Reference	Name	Date of Loss	Place of Loss	Description
W00962	25/03/1933	Unknown	Howth Harbour	Large fishing vessel sank at its moorings during a storm
W00963	25/03/1933	Unknown	Howth Harbour	Small fishing vessel sank at its moorings during a storm

Table 1: Historic Shipwreck Inventory, Howth Harbour, recorded shipwreck events

There are only two entries in the Historic Shipwreck Inventory of confirmed wrecksite locations at Howth Harbour and both of these occur outside the Harbour to its northeast and east (Table 2, Figure 9). The Irish National Seabed Survey identified one location in its multi-beam surveys across the sound outside the harbour; wrecksite (W0966) is an anomaly measuring 35m long, 7m wide and standing 1m off the seabed and is indicative of a shipwreck. It lies 0.5 miles northeast of the harbour entrance. W09587 was identified by the UK Hydrographic Office and is believed to the site of the *Dieter* (W09587), which is a recent loss (1989) and lies some 300m east of the East Pier lighthouse (Figure 9). Both locations lie outside the proposed development area.[6]

Reference	Name	Date of Loss	Location (ITM)	Description
W00966	Unknown	Unknown	729454E 740101N	Possible wreck identified during National Seabed Survey (INSS wreck G140), measuring 35m long, 7m wide and standing 1m off the seabed. 0.5mile NE of Harbour entrance
W09587		*Dieter*	728898E 739912N	Lost in 1989

Table 2: Historic Shipwreck Inventory, Howth Harbour, known shipwreck locations

3.5 National Inventory of Archaeological Heritage

There are nine sites of architectural heritage interest directly associated with the Harbour and these are protected structures (Table 3, Figure 9). There are also sites that are located close to the harbour but outside it (Figure 9).

Registration	ITM E	ITM N	Site type
11359034	728579	739874	Howth Harbour Lighthouse
11359035	728397	739745	The Water Club, clubhouse
11359036	728383	739724	Howth Harbour, Building misc.

[6] The *Dieter* is located at ITM 728898E 739912N.

Registration	ITM E	ITM N	Site type
11359037	728370	739703	Howth Harbour, Boathouse
11359038	728325	739646	Mariner's Hall, Church
11359039	728311	739622	Howth Harbour, House
11359040	728170	739506	Howth Harbour
11359041	728763	739669	Howth Harbour
11359044	728376	739714	Howth Harbour, Boathouse

Table 3: National Inventory of Architectural Heritage sites at Howth Harbour

The nineteenth-century pier walls are protected structures, as are the nineteenth-century buildings that survive on the West Pier. As described above, it is likely that the East Pier absorbs the footprint of the pre-existing eighteenth-century structure, while the West Pier was built anew in the early 1800s.

3.6 Fingal County Development Plan

The Fingal County Development Plan 2017–2023 identifies the East Pier as a High Amenity area, and the West Pier as a General Employment Area. It also recognises the following sites as Protected Structures:

RPS	Site type	NIAH
560	Mariner's Hall, Church	11359038
562	Howth Harbour, Boathouse	11359037
563	Howth Harbour, Building misc.	11359036
564	The Water Club, clubhouse	11359035
565	Howth Harbour Lighthouse	11359034
595a	Howth Harbour, East Pier excluding 20th-century additions	11359041
595b	Howth Harbour, West Pier excluding 20th-century additions	11359041
937	Former warehouse	11359039

Table 4: Fingal County Record of Protected Structures (RPS) entries for Howth Harbour, with correspondence to NIAH

4.0 Geotechnical investigations

Site investigations were conducted in December 2019, to inform the engineering design for the Howth FHC project, and the logs were presented to ADCO to ascertain the nature of the buried

stratigraphy at the locations investigated. The Site Investigations work is presented in Appendix 2 of the project EIAR.

A series of two cable percussion boreholes were bored to a depth of 2.2m and 2.7m below ground level on the seabed to the west of the West Pier. In addition, three rotary boreholes were bored to a depth of 7.9m below ground level in the same area. The results indicate surface levels of sand that extend to depths in the order of –5.34m, overlying boulder clay till that reaches to –6.64m and overlies limestone bedrock.

A series of environmental samples were collected more widely across the harbour basin, revealing covering marine sands and silts only.

5.0 Marine geophysical survey

Marine geophysical survey was carried out by Hydrographic Surveys Ltd in 2020, working under archaeological licence 20R0027 (see EIAR Appendix 10.1). The work comprised magnetometry and side-scan sonar survey within the harbour basin and across the proposed reclamation area to the west of the West Pier. The survey was robust and comprehensive, with survey lines closely-spaced together to ensure multiple viewing of the same area of seabed from different angles (Figures 10–11).

The magnetometry survey recorded a series of targets within the harbour basin that are the internal navigation buoys and are not of archaeological interest. The side-scan sonar survey, in conjunction with the magnetometer survey recorded a series of targets in the area west of the West Pier and these were subsequently inspected by diving. The side-scan sonar survey also recorded the active moorings for pleasure craft within the Mooring Basin, as well as the line of quay walls of the East Pier and the within which the moorings lie (Plate 1).

6.0 Underwater inspection

Underwater archaeological inspection took place on 18 June 2020 and focused on the proposed reclamation area off the West Pier. The dive area extended beyond the footprint for the reclamation. Diver-towed survey across the sea area permitted a comprehensive visual inspection of the sea floor. The work included dive inspection of the four target locations identified in the marine geophysical survey report, and the observations are recorded in Table 4 (Figure 12, Plates 2–3).

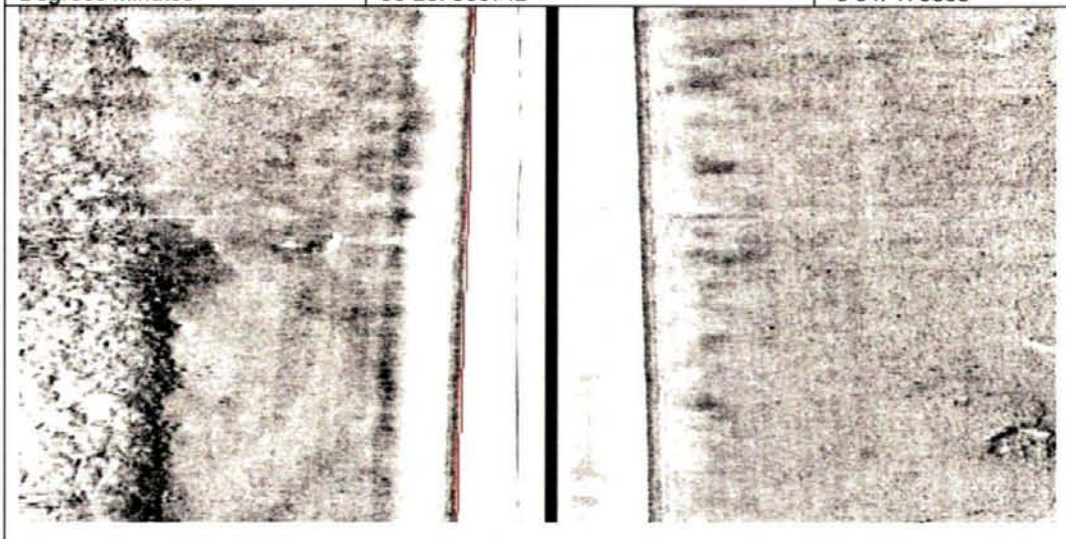
Full access was possible, the sea state was calm and while a sea fog developed through the day, visibility was good. No constraints were encountered.

