling was undertaken using the Spectral Wind-wave Flexible Mesh (SW) module of the MIKE coastal process modelling software developed by DHI. The extent and bathymetry relative to Mean Sea Level (MSL) of the Phase 3 North East wave model used for Dundalk can be seen in Figure 2.1. The same model was used to simulate the additional water level/wave height combination for each specified Joint Probability AEP event for the critical directions as part of the extension.

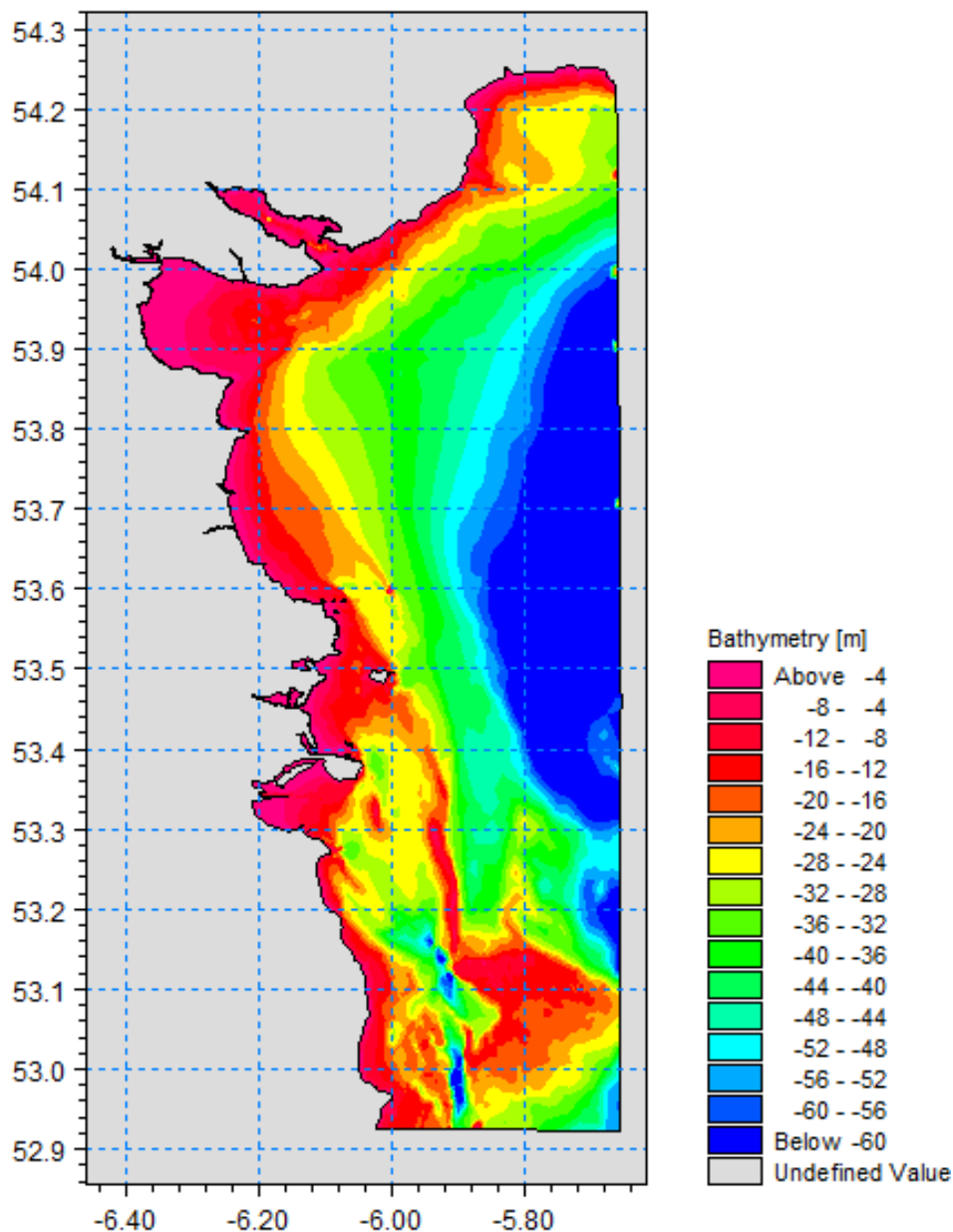


Figure 2.1: North East Model Extent and Existing Bathymetry

This wave model was used to simulate transformation of combined swell and wind waves, from offshore into Dundalk Bay. The grid resolution of the model varied spatially depending on location and model boundaries positioned to accurately represent the wave climate of the UK Met Office data extraction points.

The final critical storm directions simulated were 90, 120 and 150 degrees for a combined wave, which is a combination of both wind waves and swell waves. Simulations were undertaken for one combination of wave height and water level for joint AEPs of 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% for each critical direction for the present day. Further simulations were undertaken for the MRFS and HEFS, whereby one wave height and water level combination was selected for the 10%, 0.5% and 0.1% AEPs.

