

# DUN LAOGHAIRE BATHS

(5009)



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## **DUN LAOGHAIRE BATHS SCHEME (5009)**

### **ROYAL HASKONING 2008 STUDY - A BASE FOR TECHNICAL DATA**

- A. Royal Haskoning carried out a major study for Dun Laoghaire Rathdown County Council into the "East Pier to Sandycove Improvement Scheme Incorporating the Sutton to Sandy cove Promenade and Cycle facility".
- B. Their May 2008 Final report received on 27 September (together with bathymetric and seismic survey info to hand this month) contains much useful information from an engineering design viewpoint directly relevant to the proposed works in the Dun Laoghaire Baths project.
- C. It concludes – in line with Code of Practice recommendations - that the design life to be taken into account when proportioning features (new walkways, breakwaters etc) on the shore at Scotsman's Bay should be 50 to 100 years.
- D. The report includes base information from many sources including
  - Bathymetric (seabed) level survey.
  - Topographical (land levels) survey out almost to the line where bathymetric levels started.
  - Seismic survey (measuring depths from seabed to the underlying bedrock)
  - Tide level record studies including predictions of future sea levels taking global warming into account.
  - Records of tidal surges in Dublin Bay, ie tide heights caused by low barometric pressure and or wind forces etc.
  - Computer based wave modelling, predicting significant wave height and period – for waves which should be taken into account in structural design of elements on the foreshore in Scotman's Bay.
- E. In the following sections, where we refer to this report we call it RH2008 for short.

## **FEATURES IN THE DUN LAOGHAIRE BATHS PROJECT**

### **1 THE NEW PIER**

The objective in providing the pier is to permit swimmers to enter deep water clear of rocks at low tide. To that end it is to extend approximately 15m beyond the end of an existing concrete feature which is resting on bedrock.

#### **1.1 Tide levels affecting the pier**

- A. The proposed new pier deck level is 3.0m ODM
- B. Astronomical tides are generated primarily by cyclic variations in gravitational attraction of the moon and the sun on the water masses of the earth. Tide Tables predicting tide heights are based on continuous observations of tide over a period of time at a given port.
- C. From Tide Tables, Mean High Water Spring Tides (MHWS) at Dun Laoghaire is 1.59m ODM, though we have seen a high tide and flat sea reach close to the level of the pool decks at approximately 2.0m ODM.
- D. The Highest Astronomical Tide (HAT) – ie the highest sea level that can be expected to occur under average meteorological conditions and under any combination of astronomical conditions) is given in RH2008 as 2.0m ODM.
- E. Short period fluctuations from the basic Tide Table predicted levels can result from factors such as wind, atmospheric pressure, wave effects, and local (eg river) run off.
- F. Predictions of extreme water levels for use in design of elements such as piers quays or other structures on the foreshore are based on statistical analysis of past tides and their causative factors.
- G. The frequency of recurrence of extreme events such as sea level (or wave height) is often expressed by its return period – defined as the period which on average will separate two occurrences. However, it does not signify that – take that example of a 50 year return period sea level – exactly 50 years will separate two such sea level occurrences.

- H. If one takes a 50 year return period (ie 2% probability of being exceeded in a given year) for design purposes, RH2008 quotes a sea level high tide level in Scotsman's Bay of 2.91m ODM; it could occur in the following year with a similar 2% level of probability while within a ten year period its likelihood of occurrence is 18%. That 50 year return sea level locally rises to 3.31m ODM if allowance is made for climate change to year 2100.
- I. Mean Low water Spring Tides at Dun Laoghaire is -1.7m ODM , with Lowest Astronomical tide approximately -2.5m ODM (extrapolating from Dublin Port LAT figures in RH2008).

## **1.2 Wave heights to be withstood by the pier construction**

- A. The height of waves formed by wind depends on the length of open sea (the fetch) over which the wind can freely pass when pointing directly at the subject site. The longer the fetch the higher the potential waves. In shallow water they can peak and break, depending on water depth relative to open sea wave height.
- B. Dun Laoghaire baths and the proposed pier face north east and in north easterly storms are open to waves which have had a long open sea passage over which to build up height –Scotland would be the nearest land in that direction .
- C. Very large waves have been recorded in such storms in this corner of Scotsman's Bay. For example in 2010 waves broke over the top of the nearby Harbour East Pier near its root, at level 6.00 OD (see photo).



- D. Predictions of wave heights are based on statistics. RH2008 computer modelling produced wave height predictions for a number of "return periods". (Notes on the term "return period" are given in 1.1 G and H above).
- E. RH2008 study predicts a nearshore wave height of 2.5m for a one year return period wave combined with a one year return period sea level. (One year return

period means that event eg wave height is statistically likely to occur once in a given year).