The observations confirm the surface levels of marine sand and silts recorded in the GI works.

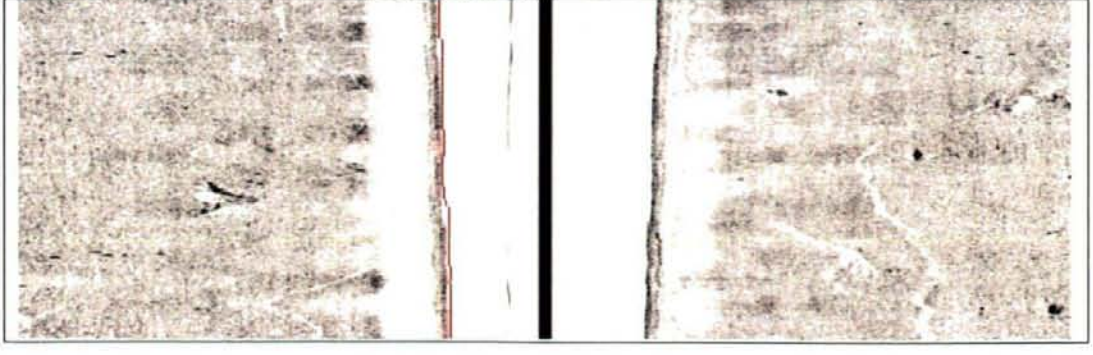
No features of archaeological interest were observed on the seabed, and one of the targets, DT_03, was confirmed to be a large upstanding metal object that is modern in origin.

A more accurate position was taken of DT_03 and it is recorded as Target 01. It is a composite steel piece that appears to be counter-weights of a steel crane, perhaps placed there as a temporary mooring. It is outside the proposed footprint for the reclamation area and will remain exposed on the seabed. It should be considered a navigation hazard and be removed.

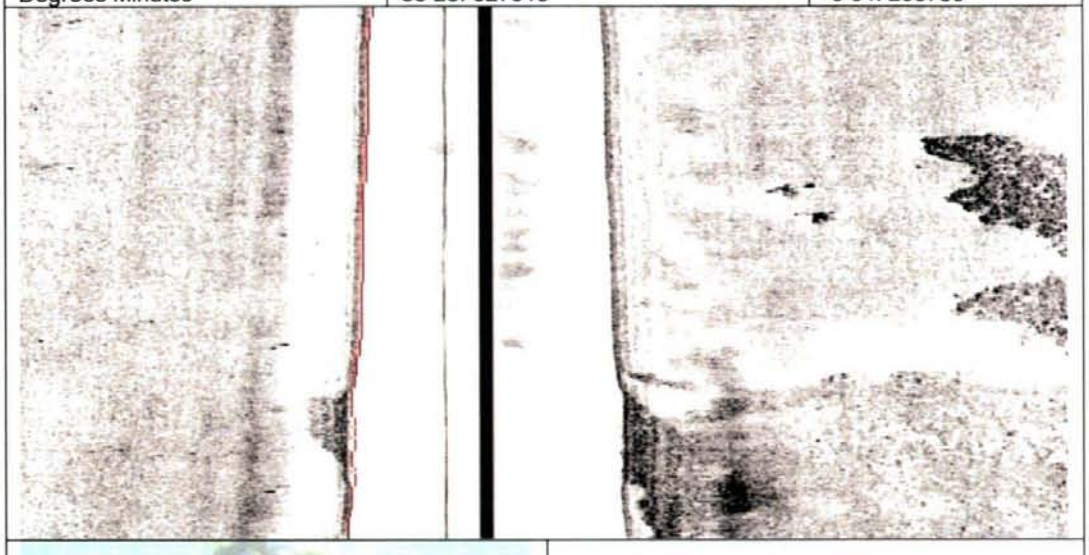
Reference	**Geophysical survey interpretation**	**Dive description**
DT_01, next to W pier base	Target off foot of rock armour	Collapse from rock armour
ITM	728388e	739811n
Lat/Long Deg Min Sec	53° 23' 34.184543"	-6° 04' 10.788311"
Decimal Degrees	53.392829	-6.069663
Degrees Minutes	53 23. 569742	-6 04. 179805

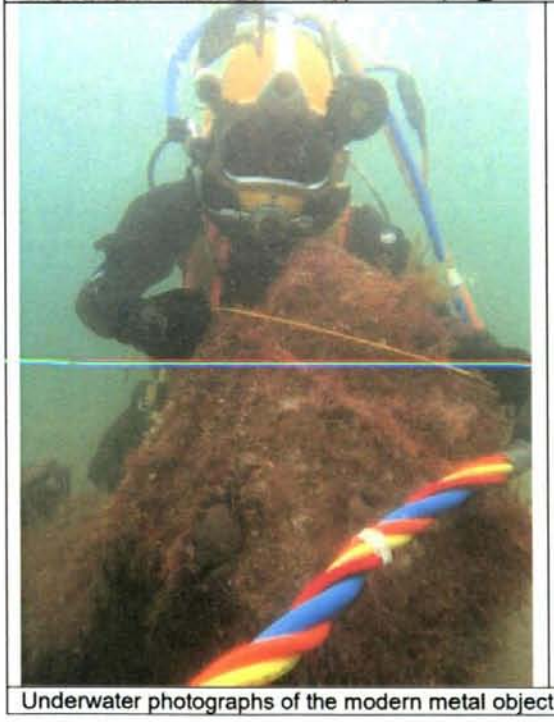


Reference	**Geophysical survey interpretation**	**Dive description**
DT_02	Single target	Boulder
ITM	728351e	739864n
Lat/Long Deg Min Sec	53° 23' 35.930626"	-6° 04' 12.712206"
Decimal Degrees	53.393314	-6.070198
Degrees Minutes	53 23. 598844	-6 04. 211870



Reference	Geophysical survey interpretation	Dive description
DT_03 with Mag target	Two targets close together	Counterweights, navigation hazard
ITM	728353e	739918n
Lat/Long Deg Min Sec	53° 23' 37.674929"	-6° 04' 12.525008"
Decimal Degrees	53. 393799	-6.070146
Degrees Minutes	53 23. 627915	-6 04. 208750





Underwater photographs of the modern metal object at DT_03/Target 1.