3 RESULTS

Following the transformation of the offshore wave conditions into the nearshore, the inshore results were extracted for six locations (A-F) around Dundalk Bay, as shown in Figure 3.1 and detailed in Table 3.1.

For each AEP event from 50% to 0.1%, the output of the study near the shoreline/defence line along Dundalk Bay in areas which are potentially liable to flooding from wave overtopping is presented in terms of spectral significant wave height (H_{m0}) in metres, spectral peak wave period (T_p) in seconds and mean wave direction (MWD) in degrees measured from north, for each water level (WL). The water level results are provided to MSL, OD Malin OSGM02 and OD Malin OSGM15, with conversions in line with the Phase 3 study. Wave climate results are representative of a point situated at approximately half the shallow water wavelength seaward from the toe of the defence structure or shoreline.

Wave climate and water level combinations are provided for present day sea levels and for each of two future sea level rise scenarios (MRFS, HEFS). These future scenarios correspond to sea level rise of 0.5m and 1.0m respectively. Simulations were undertaken using the wave climate established for the present day scenarios, with the water levels increased by the relevant amount.

The recommended wave and tidal levels for standard AEPs for the present day, and three AEPs for the future scenarios are presented in Table 3.2 to Table 3.7 for estimation locations A to F respectively.

As per Phase 3, wave setup adjustments of 0.10m and 0.05m were applied to the water levels and significant wave heights. These single values were applied across all AEP events and future water level scenarios.

All assumptions and limitations relating to the extension align with the ICWWS 2018 Phase 3, details of which can be found in the Phase 3 report (Reference 1).



Figure 3.1: Estimation Locations for Dundalk

Table 3.1: Co-ordinates for Estimation Locations for Dundalk

Location	Co-ordinates (WGS84)	
	Latitude (°N)	Longitude (°W)
A	54.0092	6.3000
B	54.0115	6.3444
C	54.0074	6.3464
D	53.9864	6.3595
E	53.9659	6.3622
F	53.9566	6.3700

Location	Co-ordinates (ITM)	
	Eastings [m]	Northings [m]
A	711429.125	808001.669
B	708513.127	808188.625
C	708392.708	807729.351
D	707588.222	805372.687
E	707463.913	803087.542
F	706975.972	802040.923

Table 3.2: Shoreline Wave Climate and Water Level Combinations – Location A

CAPO A						
AEP	Water Level (m)			Comb Wave Component		
	MSL	OD Malin OSGM02	OD Malin OSGM15	Hm0 (m)	Tp (s)	MWD (°)
50%	3.32	3.27	3.27	0.73	7.46	159
20%	3.44	3.39	3.39	0.79	7.74	159
10%	3.54	3.49	3.49	0.83	7.91	159
5%	3.63	3.58	3.59	0.87	8.00	158
2%	3.76	3.71	3.71	0.93	8.09	158
1%	3.85	3.81	3.81	0.97	8.19	158
0.5%	3.95	3.90	3.90	1.01	8.40	157
0.1%	4.17	4.12	4.12	1.10	8.89	157
10% MRFS	4.04	3.99	3.99	1.03	7.91	158
0.5% MRFS	4.45	4.40	4.40	1.20	8.41	157
0.1% MRFS	4.67	4.62	4.62	1.29	8.89	156
10% HEFS	4.54	4.49	4.49	1.20	7.92	157
0.5% HEFS	4.95	4.90	4.90	1.37	8.42	156
0.1% HEFS	5.17	5.12	5.12	1.46	8.89	155

Table 3.3: Shoreline Wave Climate and Water Level Combinations – Location B

CAPO B						
AEP	Water Level (m)			Comb Wave Component		
	MSL	OD Malin OSGM02	OD Malin OSGM15	Hm0 (m)	Tp (s)	MWD (°)
50%	3.32	3.27	3.27	0.46	7.38	148
20%	3.44	3.39	3.39	0.48	7.69	147
10%	3.54	3.49	3.49	0.51	7.87	147
5%	3.63	3.58	3.59	0.53	7.98	147
2%	3.76	3.71	3.71	0.56	8.07	146
1%	3.85	3.81	3.81	0.60	8.16	147
0.5%	3.95	3.90	3.90	0.62	8.34	147
0.1%	4.17	4.12	4.12	0.67	8.87	145
10% MRFS	4.04	3.99	3.99	0.61	7.89	144
0.5% MRFS	4.45	4.40	4.40	0.72	8.36	143
0.1% MRFS	4.67	4.62	4.62	0.79	8.87	143
10% HEFS	4.54	4.49	4.49	0.72	7.89	143
0.5% HEFS	4.95	4.90	4.90	0.85	8.37	142
0.1% HEFS	5.17	5.12	5.12	0.92	8.88	142