- F. Longer return periods result in greater height predicted waves. Thus for a 50 year wave and 200 year water level the wave height would be 3.5m. While this is comparatively less likely, there is still a 2% probability of a "50 year" wave occurring on a given year, and separately a 0.5% chance of a 1 in a "200 year" sea level occurring in a given year, though the combination probability is lower than the individual probabilities.
- G. RH2008 proposed a "lower walkway" ie path along the seafront at level 3.5m ODM, and concluded that it would, in north easterly gales, be subject to overtopping "several times throughout the year"
- H. Given the potential high and low sea levels noted in 1.1, and allowing for the potential wave heights referenced above in this section, it is clear that the pier at 3.0m ODM will be subject at different times to waves at higher sea levels passing over it, and also waves in relatively shallow water at low tide breaking head on against it.
- I. The pier is beneficially oriented almost north east ie toward the direction if the larges predicted waves in the area. In that scenario it will present its least lateral dimension to direct wave impact forces.
- J. Wave directions slightly either side of "head on" will tend to reflect off it and thus not expend their full energy on the structure.
- K. We reckon there could be elements of significant wave action sideways towards the new pier - having been reflected off the Harbour East Pier, or seeking to move eastward out of the "pocket" formed by the East Pier and the Queen's Road sea frontage.

Sideways wave impact forces on the new pier from that direction would in our opinion be likely to be greater than from the easterly Windsor Terrace / Martello Terrace direction. The latter sea frontage is rocky for some distance from shore and could be expected to dissipate wave energy and also reduce reflection.

- L. To mitigate the effect of those forces it is proposed to line the eastern side of the new pier with rock armour, similar to that proposed in RH2008 for protection of the lower walkway – as in next paragraph .

- M. The armour would consist of 3.5 to 7 tonne rocks with a crest level at 3.0m ODM (the crest being three rocks in width); beyond that the profile would slope at 1 in 2.5. There would be two layers of outer armour placed on a core of smaller rock which would be sized to be filter stable relative to the armour layer, thus obviating the need for a geotextile – given the rocky nature of the foreshore.

### **1.3 Foundation conditions for the pier**

- A. The topographic survey and visual inspection show that granite rock is outcropping under the new pier footprint for all but the last 15m of its length.
- B. While RH2008 recommends verification of the specific rock properties at later design stage it summarises the seismic survey results as showing “rock is located very close to the surface over the whole frontage for a distance of between 200m to 300m offshore”; its consequent conclusion is that there is a solid foundation layer over the nearshore on which proposed structures can be founded.
- C. Drawings prepared by Hydro Surveys and incorporated in RH2008 indicate a sea bed level of approximately -2.0 ODM at the tip of the pier. Hence it can be constructed directly on rock in entirety.

### **1.4 Pier Construction**

- A. To withstand significant wave forces we believe the pier could be constructed in reinforced concrete based on and anchored to the granite bedrock.
- B. Specific construction methods and elements of detail design could be influenced by the expertise / available plant / experience of the selected contractor.
- C. However we would envisage the pier being built in stages proceeding outwards from the land, if necessary using temporary ramps or platforms of stone fill for plant standing. Working time for some operations will be limited by tides, though placement of concrete underwater via tremie is structurally agreeable with suitable precautions.
- D. Insitu construction could take the form of reinforced concrete slab base with RC outer retaining walls and cross diaphragms, infilled with granular material and capped with reinforced concrete deck slab.

- E. Elements of precast concrete could be incorporated if advantageous.
- F. Anchor rods would be drilled and grouted into the bedrock.
- G. Concrete for the pier would be 50/50 CEMII/GGBS cement to provide additional resistance to attack from sulphate and chloride in the seawater as well as being environmentally sensible in carbon footprint terms.
- H. There could be benefit in using fibre reinforcement in some of the concrete to reduce permeability and increase abrasion and impact resistance etc.

## **2 RETAINED BUILDINGS**

- A. It is proposed to demolish most of the more recent structure additions to the original pavilion building, including the water tank enclosure on its roof.
- B. Internal alterations to the retained structure are to include:
  - Formation of a wall opening from the ground floor gallery and construction of a linking bridge to the western deck.
  - Removal of the western stairs and provision of a floor for the café/gallery at ground floor (11.25) and the studio/workshop at 7.57 level.
  - Reconfiguration of window opens at 7.57 floor, on the seaward side.
  - Infilling of several wall openings and removal of minor partitions.
  - Possible insertion of a lift in the wall protrusion on the rear (north east) façade.
- C. In structural terms the alterations outlined are not major. We would envisage new floors being constructed in reinforced concrete, and lintols over new openings being RC or concrete encased steel.
- D. The studio workshop at 5.36 would be at some risk of seawater ingress in storm conditions.

A variety of flood protection measures could be considered for incorporation in the design (for example modular drop in barriers for doorways which could be inserted when a high tide and north easterly storms is predicted).