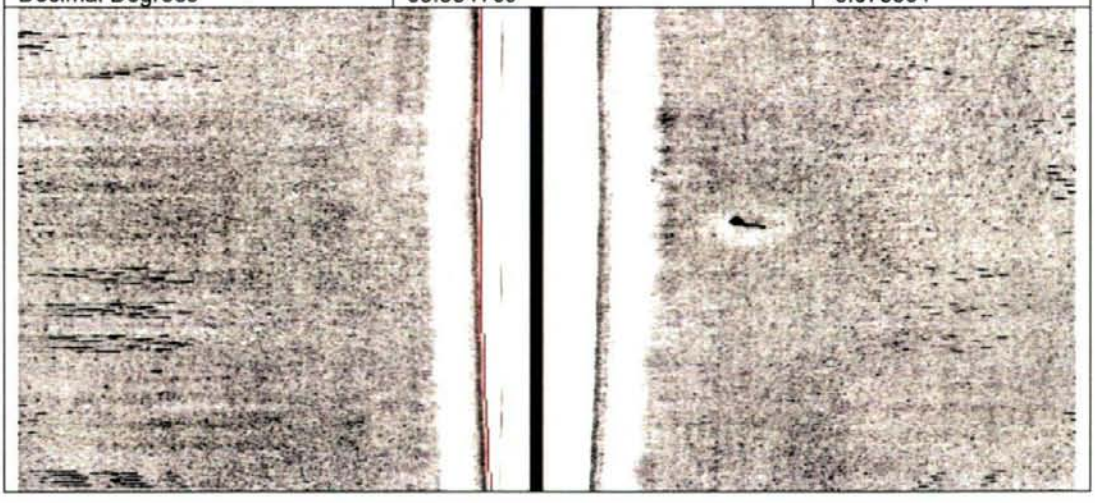
Reference	Geophysical survey interpretation	Dive description
DT_04 with Mag target	Single target	Nothing present on seabed
ITM	728130e	739686n
Lat/Long Deg Min Sec	53° 23' 30.368221"	-6° 04' 24.926883"
Decimal Degrees	53.391769	-6.073591
		

Table 5: Marine geophysical survey targets inspected.

6.0 Intertidal inspection

The opportunity was taken to consider the glacis of the West Pier, which is to be buried as part of the reclamation area. The southern section is already covered in rock armour protection, which also serves to create a new surface level.

The West Pier remains the commercial side of the harbour that it has been since the nineteenth century. The active quayside is improved to accommodate the modern fishing vessels (Plate 4). The surface area is split between a service zone for the vessels and a commercial zone to the west for the general public's access to the commercial buildings and car-parking (Plate 5). While the buildings that line the west side of the pier include examples from the nineteenth century, many have been heavily adapted in more recent times and there are also modern structures (Plates 6–9).

The nineteenth-century quayside is visible at the pier head, at both the 'landing place' and the terminus roundel. The rectangular-shaped 'landing place' retains its elegant façade that is exposed at Low Water (Plates 10–15). The separation between the original stonework and the quay's improvements is clearly visible at the access steps, while the more functional rock-armoured addition to the east makes no attempt to be concealed. The landing place retains a granite cobbled surface, along with the carved footprint of where King George IV is remembered as landing in 1821 (Plates 16–17).

The terminus roundel of the pier lies to the north. It is surfaced with similar granite cobbling to that of the landing place and it has a wave barrier that is constructed in the same manner as that on the East Pier, comprising a series of five courses of stepped granite ashlar rising above the deck level, and forming a curved shape in plan (Plates 18–20). The barrier retains a confidently executed external rolled moulding on the deck level course (Plates 21–23). As viewed from the sea, the cut stonework below the rolled moulding appears to have slightly wider proportions to those above, which may suggest a difference in construction stages between the two. The terminus is recorded on the OS First Edition map of *c.* 1840 but the detail is less defined than it is recorded on the 25-inch map of *c.* 1911; this might indicate that the terminus was developed into its present state over time (compare Figure 6A and 6B). It would explain the non-uniform nature of the integration of the terminus with the pier, which is seen on the west side of the pier where the lines of stonework are not smooth (Plate 24). Rock armour has been placed around the terminus in more recent times, which masks the original base of the pier head.

The 1840 OS map records two buildings close of the pier head, one of which was the Custom House (Figure 6A). Both buildings were located on the west side of West Pier, and the map records a 'parapet' running between and either side of each building, from the terminus roundel to the shoreline. On the 1911 OS map, the parapet is not named, while a series of other buildings had been built along the western side of the West Pier (Figure 6B). The Custom House had changed function to be the Coastguard Station, and a Lifeboat House was located to its south.

Today the situation is different again. There are fewer buildings at the north end of the pier, where several buildings recorded in 1840 and 1911 have been removed (compare Figure 6 based on the 1911 map with Figures 8 and 9). There has also been reclamation of the southern half of the pier, where the original western edge of the West Pier is buried.

While many of the buildings that occupy the West Pier today retain stonework and gable-ended frontages that no doubt continue the nineteenth-century building tradition, there are only six upstanding buildings that are registered on the NIAH (Figure 9) and are protected structures. Two of these are located in the southern area where the rear-side of the premises has been reclaimed (NIAH 11359039 is a two-storeyed house (Plate 5) and NIAH 11359038, 'Mariner's Hall, is a former chapel (Plate 6)). The remaining four buildings lie to the north and their rear-sides open onto the glacis, or parapet, that forms the western edge of the West Pier. They lie next to each other and comprise, from south to north, NIAH 11359037, a single-bay gable-fronted boat house built *c.* 1870 as the Coastguard boathouse (Plate 25); 1359044, a single bay boathouse with an elegant granite ashlar façade built *c.* 1870 (Plate 7); 1359036, a two-bay two-storeyed building constructed *c.* 1870 (Plate 8); and 1359035, the 'Clubhouse', a detached five-bay two-storeyed building constructed *c.* 1880 as the Harbour Master's house (Plate 9).

The north end of the Clubhouse has been transformed into a restaurant (Plate 26), while the open space that lies to its north was populated with buildings in 1840 and 1911 that have since been removed. A modern functional structure opposite the 'Landing Place' serves as an outlet

for a Scuba-diving store, while the 1911 map records a series of small buildings to the north of this location again. There is a structure standing on only one of these locations today, while the presence of buttresses against the other standing walls suggest the lines of the former buildings (Plate 27). The standing structure is square in plan in contrast to the rectangular-planned buildings that were recorded in 1911. The building is flat-roofed and constructed with concrete blocks (Plate 28). It stands on top of a pedestalled foundation of poured concrete that continues to the foreshore. The building has a south-facing doorway and a window in each of the other three walls, suggesting its use as an observation post. It may well have been built to serve as a coastal defence structure during the Emergency (1939–1945).

The rear (west-facing) of the West Pier has not been considered previously from a cultural heritage perspective, with the exception of the NIAH entry for the former coastguard boathouse (NIAH 11359037), which records the presence of a 'granite slip way to [its] rear'. There are in fact a number of features worth recording along the glacis.

