Appendix 7A

Flood Risk Assessment

Hydro
Environmental Ltd

Flood Risk Assessment
of a Deepwater Quay
at Rossaveel, Cashla Bay, Co. Galway

On behalf of

Dept of Agriculture,
Food and the Marine

April 2016

Hydrological & Environmental
Engineering Consultants

Flood Risk Assessment of a Deepwater Quay at Rossaveel, Cashla Bay, Co. Galway

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1. INTRODUCTION

1.1 Introduction

Hydro Environmental Ltd. was appointed by Department of Agriculture, Food and the Marine to provide a site specific Flood Risk Assessment to support a Planning application a proposed deepwater Quay, causeway and hard standing area at Rossaveel (Ros an Mhil), Cashla Bay Co. Galway. The proposed development will involve infilling of the sea and foreshore area to create the Quay, the hard standing area and the access road and causeway.

1.2 Description

Planning permission was sought and obtained for a deep-water quay in Ros an Mhil in 2002. This permission was for a 200m deep water quay with -8.0 m C D depth alongside the berth and approx. 150m inside berth of -6.0m CD. Following on from the Land Use Study (Nov 2006 Rev E) carried out by Mott MacDonald (Project Consultants) for Rossaveel it is now intended to amend the planning for the deep water quay to reflect the recommendations of the Land Use Study. The revised planning application will be for 200m deep water quay with -12.0 m CD berth alongside and to drop the inside berth, replacing it with a raised hard standing area.

Figure 1 shows the general area of the site and Figure 2 presents the new proposed layout of the deep-water quay. The proposed Quay top elevation is 6.6m above Chart datum (please note that Chart datum is taken as 2.51m below Malin Head Datum) and therefore the proposed quay top is 4.09m O.D. Malin Head.

Please note this Flood Risk study only considers flood risk for the development and does not consider the potential hydrodynamic impact on the marine processes within bay (wave climate, sediment transport, tidal circulation, navigation) which were considered in the EIS.

Figure 1 Location of Proposed Deepwater Quay Site at Rossaveel Cashla Bay Co. Galway

Figure 2 Aerial Photo of Proposed deepwater Quay Site

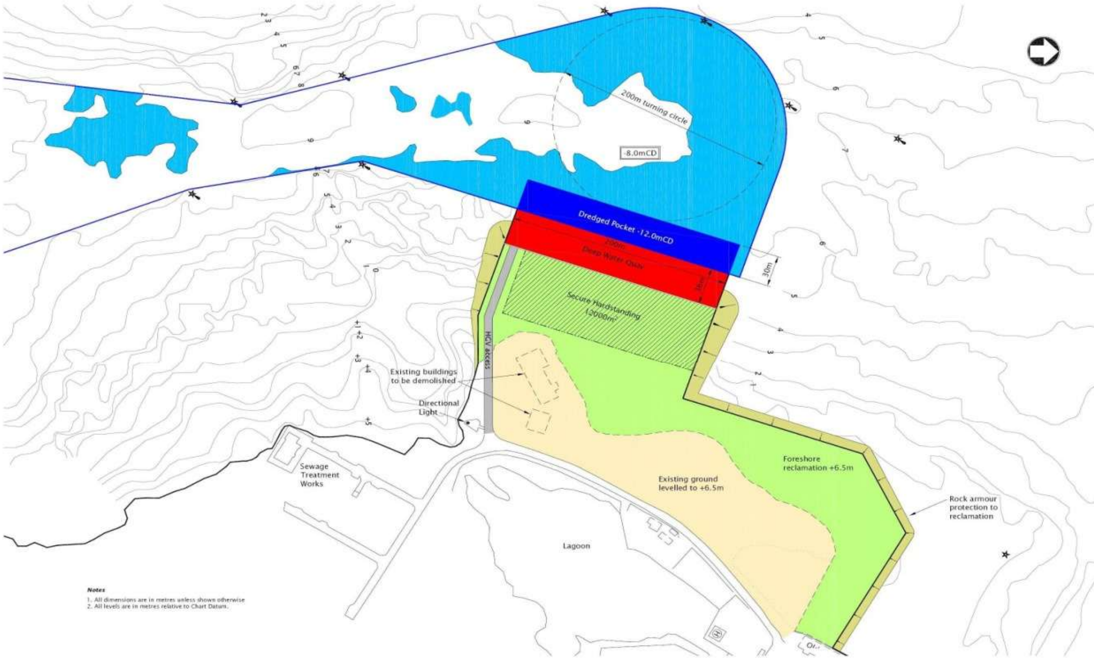

Figure 3 Proposed Layout of deep-water Quay at Rosaveal.

Plate 1 View of entrance to Cashla Bay looking southwards to Galway Bay and northwest across Cashla Bay.

Plate 2 View of Approach Road looking northwards towards existing Rossaveel Harbout and westward across the throat to Cashla Bay at Lion Point

2. Planning Guidelines Concerning Flood Risk Management

2.1 Background

In November 2009 the OPW and DoEHLG jointly published for public consultation Flood risk management planning guidelines entitled "The Planning System and Flood Risk Management" which are aimed at ensuring a more consistent, rigorous and systematic approach to fully incorporate flood risk assessment and management into the planning system, both at the strategic level of county/city and local area plans and at the specific level of planning application assessments. The aim of these planning guidelines are a tiered system of avoidance of flood risk where possible, substitution with less vulnerable development where avoidance is not possible, Justification of development where avoidance and substitution are not possible and mitigate and manage to reduce flood risk and damage to acceptable levels where justification test permits the development.

The flood risk management planning guidelines sets out how to assess and manage flood risk potential and includes guidance on the preparation of flood risk assessments by developers.

The recommended stages of assessment are:
Screening Assessment – to identify whether there may be flooding or surface water management issues related to a plan area or proposed development site that may warrant further investigation;

Scoping assessment to confirm sources of flooding that may affect a plan area or proposed development site, to appraise the adequacy of existing information and to scope the extent of the risk of flooding and potential impact of a development on flooding elsewhere and of the scope of possible mitigation measures

Appropriate risk assessment: to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development, of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures.

2.2 Site Specific Flood Risk Assessment

Mapping:

- A location map
- A Plan that shows existing site and proposed development(s)
- Identification of any structures which may influence the hydraulics.
- Flood Inundation map showing flood zone areas on the subject site / area

Surveys:

- Site levels related to Ordnance Datum
- Appropriate cross-section(s) showing finished etc. Or other relevant levels in respect to flooding.