Provision should be made for drainage via a drain line with a valve control so that water could drain out after a flood event but wave driven water could not come back up the drain pipe and thus defeat the barriers.

### **3 EXTERNAL WORKS**

#### **3.1 The new walkway across the front of the Baths Pavilion area**

- A. The walk way traverses this area at levels between 7.0m ODM (at each end) and 5.6m ODM (outside the retained "Studio"). By comparison the present walkway along Windsor Terrace / Martello Terrace and eastward is at 4.75m ODM.
- B. In high tide and north easterly storm conditions waves will break over the (2.0m ODM) deck level in front of the walkway and against the walkway wall.
- C. We envisage the walkway wall being constructed in reinforced concrete on (and anchored to) granite bedrock exposed in the demolition of the redundant former changing rooms etc. A battered outer face, or possibly a chamfer at low level on the outer face would helpfully deflect some wave energy upwards.
- D. Mindful of RH2008 proposal to provide rock armour protection along their 6.0m ODM breakwater crest, and also the experience of waves breaking over the East Pier wall at 6.0m ODM, we believe there would be considerable merit in providing protection to this walkway wall as part of the pool deck level construction – see next section 3.2 below.

For safety of walkers and to provide some protection to the Studio Room against storm wave splashing we believe there should be there should be an upstand wall to 6.6m ODM at lowest on the outer face of the walkway.

#### **3.2 The former pool deck areas**

- A. Much of the deck and pool structure in concrete is broken or displaced. This should be broken up and replaced with reinforced concrete anchored to the rock.
- B. By way of some protection to the main walkway wall, as mentioned above, we would recommend construction of a relatively low level wall on the outer edge of the deck, and placement of a rock layer outside it to absorb some wave energy before storm waves hit the walkway wall.



### **3.3 Pathways west of the Pavilion**

- A. For the most part the adjustments to the existing paths north of the Pavilion (i.e. towards the Harbour East Pier) involve raising the levels by amounts up to 1.3m. These raised levels would be formed in mass concrete, based and dowelled onto existing concrete paths if sound; if not the existing path construction should be cut out and the new concrete cast and dowelled onto bedrock.

### **3.4 Terrace west of the Pavilion**

- A. The paved surface of the proposed café terrace area beside the pavilion is presently uneven, and must be investigated to find out why. If it is caused by inadequately compacted fill then part excavation and replacement in compacted layers will suffice.

**Frank Lee**  
**LMC Consulting Engineers**

27 November 2012.

# **DUN LAOGHAIRE BATHS**

**(5009)**



**EXTRACTS FROM ROYAL HASKONING "EAST PIER TO SANDYCOVE  
IMPROVEMENT STUDY" 2008 WITH RELEVANCE FOR DUN LAOGHAIRE  
BATHS SCHEME**

<p><b>EXTRACTS</b></p> <p><b>FROM ROYAL HASKONING EAST PIER TO SANDYCOVE IMPROVEMENT STUDY 2008</b></p>	<p><b>RELEVANCE FOR DUN LAOGHAIRE BATHS SCHEME                      27 Nov 2012.</b></p>
<p>PAGE 19</p> <p><b>4.1.1 Design life</b></p> <p>An important parameter for any project which needs to be set at the outset is the design life. Once the design life is set the development and design of the scheme must ensure that any structures which form part of the new scheme should be able to perform safely throughout the design life period when subjected to any of the design parameters set for the scheme. Ongoing maintenance will still be a necessary requirement.</p> <p>.....</p> <p>From a coastal engineering perspective important considerations with respect to design life and design in general will include</p> <ul style="list-style-type: none"> <li>• Extreme tide and wave conditions</li> <li>• Effects of climate change, in particular sea level rise and the frequency of storms</li> <li>• Allowable overtopping requirements both for flood risk and public safety</li> <li>• Changes to littoral processes (sediment movement)</li> <li>• Material types</li> <li>• Ground conditions</li> <li>• Capital and maintenance costs</li> </ul> <p>.....</p> <p>For coastal engineering projects typical design lives range from 50 to 100 years and any scheme proposed for this frontage should be designed to provide a similar robust design life.</p>	<p></p> <p><i>Design considerations to be as listed</i></p> <p></p> <p><i>Design Life to be 50 to 100 years</i></p>