Type	Location	ITM Easting	ITM Northing
Observation building	Pier head	728449	739818
Retaining wall	Close to pier head	728431	739800
Retaining wall with outfall culverts	Opposite 'Landing Area	728409	739775
Retaining wall	Rear of Clubhouse	728386	739742
Steps	Rear of clubhouse	728380	739735
Slipway	Rear of NIAH	728378	739728
Slipway	Rear of Coastguard boathouse, NIAH 11359037	728362	739709

Table 6: Features recorded on the rear of the West Pier

The glacis itself is well constructed. Recorded on the 1911 OS map as a 'parapet', the glacis is constructed using irregularly-shaped granite blocks that are laid together to form a regular sloping surface that extends below the Low Water Mark (Plates 29–32). The toe of the glacis is not exposed as is buried under a tumble of rock armour that appears to have been in place for some time.

The walling that stands proud of the glacis reveals some of the narrative of the buildings that no longer stand on the pier. A length of granite walling lies to the south of the concrete observation building and inside of which the scuba-diving store is located (Plate 33). The wall retains a height of ashlared-granite cornerstones at either end. The historic OS maps do not indicate that buildings stood inside this walled area, and there are no obvious construction lines exposed in the walling as viewed from the sea. It suggests that the wall served as a length of retaining wall only.

The next length of walling is different (Plates 34–35). The walling is stepped out onto the glacis slightly further. It is constructed using better stonework, and while both its corners are also built using ashlared granite, there is a series of six lintelled culverts grouped into three clusters of two culverts each that are located more or less equidistant along its base. The culverts are blocked-up using stone. There are also two significant expanses of breaches in the wall that have been repaired, along with several smaller repairs. The wall length corresponds with the rear of properties recorded on the 1840 and the 1911 OS maps, which indicate a terrace of six buildings. The historic photograph included as Figure 7B shows the terrace as a row of two-storeyed houses (Figure 7B). The number of culverts corresponds to that of the houses and are clearly associated with them. The culverts presumably served as the foul-water egress from each house.

A stone-lined doorway separates the end of this terrace from the rear of the Clubhouse, NIAH 1359035, the former Custom House (Plate 36). There is a range of different features built into the rear wall that careful recording should unravel. A flight of stone steps leads down across the glacis at the south end of the Clubhouse (Plates 37–39). The alignment of the steps is slightly curved.

The glacis then drops in level where it is merged against a slipway (Plates 40–42). The slipway is recorded as two parallel lines on the 1911 OS map and is associated with the rear of NIAH building 11359036, which is recorded on the 1840 map as an unnamed building beside the Custom House. The slipway is stone-built and raised somewhat above the glacis. It retains two light rail lines that run along its length and would have facilitated the hauling of vessels along it. The rear of the building has a wide entrance that would have served to house a boat. A recent decking feature has been added across the rear of the building, at a time when the function of the slipway had ceased.

The glacis is then built up higher again to the south, where is extends fully across the rear of the boathouse NIAH 1359044 (Plate 43). In contrast to its elegant granite façade that faces the harbour, the rear of the building is constructed using rougher stone, although it does retain granite coping at its roof level. The rear wall has two blocked-up openings at either end, maintaining a sense of the building's symmetry but there is no central opening that would have released a boat into the sea. The high level of the glacis in this instance suggests that it might have been built over such an opening and that this element of the glacis is a later addition. The manner in which the elevated glacis is also built over some of the rear of NIAH 1359036 supports this view.

To the south again, there is a second slipway and it is associated with the former coastguard boathouse, NIAH 11359037 (Plates 44–46). The rear wall of the boathouse accommodates a well-constructed stone doorway that supports a wide timber door and which fills most of the width of the building. Though in poor repair, the structure retains its primary construction elements. The slipway is stone-built. The flagstones are exposed on its north side while the

south side has a skim of concrete covering the stone. A central channel runs down the slope of the slipway and would have taken the vessel's keel and helped direct the movement of a boat from the boathouse into the sea and back again. A stone bollard at the top of the slipway on its north side would have served as a mooring post.

From this point on as one progresses south, modern reclamation has taken place and has buried any further elements of the nineteenth-century glacis (Plates 47–50). The rear of some of the buildings that are located along this section retain certain historic elements and would repay further recording and detailing. The curved corner, for instance, of the third building to the south of the coastguard boathouse is an historic feature indicative of a feature to facilitate wheeled vehicle access (Plate 51).

7.0 Impact assessment

7.1 Dredging

The dredging of the harbour basin represents a direct and permanent impact on the harbour silts. However, this area was substantially dredged in the 1980s after the harbour was dewatered in 1979 to facilitate those works. It is unlikely that archaeologically significant material will be present in those areas that were dredged previously. It remains possible that archaeological material is *in situ* in areas and depths that were not dredged previously, and archaeological monitoring should be conducted of such areas to ensure that any cultural heritage material that may be retained in those deposits is recovered.

7.2 Reclamation

The reclamation of the seabed area to the west of the West Pier is not to include active dredging but will require the deposition of dredged spoils from the basin onto the seabed and the glacis of the West Pier. There is no indication of *in situ* wreck sites on the seabed.

However, the exposed length of glacis poses an archaeological constraint. The West Pier (NIAH 11359041) is a protected structure, and the glacis forms part of it. The slipway associated with the coastguard boathouse is also mentioned as being part of that protected structure (NIAH 11359037).

The proposed development seeks to bury the remaining exposed part of the glacis (Figure 2). The work will also include certain realignment of the boundary walls to the rear of the buildings along the West Pier, namely:

- The Pier head roundel and the observation building will remain as they are, while the sea area to their west will be reclaimed for use as natural and managed amenity areas, and the boundary with the sea will be protected by rock armour. Additional rock armour will also be placed beneath the roundel. These works represent a direct and permanent

impact on an area where the historic built structure will remain in place. Care should be taken to record fully the current built environment prior to such works proceeding. The new rock armour placement at the roundel should ensure to leave the granite ashlar exposed.

- The boundary wall associated with the former terrace of houses recorded on the 1840 and 1911 maps will be removed and the space transformed to include an access roadway, footpath and a managed amenity area. The proposed works represent a direct negative and permanent impact on an area of historic walling that requires proper archaeological recording. It also presents an opportunity for archaeological excavation of the open space to the east of the standing wall where such work might expose the foundations of the former terrace of houses.
- The area to the west of protected structures NIAH 1359035 (Clubhouse), 1359036 (building), 1359044 (boathouse) and 1359037 (coastguard boathouse) will be redeveloped to include a strip of hard-standing, footpaths, a roadway and parking, that will in turn lead to an area of managed amenity, a new slipway at the reclaimed shoreline and rock armour. The proposed works represent a direct negative and permanent impact on the historic glacis and the features recorded on it, including the steps, that run across the glacis at the south end of the Clubhouse; the slipway at the rear of the building 1359036, and the slipway noted as part of the coastguard boathouse. The features will need to be fully recorded archaeologically, and consideration should be given to absorbing elements of their plan in the new surfaces that might record the location of the features buried underneath the reclaimed area.
- Additional reclamation of the area to the south will ensure an integration of the new works with the area already reclaimed. There is unlikely to be an archaeological constraint in this area because the land has been reclaimed already, but the opportunity should be taken to record the rear of the buildings on the West Pier that populate this area.