Design Standards

- The FRA should generally be undertaken on the basis of a design event of the appropriate design standard:-
  - 100 year Fluvial Flood or 1% Annual Exceedance Probability (AEP) for River Flow
  - 200 year combined Return Period event or 0.5% AEP for tide affected sites

Assessments:

A site-specific flood risk assessment should in general include the following assessments

- All potential sources of flooding that may affect the site
- Flood alleviation measures already in place
- The potential impact of flooding on the site and consideration of flood zones in which the site falls within and the demonstration that development meets the vulnerability criteria set out in the guidance.
- The potential impact of the proposed development on the flooding and flood risk to other lands and properties.
- How the layout and form of the development can reduce those impacts, including arrangements for safe access and egress, which may include an evacuation plan for the development.
- Proposals for surface water management according to sustainable drainage principles
- The effectiveness and impacts of any necessary mitigation measures
- The residual risks to the site after the construction of any necessary measures and the means of managing these risks

2.3 Decision Making Process

Management of flood hazard and potential risks in the planning system is based on

1 Sequential Approach
2 Justification Test

1. Sequential Approach

The aim of the sequential approach is to guide development away from areas at risk from flooding. The approach makes use of flood risk zones, ignoring presence of flood protection structures, and classifications of vulnerability of property to flooding.

ZONE	DEFINITION
Zone A High Probability –	More than 1% probability of river flooding and more than 0.5% probability of tidal flooding. Development

Highest risk of flooding	should be avoided and/or only considered through application of Justification test. Only water compatible development , such as docks and marinas, dockside activities that require a waterside location, amenity open space, outdoor sports and recreation and essential transport infrastructure that cannot be located elsewhere would be considered appropriate for this zone (i.e. not requiring application of Justification test).
Zone B Moderate Probability	Between 1 and 0.1% probability of river flooding or between 0.5 and 0.1% probability of coast flooding. Development should only be considered in this zone if adequate land or sites are not available in Zone C or if development in this zone would pass the Justification Test.
Zone C Low Probability	Less than 0.1% probability of river or coastal flooding. Development in this zone is appropriate from a flooding perspective.

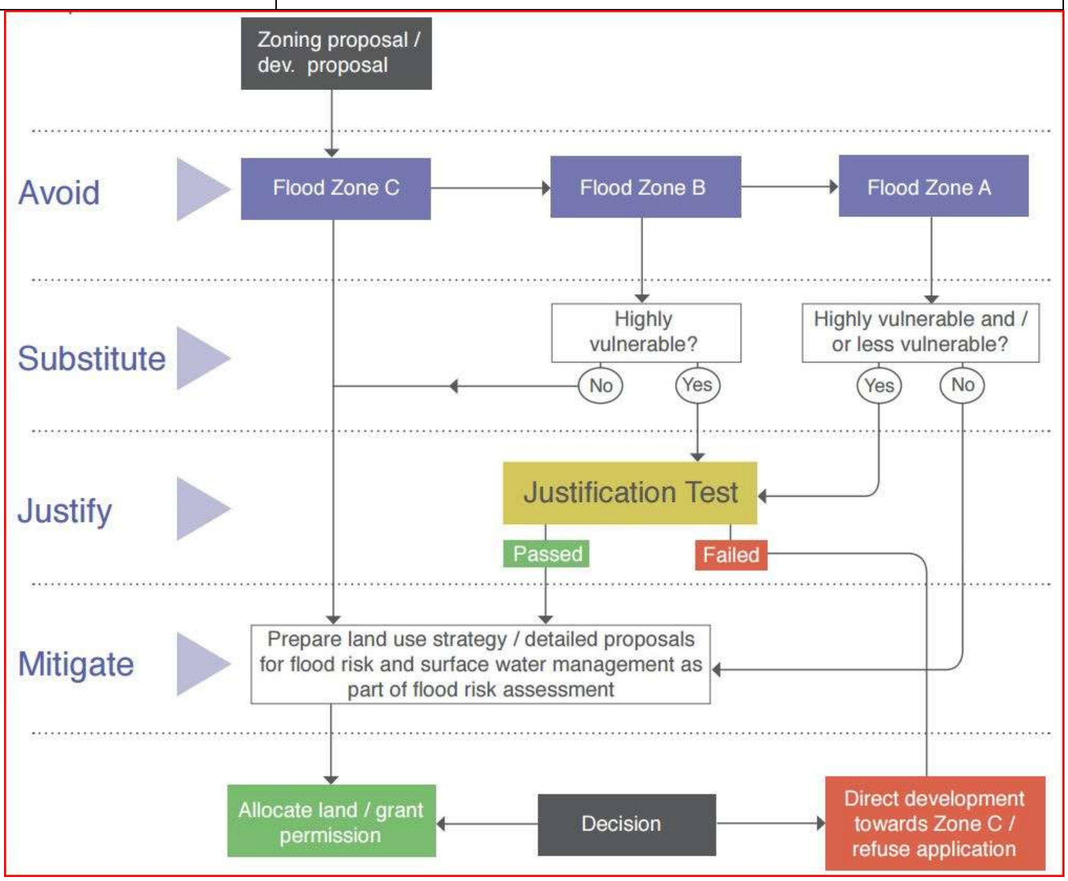

Figure 4 Sequential Approach Mechanism in the Planning Process (copy of Fig. 3.2 from the Planning System and the Flood Risk Management Planning guidelines)

2. Justification Test

Further sequentially-based decision making should be applied when undertaking the Justification Test for development that needs to be in flood risk areas for reasons of proper planning and sustainable development:

1. within Zone or site, development should be directed to areas of lower flood probability;
2. where impact of the development on adjacent lands is considered unacceptable the justification of the proposal or Zone should be reviewed
3. where the impacts are acceptable or manageable, appropriate mitigation measures within the site and if necessary elsewhere should be considered.

Application of the Justification Test in Development management.