<p><b>(4.1.2 Climate change)</b> .....</p> <p>For the Dublin Coastal Flooding Protection Project (DCFPP, 2005) an extensive review was undertaken of the latest guidelines available at the time including national and international best practice. Based on that work the following recommendations were made and have been included in the development of concepts within the feasibility stage of the project.</p> <ul style="list-style-type: none"> <li>• The Medium-High climate change scenario should be used as a baseline minimum for design</li> <li>• An annual average sea level rise of 4.15mm/year should be used and is applicable to the end of the century. This includes an allowance of 0.3mm/year for land subsidence.</li> <li>• Defence should be designed and constructed to be flexible and in a phased approach to allow for review and accommodation of changes to predictions pending future research into and realisation of actual SLR values.</li> </ul>	<p><i>Allowance for annual sea level rise due to climate change 4.13mm/year</i></p>
<p>PAGE 20 .....</p> <p>For coastal engineering projects in general structures are generally designed to withstand extreme events of magnitude not less than 1 in 50 to 1 in 100 year return period. For example rock armour would be designed to withstand an extreme wave with return period of say 100 years.</p>	<p><i>Design structures, rock armour for 50 to 100 year design life</i></p>

## **Tides**

### **Tide Levels**

A good understanding of the tidal conditions at the site will be extremely important in order to assess the risk of the site from coastal flooding and in the design and assessment of any new scheme proposed. Normal astronomic tide levels for Dublin and Dun Laoghaire were obtained from the Admiralty Tide Tables. These values are presented in Table 4.1 below. It can be seen from the data that the site has a Neap tidal range of 1.9m and a Spring tidal range of some 3.3m.

**Table 4-1: Astronomical Tide Levels**

	Dublin (North Wall)		Dun Laoghaire	
	mCD	mODM	mCD	mODM
Highest Astronomical Tide (HAT)	4.5	2.0	-	-
Mean High Water Spring Tide (MHWS)	4.1	1.6	4.1	1.6
Mean High Water Neap Tide (MHWN)	3.4	0.9	3.4	0.9
Mean Low Water Neap Tide (MLWN)	1.5	-1.0	1.5	-1.0
Mean Low Water Spring Tide (MLWS)	0.7	-1.8	0.8	-1.7
Lowest Astronomical Tide (LAT)	-0.1	-2.61	-	-

In addition to normal astronomic effects, meteorological effects such as low barometric pressure and strong winds can increase tide levels along coastal waters. This increase in tide level due to meteorological effects is called a surge. A detailed analysis of tidal records from Dublin Port over an 80 year period was undertaken by Royal Haskoning for the recently completed Dublin Coastal Flooding Protection Project (DCFPP). That project was commissioned following the extreme tidal event of the 1<sup>st</sup> February 2002 which had a tidal surge of approximately 1m. This surge combined with a relatively large astronomic tide to produce the highest tide level on record at Dublin over that 80 year period. The tide level on the day reached a level of 2.95m ODM (5.46CM) at Dublin Port.

*Tidal Ranges based on Astronomic prediction*

*Tidal surge (in Feb 2002) of 1m due to combination of effects produced highest tide in Dublin over an 80 year period*

The detailed tidal analysis found that even higher tidal surges had occurred in the past, with the highest noted in the period of data analysed being 1.28m, although it coincided with a lower astronomical tide resulting in a high but lower tide than that which occurred on the 1<sup>st</sup> February 2002.

As such an important design parameter for any scheme along the Scotsman's Bay will be the use of an appropriate extreme tide level for the site. As part of the DCFPP (Dublin Coastal Flooding Protection Project) an extreme tidal analysis was carried out and the resulting extreme tide levels determined for Dublin Port are presented in Table 4.2 below. As part of the DCFPP study a tidal hydrodynamic model was used to investigate both the astronomic and extreme tide levels at a number of locations in Dublin Bay and north of Howth. The model confirmed that whilst there is some variation in levels, this is not significant within Dublin Bay and as such the extreme tide level presented in Table 4.2 have be used for design purposes within this study. Values presented for 2100 include an allowance of 4.15mm/yr as discussed in section 4.1.2.

**Table 4-2: Extreme Tide Levels**

Return Period (Years)	Dublin Port	
	Present Day (mODM)	Climate Change 2100 (mODM)
1	2.27	2.67
2	2.35	2.75
5	2.48	2.88
10	2.61	3.01
20	2.75	3.15
50	2.91	3.31
100	3.03	3.43
200	3.13	3.53
500	3.24	3.64

*Higher 1.28m surge occurred in the past.*

*Return periods for extreme tide levels are as tabulated.  
Note that tide with "5 year return period" has 20% probability of occurring in any one year; similarly tide with "20 year return period" has 5% probability of occurring in any one year etc.*

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**Waves**

The study frontage is located on the southern side of Dublin Bay between Dun Laoghaire Harbour and Sandycove Point. Waves can enter Dublin Bay from the Irish Sea generally from the direction sector east of north to south (0 to 180°). The severity of waves at the study frontage will depend on the offshore direction and magnitude of the waves. For the purpose of this study information collected as part of the DCFPP and the results of the analysis of waves from that study has been used together with some additional modelling work to assess the wave climate at the site for the initial development of concepts.