8.0 Recommendations

8.1 Pre-construction phase recommendations

A detailed archaeological survey will be completed of the glacis of the West Pier that will extend from the glacis toe to the rear of the buildings that populate the West Pier. The survey will ensure to include the glacis, retaining walls, steps and the two historic slipways and their details that are built into the glacis. The survey will be to a high standard, capable of producing metrically accurate plan, section and profile drawings that capture the detail. If a laser-scan is to be deployed to achieve this, the work will meet the standards required for large building surveys and will produce modelled space and cloud-point data that is accessible and interpretable to non-specialist end-users.

The recommendation for detailed survey is in keeping with Fingal County Council's policy objective that is committed to the protection and conservation of buildings, areas, structures, sites and features of archaeological, architectural, historical and related interest.[7]

8.2 Construction phase recommendations

Archaeological monitoring licensed by the Department of Housing, Local Government and Heritage through the National Monuments Service will be conducted of all terrestrial, inter-tidal/foreshore and seabed disturbances associated with the development, with the proviso to resolve fully any archaeological material observed at that point.

The level of monitoring of the dredging operation within the harbour basin should be limited to those areas and depths not achieved in the 1980's construction campaign.

Archaeological excavation is anticipated in relation to the removal of the retaining wall on West Pier that marks the rear-side boundary of the terrace of six houses recorded on the 1840 and 1911 OS maps as it is a location of archaeological potential.

A suitable barrier membrane should be laid down to separate the *in situ* remains of the West Pier glacis from the reclaimed deposits to be laid above. This will help to ensure that the historic elements are preserved *in situ*. A conservation engineer should be consulted to ensure that this element proceeds in accordance with best practice.

8.3 Archaeological management recommendations

The following archaeological monitoring and management measures will be undertaken:

- Retaining a project archaeologist/s. An archaeologist experienced in maritime archaeology will be retained by the Department of Agriculture, Food and the Marine for the duration of the relevant works.
- Retaining a conservation engineer. A conservation engineer experienced in industrial and maritime architectural heritage will be retained by the Department of Agriculture, Food and the Marine for the duration of the relevant works, to advise specifically in relation to works associated with the West Pier.
- Archaeological licences will be required to conduct the on-site archaeological works. Licence applications require the inclusion of detailed method statements, which outline the rationale for the works, and the means by which the works will be resolved. Licence applications take a minimum of four weeks to process through the Department of Housing, Local Government and Heritage, and advance planning is required to ensure that the necessary permits are in place before site works commence. It is anticipated

[7] Fingal Development Plan, 2017–2023, pp 346–357.

that the following licence types will be required: Excavation, to cover monitoring and investigations works; Detection, to cover the use of metal-detectors; and Dive Survey, to cover the possibility of having to conduct underwater inspections. Since 2017, Excavation licence applications must be accompanied by a letter from the client on their letterhead 'confirming that sufficient funds and other facilities are available to the archaeologist to complete the archaeological excavation, post-excavation, and preliminary and final reports (including specialist reports)'. The Department of Agriculture, Food and the Marine has confirmed that sufficient funds and other facilities as required will be made available to the project archaeologist to complete all reports required.

- Archaeological monitoring will be carried out by suitably qualified and experienced maritime archaeological personnel licensed by the Department of Housing, Local Government and Heritage. Archaeological monitoring is conducted during all terrestrial, inter-tidal/foreshore and seabed disturbances associated with the development. The level of monitoring of the dredging operation within the harbour basin should be limited to those areas and depths not achieved in the 1980s construction campaign. Archaeological monitoring will be undertaken in a safe working environment that will facilitate archaeological observation and the retrieval of objects that may be observed and that require consideration during the course of the works. The monitoring will include a finds retrieval strategy that is in compliance with the requirements of the National Museum of Ireland.
- The time scale for the construction phase will be made available to the archaeologist, with information on where and when ground disturbances will take place.
- Discovery of archaeological material. In the event of archaeologically significant features or material being uncovered during the construction phase, machine work will cease in the immediate area to allow the archaeologist/s to inspect any such material.
- Archaeological material. Once the presence of archaeologically significant material is established, full archaeological recording of such material will be recommended. If it is not possible for the construction works to avoid the material, full excavation will be recommended. The extent and duration of excavation will be a matter for discussion between the client and the licensing authorities.
- Archaeological team. It is recommended that the core of a suitable archaeological team be on standby to deal with any such rescue excavation. This would be complimented in the event of a full excavation.
- Archaeological dive team. It is recommended that an archaeological dive team is retained on standby for the duration of any in-water disturbance works on the basis of a twenty-four or forty-eight hour call-out response schedule, to deal with any

archaeologically significant/potential material that is identified in the course of the seabed disturbance activities.

- A site office and facilities will be provided by Department of Agriculture, Food and the Marine on site for use by archaeologists.
- Secure wet storage facilities will be provided on site by the Department of Agriculture, Food and the Marine to facilitate the temporary storage of artefacts that may be recorded during the course of the site work.
- Buoying/fencing of any such areas of discovery will be necessary if discovered and during excavation.
- Machinery traffic during construction will be restricted to avoid any identified archaeological site/s and their environs.
- Spoil will not be dumped on any of the selected sites or their environs.
- Post-construction project report and archive. It is a condition of archaeological licensing that a detailed project report is lodged with the DHLGH within 12 months of completion of site works. The report should be to publication standard and should include a full account, suitably illustrated, of all archaeological features, finds and stratigraphy, along with a discussion and specialist reports. Artefacts recovered during the works need to meet the requirements of the National Museum of Ireland.

These measures are subject to the approval of the National Monuments Service at the Department of Housing, Local Government and Heritage. The Department of Agriculture, Food and the Marine has and will continue to engage with the Department of Housing, Local Government and Heritage.

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10.0 Acknowledgements

Thanks are extended to John Farragher and Harbour Master Harold McLoughlign of the DAFM for facilitating access, along with Pat Parle, Olivia Holmes and Graeme Thornton of Malachy Walsh and Partners. Boat support was provided by the INSS. The ADCO team on site included the report author, Rex Bangerter, Brian Macallister (dive Supervisor), Sam Macallister (Coxswain), Feargal Morrissey and Daniel Merida.

Figure 1: OS Map showing location of Howth Harbour.