Where a planning Authority is considering proposals for new development in areas at a high or moderate risk of flooding that include types of development that are vulnerable to flooding and that would generally be inappropriate, the planning authority must be satisfied that the development satisfies all of the criteria of the Justification Test as it applies to development management outlined in Box 5.1

Box 5.1 Justification Test for development management (to be submitted by the applicant)

When considering proposals for development, which may be vulnerable to flooding, and that would generally be inappropriate as set out in Table 3.2, the following criteria must be satisfied:

1. The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines.
2. The proposal has been subject to an appropriate flood risk assessment that demonstrates:
   (i) The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;
   (ii) The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;
   (iii) The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access; and
   (iv) The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.

The acceptability or otherwise of levels of residual risk should be made with consideration of the type and foreseen use of the development and the local development context.

Note: See section 5.27 in relation to major development on zoned lands where sequential approach has not been applied in the operative development plan.

Refer to section 5.28 in relation to minor and infill developments.

Assessment of major proposals for development in areas of flood risk pending implementation of these Guidelines

5.27 From a flood risk management perspective, proposals fitting into this category should be considered as though the land was not zoned for development. In such situations the applicant should be required, in consultation with the planning authority, to prepare an appropriate SFRA and to meet the criteria for the Justification Test as it applies to development plan preparation. The planning authority must then assess the proposal against the Justification Test as it applies to the development management process. Where the information is not sufficient to fully assess the issues involved, the development should not be approved on the basis of flood risk and / or on the grounds of prematurity prior to addressing flood risk as part of the normal review of the development plan for the area.

Assessment of minor proposals in areas of flood risk

5.28 Applications for minor development, such as small extensions to houses, and most changes of use of existing buildings and or extensions and additions to existing commercial and industrial enterprises, are unlikely to raise significant flooding issues, unless they obstruct important flow paths, introduce a significant additional number of people into flood risk areas or entail the storage of hazardous substances. Since such applications concern existing buildings, the sequential approach cannot be used to locate them in lower-risk areas and the Justification Test will not apply. However, a commensurate assessment of the risks of flooding should accompany such applications to demonstrate that they would not have adverse impacts or impede access to a watercourse, floodplain or flood protection and management facilities. These proposals should follow best practice in the management of health and safety for users and residents of the proposal.

3. Flood Risk Assessment

3.1 Introduction

This assessment follows the requirements set out in the Flood Risk Management Planning Guidelines (2009) for assessing Flood Risk of Proposed developments. The sources of Flood Risk to a development site can be defined as fluvial, coastal, pluvial, groundwater and urban storm water drainage. The Flood Risk Management Planning Guidelines identifies three stages for carrying out flood risk assessments, namely:

Stage 1 Flood Risk Identification/Screening

Stage 2 Initial Flood Risk Assessment

Stage 3 Detailed Flood Risk Assessment

3.2 Stage 1 Flood Risk Identification (Screening)

3.2.1 Introduction

The source of flooding to the Deep-water Quay development in Cashla Bay is coastal in the form of tidal storm surge flooding and combined wave climate along its exposed southern and western faces. The Development is predominantly in Flood Zone A as it is located generally below high and low water and will involved significant infilling/reclamation of land from Cashla Bay to construct the proposed Quay, hard standing area and approach causeway road. Dredging of the sea bed along the Quay is proposed to achieve deep waters of -12m below Chart Datum. Dredging of a vessel turning circle off the Quay in Cashla Bay is also proposed.

There are no other sources of flood risk to the development with fluvial, pluvial, groundwater and urban drainage sources discounted by the stage 1 screening of this site specific assessment. The OPW PFRA mapping and the Irish Coastal Protection Strategy Study (ICPSS) shows only coastal flooding as the souces with the site and approach road generally within Flood Zone A Coastal. The entire proposed Quay Area and the Hardstanding is located in the sea below low-water mark.

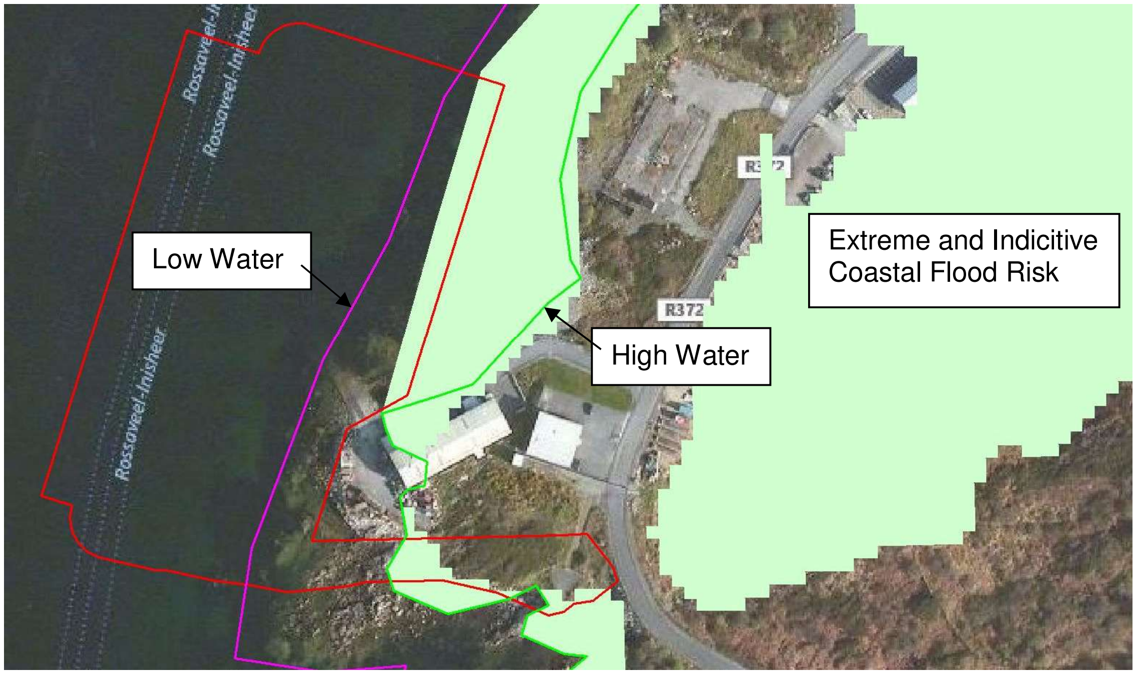

Figure 4 Showing the Low and high water lines from the admiralty charts and the on land extreme Coastal Flood risk areas.

Other sources such as fluvial flooding from the Cashla River will not affect the site, nor is the site subject flood risk from groundwater and pluvial sources.