This previous work indicates that the largest and most frequent waves within the Irish Sea off Dublin Bay come from a southerly direction. However, for these waves to enter Dublin Bay they must turn through 90 degrees and then further still to reach the study frontage which is located on the southern side. As such the shallow water process of diffraction, as the site is also located in the lee of both Sorrento Point and Sandycove Point. This subsequently results in a much reduced wave height at the site for the predominant offshore wave direction.

**The critical offshore wave direction for the study frontage is from a north easterly direction.** Waves from this direction are less affected by the processes of refraction and diffraction as they enter the bay and approach the outer southern frontage of Dublin Bay relatively unaltered by these processes. Personnel from DLRCC have confirmed that north easterly gales produce the worst conditions at the site.

Modelling work undertaken for the DCFPP using the 2D wave transformation model SWAN has also confirmed this. The results for similar wave conditions from three different offshore directions, north east, east and south east, are shown in Figures 4.5 to 4.7. As can be seen from the plot titles, all runs are for an offshore wave climate with a 1 year return period. The largest offshore waves are from the south east (5m) with the smallest from the east (3m). However, at the study frontage it can be seen that the largest nearshore waves occur for the northeast offshore wave direction, see Figure 4.5.

*(LMC highlighting)  
Critical direction producing largest waves at region of Dun Laoghaire Baths is likely to be north east*

*Computer modelling study done for 2005 DCFPP – results illustrated in Figure 4.5 - confirms largest waves in Scotsman's Bay shore area come from the north east.*

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..... As such further wave modelling runs for wave conditions from a north easterly direction were undertaken for the study using the SWAN model in order to determine appropriate design waves with which to develop feasible concepts. The additional runs undertaken are shown in the Table 4.3 below.

**Table 4 -3 Additional SWAN Wave Model Runs from North East Direction**

Condition	Offshore Direction	Water level (mODM)	Wave height Hs (m)	Wave Period (s)	Wind speed (m/s)
1	30	1.59	3.58	6.9	18.2
2	30	2.27	3.58	6.9	18.2
3	30	3.13	3.58	6.9	18.2
4	30	2.27	5.87	8.5	27.6
5	30	3.5	3.58	6.9	18.2

Note: Condition 1 - 1 year wave & MHWS

Condition 2 - 1 year wave & 1 year water level

Condition 3 - 1 year wave & 200 year water level

Condition 4 - 50 year wave & 200 year water level

Condition 5 - 1 year wave & 200 year water level with sea level rise to 2100

Nearshore wave conditions were obtained at the points shown in Figure 4.8

*Additional computer modelling was carried out specific to Scotsman's Bay for Haskoning 2008 study*

*One example:*

*For 1 return period wave and 1 year return period water level – ie quite frequently likely conditions – offshore wave height of 3.58 is predicted*

*(A return period of 1 year means that that event eg water level or wave height could be expected to be exceeded once a year)*

*Points D,J and Q in Figure 4.8 are close in location to the Baths site.*



**Table 4-4 Nearshore Wave Heights within Scotsman's Bay**

Nearshore Output Point	Wave and Water Level Condition									
	1		2		3		4		5	
	Hs(m)	Dir(°)	Hs(m)	Dir(°)	Hs(m)	Dir(°)	Hs(m)	Dir(°)	Hs(m)	Dir(°)
<b>D</b>	2.44	59	2.49	59	2.52	59	3.52	62	2.53	59
<b>E</b>	2.05	56	2.19	56	2.32	56	2.91	58	2.37	56
<b>G</b>	1.98	38	2.05	38	2.11	39	2.91	42	2.13	40
<b>H</b>	1.93	39	2.03	38	2.09	38	2.75	43	2.11	39
<b>J</b>	2.51	60	2.53	60	2.56	60	3.73	62	2.57	60
<b>L</b>	2.19	49	2.24	50	2.3	51	3.38	51	2.32	51
<b>O</b>	2.25	51	2.29	51	2.32	51	3.4	52	2.33	51
<b>Q</b>	2.38	62	2.4	62	2.43	62	3.7	63	2.44	62

Hs – Significant wave height (average height of the highest 1/3 of the waves in a given storm).

**As can be seen from the above results waves in excess of 3-3.5m can occur at the site for an extreme north easterly storm, see condition 4.** These wave heights, whilst only occurring on a very extreme event, are significant and are extremely important in respect of the design of any future scheme both from a coast protection and health and safety perspective. **Even for more moderate conditions which could be expected to occur on average once a year (condition 1) it can be seen that waves in excess of 2m can occur**

*Points D,J and Q are toward the west of Scotsman's Bay, close in location to the Baths site.*

*(LMC highlighting)*

The fact that these relatively large waves can occur at the site is a function of the relatively deep water conditions which exist along this frontage close to the shore and particularly so at the western side of Scotsman's Bay along the East Pier. The admiralty charts of the area show bed level as low as -5 to 7.5mODM over much of the frontage at a distance of 150 to 250m from the shore. These values have been verified by the bathmetric survey completed for this study, see results presented in Appendix B.