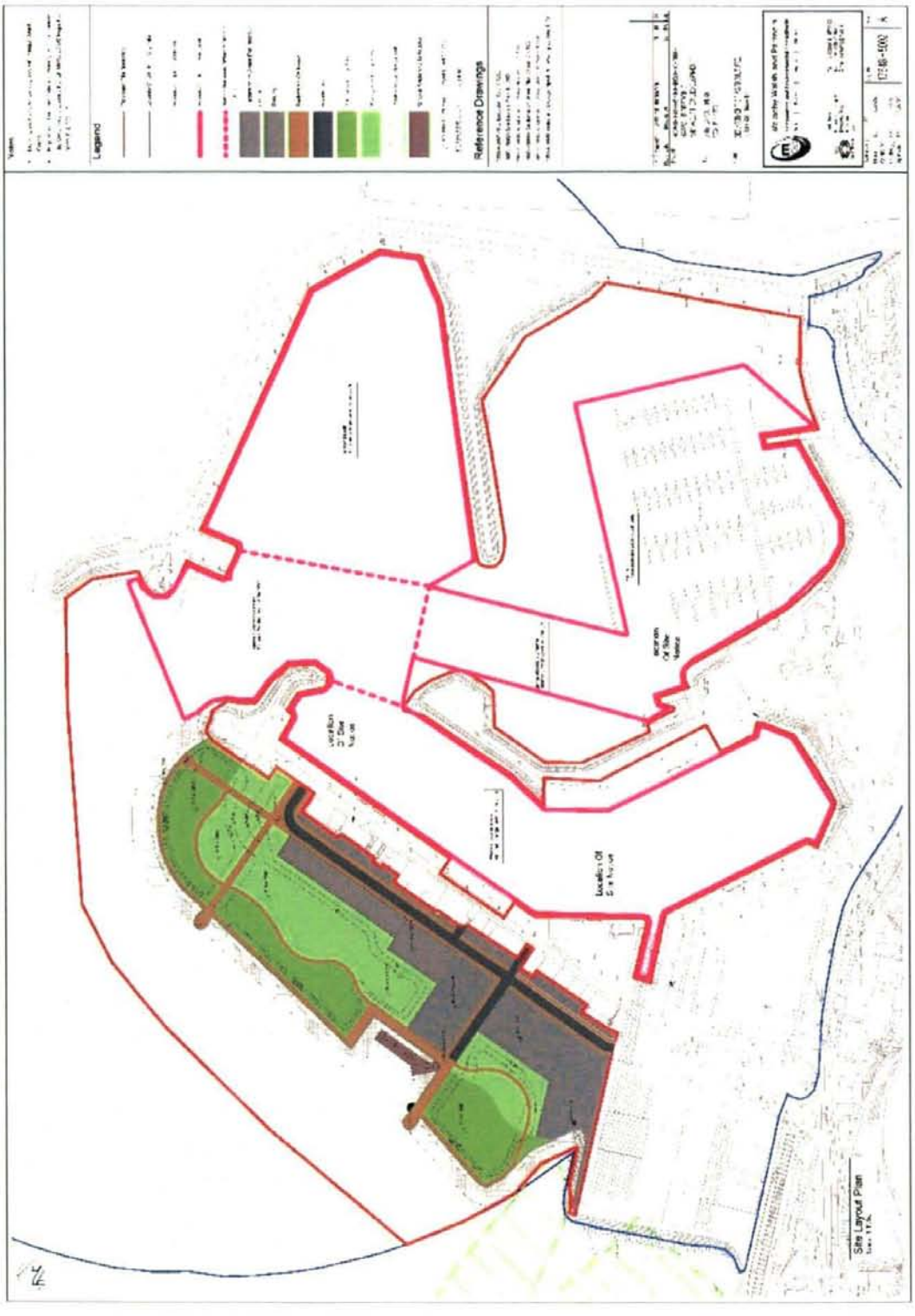


Figure 2: Project Drawing showing proposed development along the West Pier.

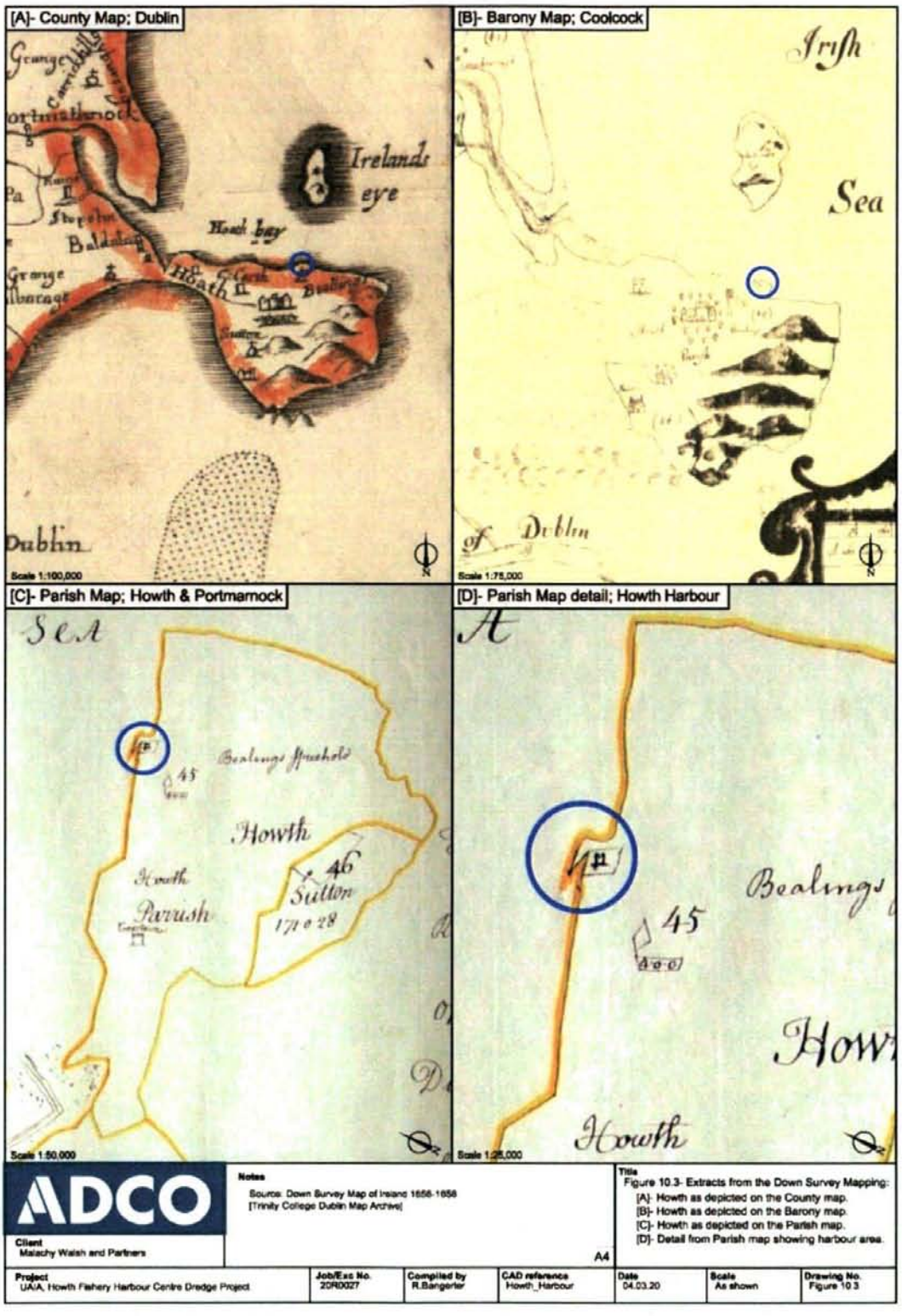


Figure 3: Extracts from the Down Survey mapping of Howth.