3.3 Stage 2 Flood Risk Assessment

3.3.1 Tidal Predictions

The tide level characteristics for Rossaveel are presented in Table 1 below based on Mott MacDonald 2002 report.

Table 1 Tides at Rossaveel

Tide	Level (m) above chart datum
Highest Astronomical Tide (HAT)	+5.6
Mean High Water Springs	+4.9
Mean High Water	+4.4
Mean High Water Neaps	+3.8
Mean Sea Level	+2.8
Mean Low Water Neaps	+1.9
Mean Low Water Springs	+0.7
Lowest Astronomical Tide (LAT)	+0.0

Note Chart datum is 0.0m LAT and 2.9m below Malin Head Datum

The astronomical tides for Cashla Bay give a mean spring tide highwater level of 2.20m OD malin with a mean tidal range of 4.2m. The Highest Astronomical tide (HAT) is 2.7m O.D. Malin. Storm surge tides of significance occur when an Atlantic depressional system (cyclone)backed by gale force Southerly to westerly winds coincide with the higher spring tides, raising locally the sea water level due to reduced atmospheric pressure and increased wind shear.

The OPW operate an automatic water level recorder at Rossaveal Harbour. Data was obtained from the OPW for this gauge from September 2010 to January 2016 providing over 5years of data for an Annual maxima tidal elevation series. The highest tide from this series were recorded on the 3rd Jan 2014 giving a highwater of 6.42m chart Datum. A second high tide event occurred 1month later on the 1st Feb 2014 producing a high tide level of 5.77m Chart datum and historical maximum levels at both Galway Docks gauge and Oranmore Gauge. These recent tidal events caused significant flooding in the Galway and Shannon Estuary Area and are reported as being one of the Highest tides historically (possibly exceeded the Hurricane Debbie event of Sept 1961). The recorded high Tide at Rossaveel is reported to be the highest in recent history.

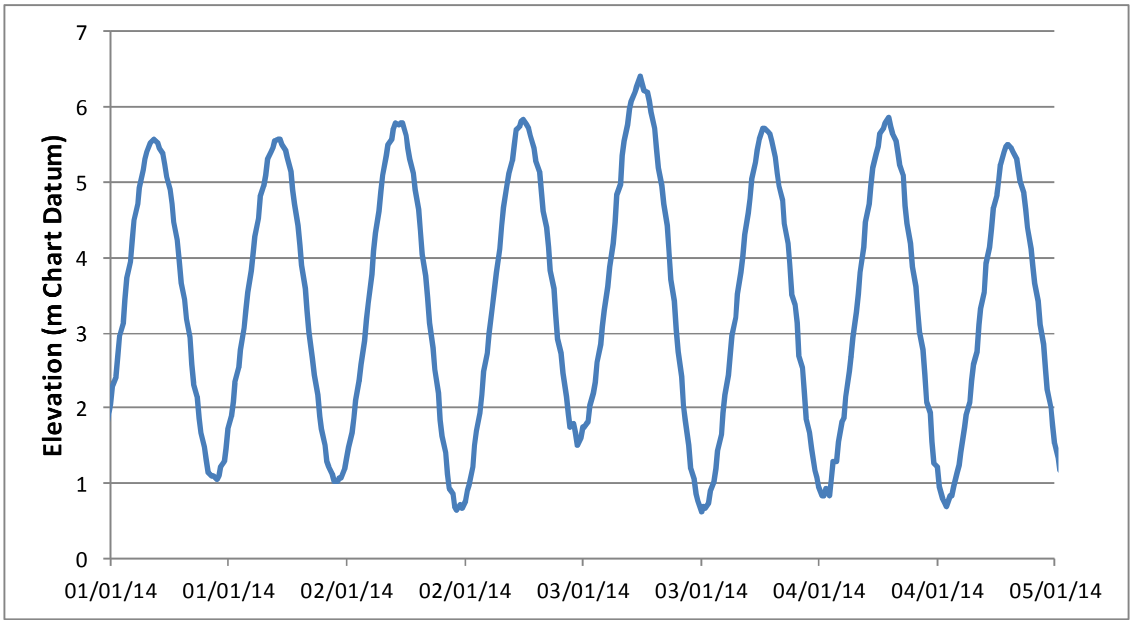

Figure 5 Storm Surge tide recorded at Rossaveel Gauge (30061) on the 3rd January 2014 (the tide Typically lifted by 0.6m)

3.3.2 Statistical Analysis of Tides

From gauged tidal data for Galway, Oranmore and Rossaveal Annual maximum series were extracted and analysised statistically by fitting extreme Value (Gumbel) statistical distribution to the series so as to predict the return period still water tide level. Use was also made of gauged information for Tarbert so as to produce a tidal growth curve for the West coast of Ireland.

Table 2 Annual maximum series of tides at Galway

Year	m OD Malin	Stage (m)	Date	comment
1992	3.27	3.04	**01/11/1993**	Tidal Peaks
1993	3.23	3	**01/12/1994**	Tidal Peaks
1994	3.48	4.25	**17/01/1995**	Tidal Peaks
1995	3.03	3.8	**25/10/1995**	Tidal Peaks
1996	3.63	4.4	**02/10/1997**	Tidal Peaks
1997	3.08	3.85	**16/10/1997**	Tidal Peaks
1998	3.14	3.91	**01/03/1999**	Tidal Peaks
1999	3.31	4.08	**25/12/1999**	Tidal Peaks
2000	3.07	3.84	**12/12/2000**	Tidal Peaks
2001	3.57	4.34	**01/02/2002**	Tidal Peaks
2002	2.99	3.76	**08/10/2002**	Tidal Peaks
2003	2.87	3.643	**02/08/2004**	Tidal Peaks
2004	3.18	3.946	**08/01/2005**	Tidal Peaks
2005	3.19	3.96	**30/03/2006**	Tidal Peaks
2006	3.23	4	**20/02/2007**	Tidal Peaks
2007	2.93	3.7	**27/10/2007**	Tidal Peaks
2008	2.94	3.712	**22/08/2009**	Tidal Peaks
2009	3.11	3.883	**02/03/2010**	Tidal Peaks
2010	3.07	3.844	**08/10/2010**	Tidal Peaks
2011	2.95	3.716	**29/10/2011**	Tidal Peaks
2012	3.18	3.95	**14/12/2012**	Tidal Peaks
2013	3.68	4.452	**01/02/2014**	Tidal Peaks
2014	3.15	3.916	**03/08/2015**	Tidal Peaks