The output points D, J and Q are located at the western side of the bay and G and H on the eastern side, see Figure 4. As can be seen from the results in the table above, the wave heights at the western side are generally higher than those at the eastern side. This is a function of the fact that the waves are more affected by refraction and diffraction as they move into the eastern side of Scotsman's Bay from offshore.

The above waves are located approximately 100 to 200m from the coastline and hence will reduce slightly as they approach the coast line. However, it should be noted that an earlier study<sup>1</sup> carried out for this frontage transferred wave to within 50 metres of the existing sea wall using a 1 dimensional model and concluded that waves of between 2 to 3m could impact on the sea wall which is consistent with the results presented here. Furthermore the concepts presented in section 5 present two schemes which contain a new promenade and structures that project to varying degrees further offshore. **As such the larger waves presented in Table 4.4 above will be representative of the design conditions required.**

It should be noted that the wave modelling work for this study was carried out prior to the completion of the hydrographic survey. As such it contains old seabed bathymetry. For the next stage of the project, preliminary design, it is recommended that the existing model is updated to include both the new bathymetric and topographic survey data. The nearshore wave conditions should then be investigated further to finalise design parameters and assess the concepts further from the point of view of viability, safety and design.

*The relevant points closest to the Dun Laoghaire Baths are D,J,Q*

*Predicted wave heights at the western side of Scotsman's Bay are generally higher than at the east.*

*(LMC highlighting)*

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**Seismic Results**

The results of the seismic survey are presented in Appendix B and show that rock is located very close to the surface over the whole frontage for a distance of between 200 to 300m offshore. Beyond this limit the rock head begins to fall away and overburden values of between 1 to 10 metres are noted within the limit of the survey. The depth of overburden generally increases with distance offshore.

The results are reassuring in the context of conformation of a solid foundation layer over the nearshore on which the proposed structures can be founded. However, it does also present a picture of a high level hard coastline which is scoured of fine sediment during stormy conditions.

**4.1.5 Geotechnical Issues**

Geotechnical investigations in the form of trial holes or boreholes have not been undertaken as part of this stage of the project. However, the site inspections and results from the hydrographic survey provide a good insight into the conditions likely to be encountered across the site. High rocky outcrops are visible over much of the frontage and the results of the seismic survey confirm that this rock head is positioned relatively close to the seabed over a distance of some 300m from the coastline.

**As such it would appear that a good foundation layer exists onto which new sea wall and breakwater structures can be placed.** This information is sufficient to remove a certain level of risk associated with the design of these structures. However, the information should be verified and the quality of the rock tested through the completion of a number of boreholes and cores. This work could be undertaken at the preliminary design and/or the detailed design stage.

*Near the shore, where the proposed pier is located, rock is close to the surface.*

*This will provide a solid foundation.*

*(LMC highlighting)*

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In addition to this the rest of the frontage, until Sandycove Harbour, will be enhanced through the creation of a major new promenade and amenity features. Along the frontage accessibility will be improved by the implementation of new upper and lower walkways with plaza and viewing areas. Several access points to the water would be created through the use of steps and a number of recreational activities would be provided such as a playground, aquatic play area, gardens etc.

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The existing lower walkway presently lies at a level which is similar to that of a MHWS tide. As such it is frequently overtopped by wave action and occasionally submerged at high tide. This has resulted in progressive damage and deterioration with much broken and spalled concrete in places. **Furthermore the frequent wetting of the lower walkway encourages the growth of algae on the walkway in some locations which can render it dangerous for use as a public footpath. In this scheme the new lower walkway would be constructed at a higher level of +3.5mODM to ensure that it is accessible for most of the year and to remove the risk of algae growth, see Figure 5.2.6. Nevertheless during more extreme conditions the lower walkway would be subject to wave overtopping and as such may need to be closed to public access at several times throughout the year. This is likely to occur only on north easterly gales. This issue is discussed later in section 5.2.3. As part of the preliminary design stage a more detailed percentage of time throughout the year that the lower walkway could be closed. This information can be used to optimise the design of the lower walkway.**

*(Existing Newtownsmith walkway is at 1.79m ODM)*

*(LMC highlighting)*

*Note implications for Interim Baths Scheme - retained existing baths deck is at +2.0 ODM approx, and new pier is to be at +3.0 ODM*