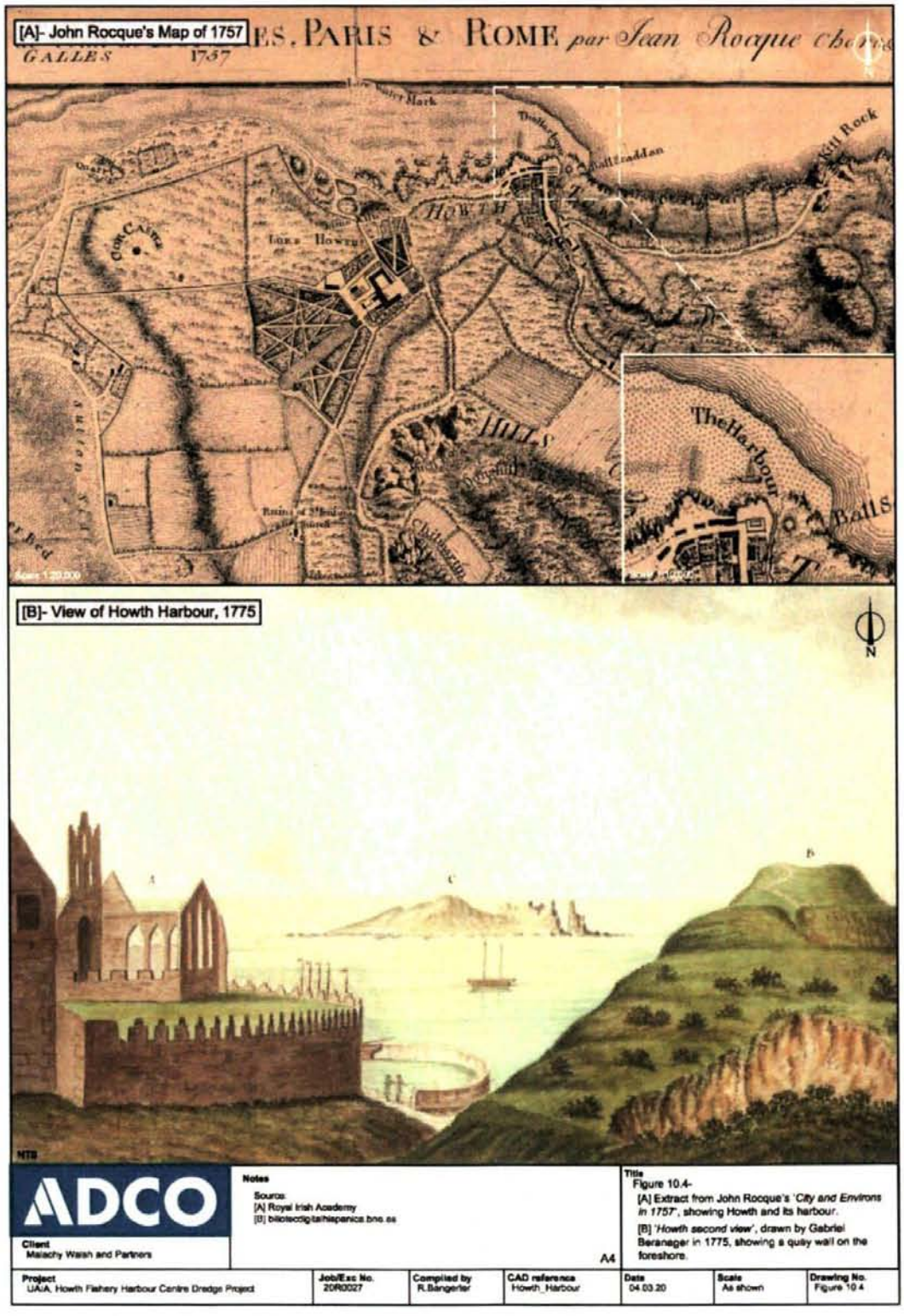


Figure 4: Extracts from eighteenth-century illuminations showing Howth harbour.