Median annual tide level for Galway Port is 3.15m OD

Table 3 Annual maximum series of tides at Oranmore

Year	m OD Malin	Stage (m)	Date	comment
1982	2.81	1.79	**08/09/1983**	Tidal Peaks
1983	2.88	1.86	**19/02/1984**	Tidal Peaks
1984	3.04	2.02	**23/11/1984**	Tidal Peaks
1985	2.82	1.8	**28/03/1986**	Tidal Peaks
1986	2.92	1.9	**03/12/1986**	Tidal Peaks
1987	3.02	2	**27/09/1988**	Tidal Peaks
1988	3.09	2.07	**09/03/1989**	Tidal Peaks
1989	3.05	2.03	**26/02/1990**	Tidal Peaks
1990	3.40	2.38	**05/01/1991**	Tidal Peaks
1991	2.93	1.91	**29/08/1992**	Tidal Peaks
1992	3.07	2.05	**12/01/1993**	Tidal Peaks
1993	3.16	2.14	**12/01/1994**	Tidal Peaks
1994	3.49	2.47	**17/01/1995**	Tidal Peaks
1995	2.94	1.92	**28/09/1996**	Tidal Peaks
1996	3.48	2.46	**10/02/1997**	Tidal Peaks
1997	2.99	1.97	**30/03/1998**	Tidal Peaks
1998	3.10	2.08	**02/01/1999**	Tidal Peaks
1999	2.89	1.87	**26/12/1999**	Tidal Peaks
2000	2.99	1.97	**09/03/2001**	Tidal Peaks
2001	3.26	2.24	**02/02/2002**	Tidal Peaks
2002	2.78	1.76	**08/10/2002**	Tidal Peaks
2003	2.88	1.86	**19/03/2004**	Tidal Peaks

2004	3.28	2.26	**08/01/2005**	Tidal Peaks
2005	3.03	2.01	**29/03/2006**	Tidal Peaks
2006	3.00	1.98	**19/01/2007**	Tidal Peaks
2007	2.82	1.8	**27/10/2007**	Tidal Peaks
2008	2.83	1.81	**22/08/2009**	Tidal Peaks
2009	3.26	2.24	**03/03/2010**	Tidal Peaks
2010	3.00	1.98	**08/10/2010**	Tidal Peaks
2011	2.84	1.82	**26/10/2011**	Tidal Peaks
2012	3.02	2.004	**14/12/2012**	Tidal Peaks
2013	3.60	2.583	**01/02/2014**	Tidal Peaks
2014	3.04	2.015	**03/08/2015**	Tidal Peaks

Median annual tide level for Oranmore is 3.03m OD
(note 3.59m OD Malin occurred on the 3rd Jan 2014 and the 3.60 m OD Malin occurred on the 1st Feb 2014)

Table 4 Annual maximum series of tides at Rossaveel

Year	m OD Malin	Stage (m)	Date	comment
2011	2.99	5.899	**20/02/2010**	Tidal Peaks
2012	2.89	5.801	**26/10/2011**	Tidal Peaks
2013	3.09	6.003	**14/12/2012**	Tidal Peaks
2014	3.51	6.416	**03/01/2014**	Tidal Peaks
2015	2.98	5.885	**03/08/2015**	Tidal Peaks

Median tide level is 2.99m OD Malin

Statistical analysis on the annual maximum series of tide levels for the Oranmore gauge site which provides 33years of continuous data was carried out fitting an EV1 (Gumbel) statistical distribution to the data by the method of plotting positions. The results from this statistical analysis in terms of the relationship between tide flood level and return period is presented in Figure 6 and Table 5. This analysis suggests that the 3rd Jan and 1st Feb 2014 tidal surge levels of 3.59 and 3.60m OD malin respectively is equivalent to a 50year return period event.

From this statistical analysis of the oranmore gauge the 200 and 1000year tidal surge flood levels are 3.83 and 4.09m OD. Malin with standard errors of 0.164 and 0.211m respectively is estimated.

Table 5 Tide and Storm Surge Return Period Flood levels from local Oranmore Gauge and the CFRAM/ ICPSS predictions (node W5)

Return Period T (years)	Y_{EV1}	Flood Level Gauge Site H_T m OD	Statistical Standard Error (m)	Flood Level CFRAM/ICPSS W5 Oranmore H_T m OD
2	0.37	3.01	0.033	3.07
5	1.50	3.20	0.056	3.23
10	2.25	3.32	0.076	3.34
50	3.90	3.59	0.123	3.59
100	4.60	3.71	0.143	3.7
200	5.30	3.83	0.164	3.81
1000	6.91	4.09	0.211	4.06

These predicted tidal flood levels agree reasonably well with current CFRAM and ICPSS coastal flood level projections for Oranmore Bay at Node W5 of the Western ICPSS model which gives 3.83 and 4.06m OD Malin respectively for the 2000 and 1000year events.