<p>PAGE 33</p> <p>The frontage from the baths to the end of Newtownsmith to the east would be protected from erosion and damage by rock armour at the front of the lower walkway. The rock armour will be broken into sections, as shown in Figure 5.2.1, and only included where wave impacts and overtopping are likely to be an issue. At some of these breaks, steps will lead down from the lower walkway to the waters edge.</p>	<p><i>Haskoning proposed rock armour protection for the +3.5m ODM walkway across the bay frontage. Corollary is that rock armour would be required for Interim Scheme pier at +3.0m ODM</i></p>
<p>PAGE 37</p> <p><b>5.2.3 Engineering Issues</b></p> <p>A series of technical section have been developed for concept A at the same location as the landscape sections. These provide details on the type of construction proposed at this stage of the study. These sections are found in Figures 5.2.9 to 5.2.13 and are inserted at the end of this section of the report.</p> <p><b><u>Coastal Protection &amp; Flood Defence</u></b></p> <p>Whilst the main objectives for the study are to consider how the frontage can be enhanced to improve the amenity, cultural and recreational appeal of the area, an additional objective which is equally important is to cater for improved coast protection and flood defence needs. The frontage can be subjected to very extreme conditions at times and indeed the investigations undertaken to date for this study have confirmed that very extreme waves could exist at the site during north easterly gales.</p> <p>The issue of coast protection is perhaps the more important of the two issues and the existing coastal promenade and defence structures have been subjected to ongoing damage and erosion over the years. Figure 5.8 shows an example of the damage which is occurring. Flood risk is less of an issue primarily due to the fact that the ground levels along the frontage are much higher than the sea level.</p>	

**However, localised flooding due to wave overtopping is certainly a risk and indeed wave overtopping of the upper walkway has been known to happen.**

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The issue of coast protection and flood defence have both been incorporated into the development of Concept A. Where possible improved amenity and coast protection or flood defence form an integral part of the overall facilities proposed. For example the creation of a lagoon in the area between the baths and the east pier requires the construction of a new breakwater which in itself also provided much improved coast protection to this area. Similarly the provision of a new lower walkway which is placed at a higher level and is much wider than the existing one not only improved the amenity value of the area during normal conditions but provides a good buffer zone for wave overtopping to be collected during storm events. This in itself introduces other issues which need to be considered such as the need to close the lower walkway during storm events and this is discussed later under health and safety.

Given the exposed nature of the frontage during storm conditions, the abrasive damage noted to the existing seawall as a result of shingle and wave action (see Figure 5.3) and the proposed design like of 100 years, the use of rock armour has been considered to provide enhanced long term coast protection needs at the site. As can be seen from Figure 5.1 & 5.2.1 the rock armour is not continuous over the full frontage. Gaps are left where access to the water is proposed and also at locations of lower vulnerability. The rock armour has been sized to cope with the design waves identified through the modelling work and two sizes are proposed.

The first is required for the new Newtownsmith promenade frontage where between 3.5 to 7 tonne rock is required. The rock would be placed with a crest level of 3.5m OMD which is the same level as the proposed lower walkway. The crest should be a minimum of three rocks in width and rock would be placed at a slope of 1 in 2.5, see Figures 5.2.10 to 5.2.12. The outer armour layer would consist of two layers and be placed on a core of smaller but filter stable rock relative to the armour layer. This would remove the need for placing geotextile which is not considered necessary given the rocky nature of the foreshore.

*Haskoning anticipate the need to close the lower walkway (level +3.5m ODM) during storm events By inference this will also be required for the infilled pools deck area and the new pier in the Baths Interim Scheme.*

*Need for rock armour noted*

*3.5 to 7 tonne rock armour appropriate for "Newtownsmith frontage" and lower walkway. Geotextile underlay not required for buildup specified, two layers of rock armour on core of smaller filter stable rock.*

The lower walkway has been placed at a level of 3.5mOD and is a minimum of 10 metres wide. This level has been chosen to ensure that the walkway will not be subjected to overtopping too frequently throughout the year. However, during more extreme conditions it will be overtopped significantly and will not be functional as a recreational facility, see Figure 5.2.11. On these occasions it will act as a buffer zone within which wave overtopping will collect. An overtopping assessment for the design conditions presented in Table 4.3 and 4.4 have shown that in addition to this wide lower walkway a wall will be required along the interface between the lower and upper walkways. The wall would be placed to a minimum level of +5.75mOD to ensure extensive flooding of the upper walkway and hinterland did not occur.

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Construction of the lower walkway will need to be of a robust nature. Whilst the rock armour in front of the walkway will encourage waves to break, during very high tides when the tide level is close to the crest level of the rock, waves may break directly onto the lower walkway. For this reason it is proposed that the lower walkway should be constructed of fibre reinforced concrete and consists of a slab not less than of 0.5m thick.

*References to anticipated occurrence of overtopping will apply to Interim Scheme area where pools are to be infilled, and the new pier.*

*Fibre reinforced concrete has beneficial properties for concrete exposed to waves etc*

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**Health & Safety**

Within any scheme there are a wide range of health and safety issues which need to be addressed. This includes design issues and the use of the principles of prevention through to onsite construction issues. The design health and safety issues can affect both the workers during the construction period and also the users of the finished product.