Table 3.4: : Shoreline Wave Climate and Water Level Combinations – Location C

CAPO C						
AEP	Water Level (m)			Comb Wave Component		
	MSL	OD Malin OSGM02	OD Malin OSGM15	Hm0 (m)	Tp (s)	MWD (°)
50%	3.32	3.27	3.27	0.35	7.38	69
20%	3.44	3.39	3.39	0.38	7.67	72
10%	3.54	3.49	3.49	0.41	7.87	74
5%	3.63	3.58	3.59	0.45	7.97	76
2%	3.76	3.71	3.71	0.50	8.07	78
1%	3.85	3.81	3.81	0.54	8.16	83
0.5%	3.95	3.90	3.90	0.56	8.34	81
0.1%	4.17	4.12	4.12	0.66	8.87	85
10% MRFS	4.04	3.99	3.99	0.58	7.88	85
0.5% MRFS	4.45	4.40	4.40	0.75	8.36	89
0.1% MRFS	4.67	4.62	4.62	0.85	8.87	92
10% HEFS	4.54	4.49	4.49	0.76	7.89	92
0.5% HEFS	4.95	4.90	4.90	0.95	8.37	95
0.1% HEFS	5.17	5.12	5.12	1.05	8.88	97

Table 3.5: Shoreline Wave Climate and Water Level Combinations – Location D

CAPO D						
AEP	Water Level (m)			Comb Wave Component		
	MSL	OD Malin OSGM02	OD Malin OSGM15	Hm0 (m)	Tp (s)	MWD (°)
50%	3.32	3.27	3.27	0.53	7.42	147
20%	3.44	3.39	3.39	0.59	7.73	146
10%	3.54	3.49	3.49	0.64	7.90	146
5%	3.63	3.58	3.59	0.68	8.00	145
2%	3.76	3.71	3.71	0.74	8.10	145
1%	3.85	3.81	3.81	0.78	8.20	144
0.5%	3.95	3.90	3.90	0.83	8.41	144
0.1%	4.17	4.12	4.12	0.93	8.90	143
10% MRFS	4.04	3.99	3.99	0.85	7.92	143
0.5% MRFS	4.45	4.40	4.40	1.04	8.43	141
0.1% MRFS	4.67	4.62	4.62	1.15	8.91	141
10% HEFS	4.54	4.49	4.49	1.07	7.92	141
0.5% HEFS	4.95	4.90	4.90	1.26	8.44	139
0.1% HEFS	5.17	5.12	5.12	1.36	8.91	139

Table 3.6: Shoreline Wave Climate and Water Level Combinations – Location E

CAPO E						
AEP	Water Level (m)			Comb Wave Component		
	MSL	OD Malin OSGM02	OD Malin OSGM15	Hm0 (m)	Tp (s)	MWD (°)
50%	3.32	3.27	3.27	1.00	7.44	113
20%	3.44	3.39	3.39	1.06	7.73	113
10%	3.54	3.49	3.49	1.10	7.92	113
5%	3.63	3.58	3.59	1.15	8.01	113
2%	3.76	3.71	3.71	1.21	8.11	113
1%	3.85	3.81	3.81	1.25	8.21	113
0.5%	3.95	3.90	3.90	1.30	8.43	113
0.1%	4.17	4.12	4.12	1.40	8.91	114
10% MRFS	4.04	3.99	3.99	1.31	7.92	114
0.5% MRFS	4.45	4.40	4.40	1.51	8.44	114
0.1% MRFS	4.67	4.62	4.62	1.61	8.91	114
10% HEFS	4.54	4.49	4.49	1.50	7.92	115
0.5% HEFS	4.95	4.90	4.90	1.71	8.45	115
0.1% HEFS	5.17	5.12	5.12	1.82	8.91	115

Table 3.7: Shoreline Wave Climate and Water Level Combinations – Location F

CAPO F						
AEP	Water Level (m)			Comb Wave Component		
	MSL	OD Malin OSGM02	OD Malin OSGM15	Hm0 (m)	Tp (s)	MWD (°)
50%	3.32	3.27	3.27	0.61	6.53	113
20%	3.44	3.39	3.39	0.66	7.74	114
10%	3.54	3.49	3.49	0.70	7.93	114
5%	3.63	3.58	3.59	0.74	8.02	114
2%	3.76	3.71	3.71	0.79	8.12	114
1%	3.85	3.81	3.81	0.83	8.22	114
0.5%	3.95	3.90	3.90	0.86	8.44	114
0.1%	4.17	4.12	4.12	0.96	8.92	114
10% MRFS	4.04	3.99	3.99	0.88	7.93	114
0.5% MRFS	4.45	4.40	4.40	1.05	8.45	114
0.1% MRFS	4.67	4.62	4.62	1.15	8.92	114
10% HEFS	4.54	4.49	4.49	1.06	7.93	115
0.5% HEFS	4.95	4.90	4.90	1.24	8.46	114
0.1% HEFS	5.17	5.12	5.12	1.34	8.92	114

4 REFERENCES

Reference 1: RPS, June 2023, “Irish Coastal Wave and Water Level Modelling Study 2018 – Phase 3 – Dundalk”