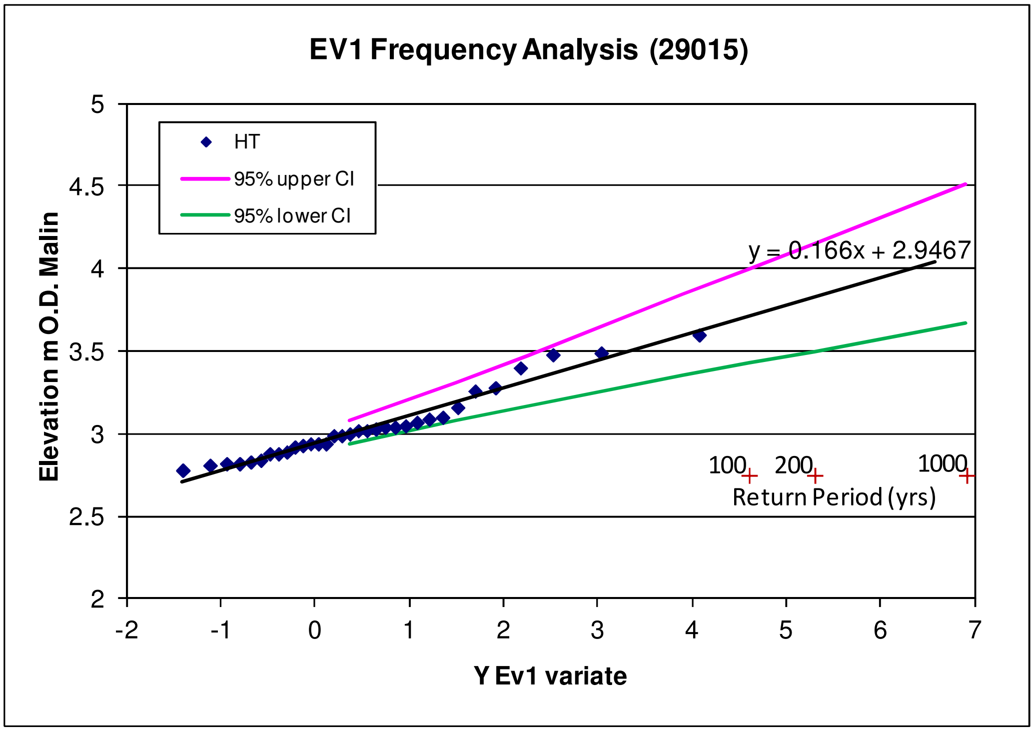

Figure 6 Statistical Analysis of Oranmore Tidal Gauge at Dublin Road Bridge

A tidal growth curve relationship was developed for single site analyses of the Galway, Oranmore and Tarbert gauged AM series using the index tide level of the 2year tidal event H2. A tidal regional growth curve is derived taking the average of these growth factors.

Table 6 Estimated Tidal Growth Curves from CFRAM Study, and AM series at Galway and Oranmore

Return Period	Ev1 Plotting Position	Oranmore Gauge	Tarbert Gauge	Galway Gauge	Average XT average tide growth curve
2	0.37	1	1	1	**1**
5	1.50	1.063	1.051	1.066	**1.060**
10	2.25	1.104	1.090	1.110	**1.101**
50	3.90	1.195	1.179	1.207	**1.194**
100	4.60	1.234	1.218	1.248	**1.233**
200	5.30	1.272	1.256	1.289	**1.272**
1000	6.91	1.361	1.345	1.383	**1.363**

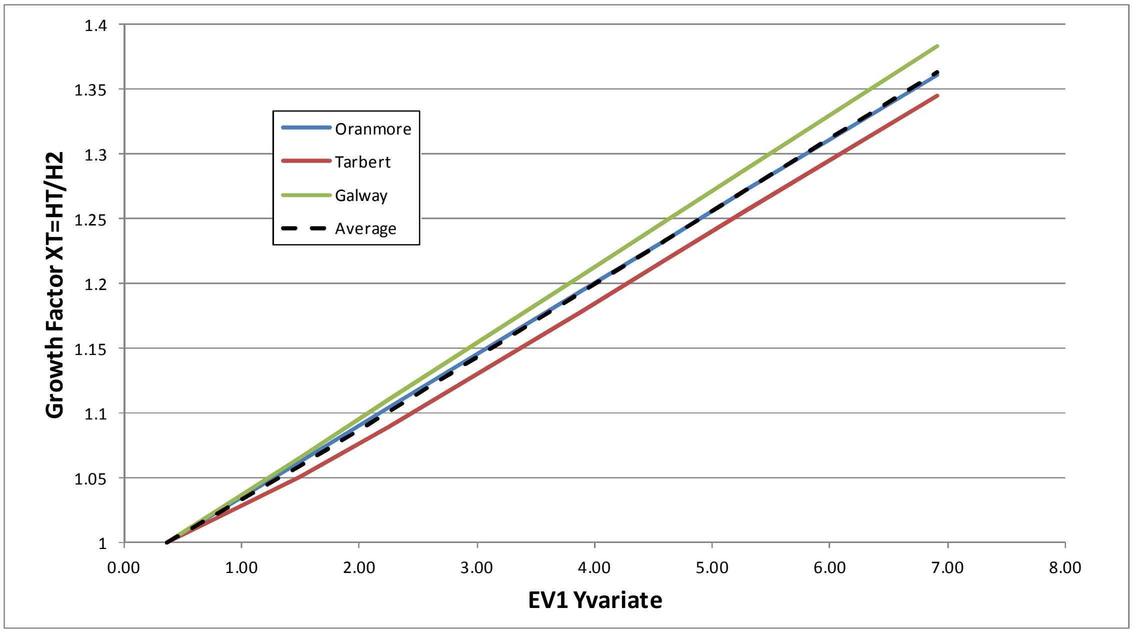

Figure 7 Growth Curve Relationship for West of Ireland Gauges

$H_T = H_2 * X_T$

Therefore an estimate of the 200year tide using a statistical based average tidal growth curve is

H200 = 3.02 *1.272 = 3.84m OD at Oranmore
H200 = 3.145*1.272 = 4.00m OD at Galway City
H200 = 2.99*1.272 = 3.80m OD at Rossaveel

And the 1000year estimate is

H1000 = 3.02 *1.363 = 4.12m OD at Oranmore
H1000 = 3.145*1.363 = 4.29m OD at Galway City
H1000 = 2.99*1.363 = 4.08m OD at Rossaveel

If the statistical factorial error is included so as to represent the upper 67% confidence interval then the 200 and 1000year estimates for Rossaveel increase to 3.92m OD Malin and 4.24m OD respectively.

ICPSS estimate for Node W16 located at the entrance to Cashla Bay gives a 200year retrun period high tide estimate of 3.47m OD Malin and a 1000year high tide estimate of 3.69m OD Malin. These ICPSS estimates are considered to underestimate the return period magnitudes as they suggest that the recent tide event on the 2nd Jan 2014 (high tide of 3.51m OD Malin at Rossaveel and 3.59m OD at Oranmore) exceeds a 200year return period when in fact the gauged data suggests a return period of the order of 50years. It should also be noted that exactly 1month latter at

Oranmore this tide was exceeded by 1cm on the 1st February 2014 (Statistically not impossible for two extreme events to occur close to one another but unlikely).

The originally Mott McDonald Design Report (Jan 2002) estimated the 200year Tide level to be 6.69m above chart datum which is 3.79m OD Malin. This study did not consider the 1000year event in the analysis.