Whilst at this stage it is not proposed to carry out a detailed health and safety risk assessment a number of safety issues are discussed for further consideration at later stages. These relate specifically to the public safety of the finished structures and in particular the risk of overtopping to the lower walkway and lagoon breakwater during storm events.

As discussed in section 4 the frontage can be subjected to very severe wave conditions particularly during north easterly storms. During such storms the tide levels are also usually elevated and if this coincides with a spring tide condition waves at the site of between 2 to 3 metres could be experienced.

As discussed earlier the lower walkway has been designed to act as a buffer zone during such conditions when it is expected to be heavily overtopped. Furthermore our initial overtopping assessment for the **lagoon breakwater would suggest that it too will be severely overtopped during these storm events based on the proposed crest level of +6mODM for the upper walkway.** The crest level has been placed at this level as it is similar to that of the east pier and it helps to maximise the views across the bay from the top plaza area proposed at the back of the Beach Gardens which is around +9mODM.

*Some matters noted in this section will need to be the subject of consideration by the PSDP for the Interim Baths Scheme in his / her duties, and also to be the subject of detailed designer risk assessments*

*(LMC highlighting)*

*If level 6.0 ODM is at risk in these conditions, then wave splash if not overtopping could affect the lowest basement Studio workshop where the new walkway level is 5.86 and floor level ?5.73m ODM*



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Whilst it is noted that these are extreme conditions with return periods in excess of 200 years, they can nevertheless occur and should a member of the public access the breakwater during such a condition, there is a considerable risk that they could be washed off. **As such it should be recognised that both the lower walkway and the upper walkway on the lagoon breakwater would need to be closed to public access during these storm conditions. On order to safely ensure this the council would need to operate a monitoring programme and suitable closure barriers incorporated into the design which can be erected or closed at short notice.** For the lower walkway these barriers would double up as a flood defence at access gaps in the back wall to prevent flooding of the upper walkway.

It should also be noted that rock armour poses a health and safety hazard as people climb across it for access, seating or fun. Rock armour can also collect debris and provide a refuge for rodents.

A tool which is currently in operation by Dublin City Council and Fingal Council, and which was developed by Royal Haskoning, is the existing tidal flood forecasting system for Dublin Bay. At present no warning points have been set up for Dun Laoghaire Rathdown Coastal frontage. However it would be relatively straightforward to develop a series of transfer matrices for the Scotsman's Bay frontage which could be incorporated into the system in the future to provide forecasts of extreme tide level, wave heights and even overtopping volumes which on exceeding a particular threshold could initial (*sic*) an operational response by the council to close the lower walkway and breakwater to the public.

The issue will need to be assessed further as part of the preliminary design stage in terms of the likely frequency of such closures and the safety risk. The results may indicate that even with closure as an option it may be prudent to place a wall along the seaward side of the upper walkway on the breakwater to reduce overtopping and the risks associated with it.

*A return period of 200 years corresponds to a probability of 0.5% that the event referenced will happen in any given year.*

*(LMC highlighting)*

**EXTRACTS ONLY** FROM TABLE 5-1 PAGES 49 & 50**Table 5-1 General Risk Assessment for Concept Options**

(Possible) Risks	Measures to address issues	Phase in which it will be addressed (more detailed)		
		Feasibility Study	Preliminary Design	Detailed Design
Damage to used materials, i.e. insufficient robustness of used materials	Use only concrete or rock in most vulnerable areas	X	X	X
Overtopping of lower walkways	Raise level of walkways Protect with Armour	X	X	X
Algae growth (slippery) lower walkways	Raise level of walkways Protect with Armour Use no-slip or algae resistant materials	X	X	X
Flood risk - insufficient accuracy on overtopping volumes	Modelling of wave overtopping using more accurate wave climate and bathymetric information		X	X
Flood risk of lower walkways	Raise level of walkways Protect walkways with a flood wall Close walkway during storm conditions	X	X	X
<b>Health &amp; Safety</b>				
Breakwater - People washed off breakwater	Close access to structure during storm conditions Raise level of structure Place armour protection to reduce wave energy/impact Optimise breakwater design through detailed wave climate modelling Put up signs	X	X	X

*Some matters noted in this section will need to be the subject of consideration by the PSDP for the Interim Baths Scheme in his / her duties, and also to be the subject of detailed risk assessments*

Lower Walkway - slipping off walkway into water or onto rocks	Reduce slipperiness by avoiding algae growth (see Coastal Issues) Put up signs	X	X	X	
Lower Walkway - people climbing onto rocks	Design access steps onto foreshore Put up signs Put up fence		X	X	
People falling from steps	Provide adequate hand railings Design steps with sufficient going and width and not too much rising	X	X	X	