3.3.3 Recommended Design Flood Tide Level

Based on the above estimates for return period tide still water levels a value of 3.80m OD Malin and 4.08m OD Malin from the statistical analysis of local gauges is selected for the 200 and 1000year return period events. These estimates are considered to be more reliable than the ICPSS estimates and agree with the Mott MacDonald Study 200year estimate (Jan 2002).

3.3.4 Wave Climate

The proposed site is located just inside the throat to Cashla Bay at Lion Point, refer to Figure 1. Cashla Bay is exposed to the open sea of Galway Bay to the South. The inlet to Cashla Bay narrows at Loin Point to a width of 375m. The Aran Islands afford considerable sheltering protection to Cashla Bay from deepwater Atlantic storm swell waves propagating from the South to the Southwest. The north-south alignment of Cashla Bay protects it from Westerly Waves unable to diffract sharply into Cashla Bay. For the above reasons Cashla Bay and the subject site is considered to be generally only exposed to locally generated wind waves with the maximum local fetch from the south commencing just north of the Aran Islands and the north Clare Coastline.

As part of the originally marine process studies for this Deepwater Quay carried out by Mott MacDonald (Jan 2002) a detailed wave climate study was carried out to assess wave exposure of the deepwater quay site to waves using the MIKE 21 Wave Climate model. A review of this study is presented below.

The exposure of Cashla Bay to deep Atlantic swell waves, identified that the Aran Islands provided an effective but not complete barrier with waves potentially having the ability to penetrate through the Gregory sound and to a lesser extent the other sounds in order to reach Cashla Bay. The critical direction for such wave propagation is from 196 to 226degree sector based on the Shore protection manual diffraction analysis. The penetrating wave heights that potentially reach Cashla Point from these sectors through Gregory Sound are summarised below in Table 7 for 1 year and 100year swell wave events.

Table 7 Computed Hs Significant Wave Heights Penetrating through Gregory Sound (Mott MacDonald (2002))

Return Period	Incident Swell Wave Hs (m) approaching Gregory Sound	Swell Wave Hs at Cashla Point (m)
196º direction		
1yr	3.4	1.4
100yr	5.8	2.3
226º direction		
1yr	5.6	0.9
100yr	8.8	1.4

Significant Wave period for these directions approximated to be 15seconds

Wind wave hindcasting analysis using 3hourly duration return period wind magnitude events for Sector 120 to 225º was carried out to generate critical wave conditions at the entrance to Cashla Bay (1year return period, 3hour duration wind was estimated to conservatively have a speed of 25m/s and 31m/s for a 100year 3 hr duration event).

Table 8 Computed Return Period Wind Waves at the mouth to Cashla Bay (Mott MacDonald (2002))

Return Period	Significant Wave Height Hs (m)	Approx Significant Wave Period Seconds
1yr	2.2	6
100yr	2.8	6

Local wave climate modelling of wind and swell waves into Cashla Bay was carried out by Mott MacDonald using a MIKE21 Wave Model that solves the elliptical mild slope equation and includes for refracting, wave breaking, wave diffraction, wave reflection and bed friction processes. A combination of tide and wave conditions was carried out using this model to identify adverse wave conditions at the deepwater Quay site inside Lion Point.

A series of limiting wave conditions for deep water Quay mooring operations was presented in the study and these are summarised as follows:

Table 9 Limiting wave Height for Safe Mooring Operations at Deepwater Quay

Vessel Type	Limiting Wave height Hc (m) (Head sea)	Applicable Wave Period (s)
Fishing Vessels	0.4	Up to 10
General Cargo Vessels(up to 30,000 DWT)	0.7	Up to 10
Bulk Carrier (up to 30,000 DWT)	0.8	Up to 10
Container Vessels	0.5	7 to 12
Ro Ro Vessels	0.5	7 to 12
Passenger Vessels	0.7	Up to 10
Tankers (up to 30,000 DWT)	0.7	Up to 10

The results presented for the existing undeveloped case and for the proposed deepwater berth with the south causeway showed all computed 1 in 100year swell wind waves from the southerly direction to be 0.3m or less along the outside berth on a mean highwater spring tide.

However examination of the wave climate plots indicates that the southerly causeway and head of the Quay are exposed to waves in certain cases in excess of 0.5m both 1year and 100year return period wave events.

Locally generated waves across Bay from the Carraroe Direction (293 to 337degrees was found to produce a significant wave height of 0.5 to 0.75m and a wave period of 2 to 3 seconds based on the US Army Shore protection manual procedures. A more recent navigation study has indicated that these waves would not be as significant.

3.3.4 Flood Risk Mapping

The entire site is virtually in Flood Zone A as it is essentially a marine development involving construction of a quay structure within Cashla Bay Marine Waters. The pFRA/ICPSS mapping shows access road within the 200year zone at the development and also at the existing Rossaveel Harbour area. Refer to Figure 7.

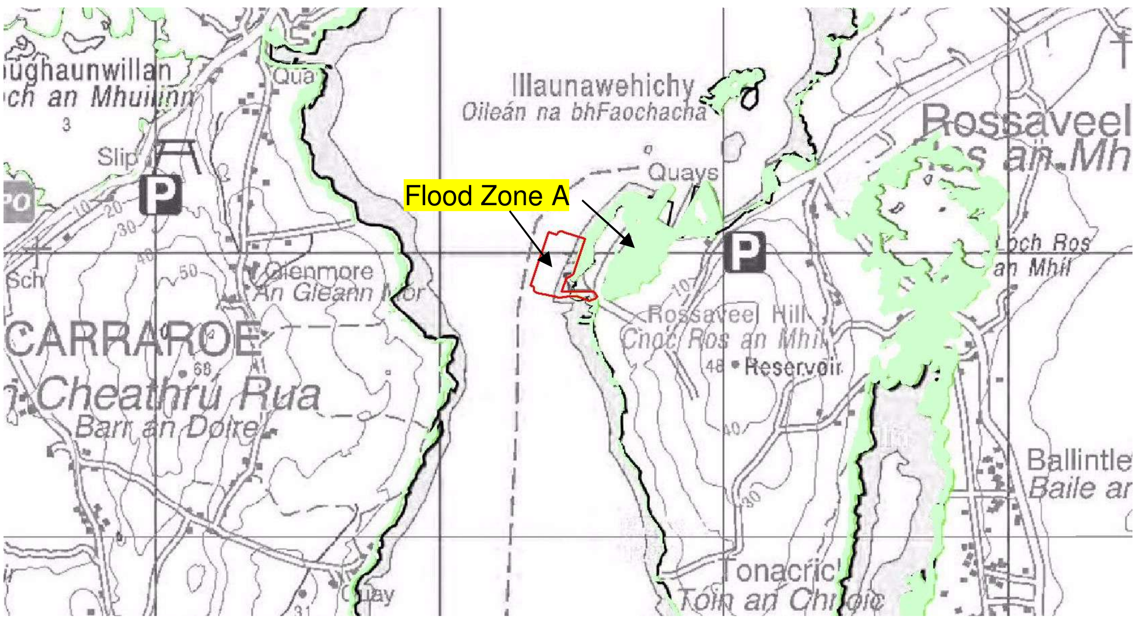

Figure 7 Coastal Flood Risk Mapping – Extract from ICPSS mapping

3.4 Stage 3 Flood Risk Management

3.4.1 Introduction

The proposed deepwater Quay development is shown to be located principally in the high coastal flood risk Zone A, being vulnerable to flooding at a frequency greater then 0.5% AEP (annual exceedence probability) which is equivalent to 200year or lower return period. The site is also exposed to wave climate which based on analysis and modelling by Mott MacDonald (2002) could potentially exceed 0.5m to 0.75m for local short period, medium wind wave and long period swell waves from a south direction and from a northwest direction locally across inner cashla Bay.

Such waves combined with a significant tide event would represent worst case flooding and given the proposed Quay level of 6.6m chart datum (3.7m OD Malin) could close down operations on the Quay temporarily during such events as waves at or close to the highwater would overtop and spill across the causeway road, the quay and across the hardstanding area making quay side operation difficult.

3.4.2 Climate Change Allowance

Research for the West coast of Ireland and included in the ICPSS indicates for the mid range future scenario a net sea level rise of 0.5m and for the high end future scenario a rise in sea level of 1m. It is also indicated that the degree of storminess both in respect to generating tidal storm surges and propagating swell and wind waves may increase. Consequently if such increases are realised it may be a requirement in the future to increase the height of the Quay side, the hardstanding area and the approach road. Therefore foundations and structural design to be provided for the current day scenario should be designed to allow for potential raising of ground level, if required so as to combat future sea level rises. From an operational perspective it may not be practical to set the Quay height at 0.5 to 1m higher than proposed to a provide for potential sea level rise (depending on the sea level scenario selected, mid-range or high) as this could increase difficulty of present day normal tide mooring operations.

3.4.3 Justification Test for Development

The proposed development as a deepwater quay is suitable as a water compatible development and therefore suitable for locating in coastal Flood Zone A without the requirement for sequential testing.

The proposed site is suitable as it is located close to deep water and in a location where reasonable tidal flows exist to prevent any significant issues with sedimentation and silting. The location just inside Lion Point is shown not to be excessively exposed to wave climate and therefore not significantly limited in respect to mooring operations and Quay side loading and unloading operations during storm events.

3.4.4 Recommended Deign Finish Level

The proposed Quay and hardstanding finish level is 6.6m chart datum which is approximately 3.7m OD Malin. Based on this study the estimated 200year and 1000year tide levels are 3.80m and 4.08m respectively. This indicates that the proposed quay level at 3.7m OD has a tidal flood risk of approximately 100year return period without waves. The stage 2 FRA indicates that an extreme wave event combined with 1in 5 year or greater tide event could overtop the proposed 6.6m chart datum Quay level.

3.4.5 Flood Risk Management

The proposed hardstanding area should be raised so as to have at least a minimum finish level that exceeds the 200year tide of 3.8m OD Malin which is approximately 6.7m Chart datum and therefore allowing it to be out of Flood Zone A for tide. This should also apply to the Causeway approach road the proposed Quay.

The southern head of the Quay and in particular southern boundary of the causeway road with the sea should be protected (possibly by a low flood wall or Rock Armouring) against wave action and overtopping by wind and swell waves from the south combining with an extreme tide highwater event (the occurrence of such events are often not that independent particularly from the south and southwest.

4. Conclusions

The proposed deepwater Quay development is located principally in Flood Zone A. Under the flood risk management planning guidelines this marine based development being a water compatible development is suitable and justifiable in such a flood zone. The impact of the infilling of the site on hydrodynamics and wave climate have been assessed in the EIS and NIS that supported the original application and a review of the relevant wave and tide modelling report (Jan 2002) indicates that the proposed development is unlikely to have any significantly impact on flood risk elsewhere in the bay.

The flood risk to the development is coastal, from either tide surge events in isolation or tides in combination with wave climate. Based on this study the estimated 200year and 1000year extreme tide levels (currently without climate change) are 3.80m and 4.08m respectively. The proposed quay and associated hardstanding area has a proposed finish level of 6.6m Chart datum (i.e. 3.7m O.D. Malin) and thus will be within Flood Zone A. The proposed finish level has a tidal return period of approximately 100years (cureent with climate change) and is also at risk from combined wave and tide events at a similar combined return period frequency.

The Irish Coastal Protection Strategy Study for the West coast of Ireland includes for the mid range future scenario a net sea level rise of 0.5m and for the high end future scenario a rise in sea level of 1m. Consequently if such increases are realised it may be a requirement in the future to increase the height of the Quay side, and in particular the hardstanding / storage / service areas on and adjacent to the Quay and the approach road. Therefore foundations and structural design should be designed to allow for potential raising of ground levels, if required in the future so as to combat sea level rise. From an operational perspective it may not be practical to set the Quay height at 0.5 to 1m higher than currently proposed in order to a provide for potential sea level rise (depending on the sea level scenario selected, mid-range or high) as this could increase difficulty of present day normal tide mooring operations.

The proposed hardstanding area should be raised so as to have a minimum finish level that exceeds the 200year tide of 3.8m OD Malin which is approximately 6.7m Chart datum and therefore allowing it to be out of Flood Zone A. Further allowances may also need to be applied to combat combined effects of tides and waves on the Quayside. This also applies to the causeway approach road that connects the Quay.

The southern head of the Quay and in particular southern boundary of the causeway road with the sea should be protected (possibly by a low flood wall or Rock Armouring) against wave action and overtopping by wind and swell waves from the south combining with an extreme highwater tide events (the occurrence of such events (Tide and waves) are often not that independent particularly from the critical south and southwest sectors).

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