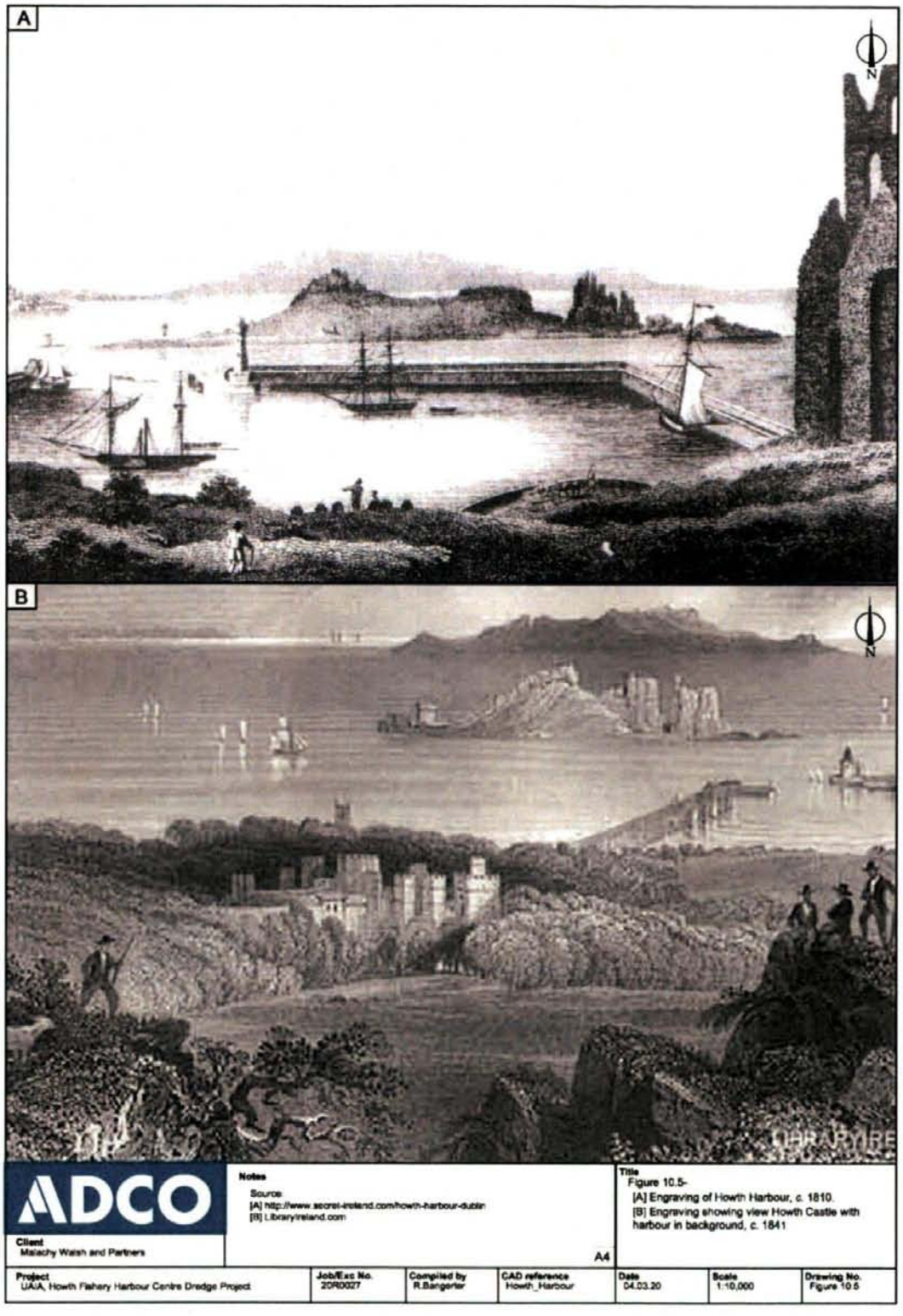
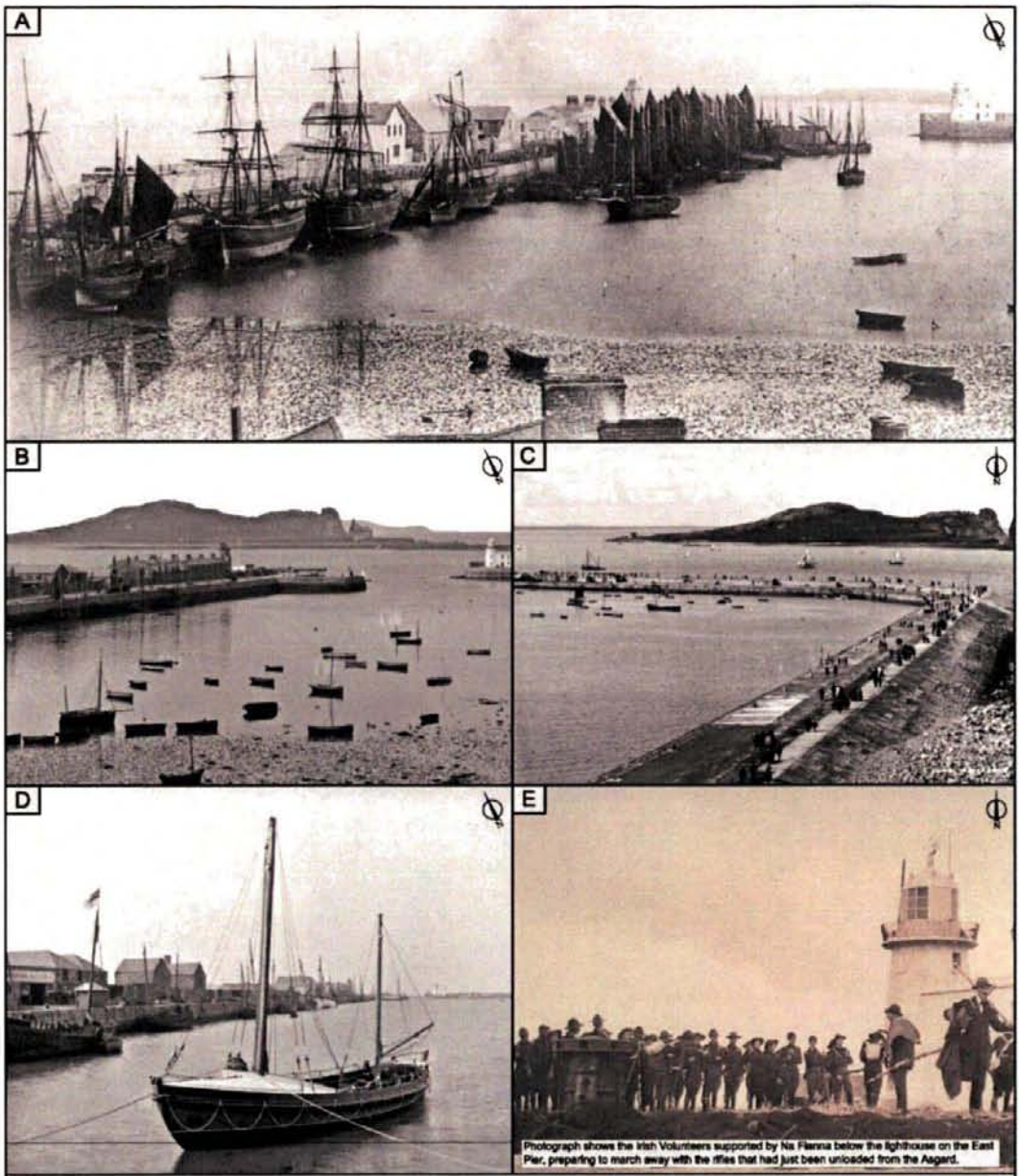


Figure 5: Extracts from nineteenth-century illuminations of Howth Harbour.

Figure 6: Extracts from historic Ordnance Survey maps showing Howth Harbour c. 1840 and c. 1911.



[A]- Historic News Print of Howth Harbour, entitled '*Boomtime for Howth as Fishing Port in 1860*'.
[B]- Historic Photograph of the West Pier, *c.* 1880-1900
[C]- Historic Photograph of the Est Pier, *c.* 1865-1914
[D]- Historic Photograph of the west side of Howth Harbour, *c.* 1865-1914
[E]- Historic Photograph showing the '*Howth gun-running*' episode in Howth Harbour, July 1914.

ADCO

Client: Malachy Walsh and Partners

Notes:
Source:
Image A, https://www.pinterest.co.uk/pin/355854808030843134
Images B-D, National Library of Ireland [Lawrence Photographic Collection]
Image E, National Museum of Ireland

A4

Title: Figure 10.7- Collection of historic photographs of Howth Harbour, dating from 1860-1914.

Project	Job/Exc No.	Compiled by	CAD reference	Date	Scale	Drawing No.
UAIA, Howth Fishery Harbour Centre Dredge Project	20R0027	R.Bangerter	Howth_Harbour	04.03.20	NTS	Figure 10.7

Figure 7: Collection of historic photographs of Howth Harbour, 1860–1914.

Figure 8: Orthoimagery of Howth Harbour with twentieth-century reclamation works highlighted.

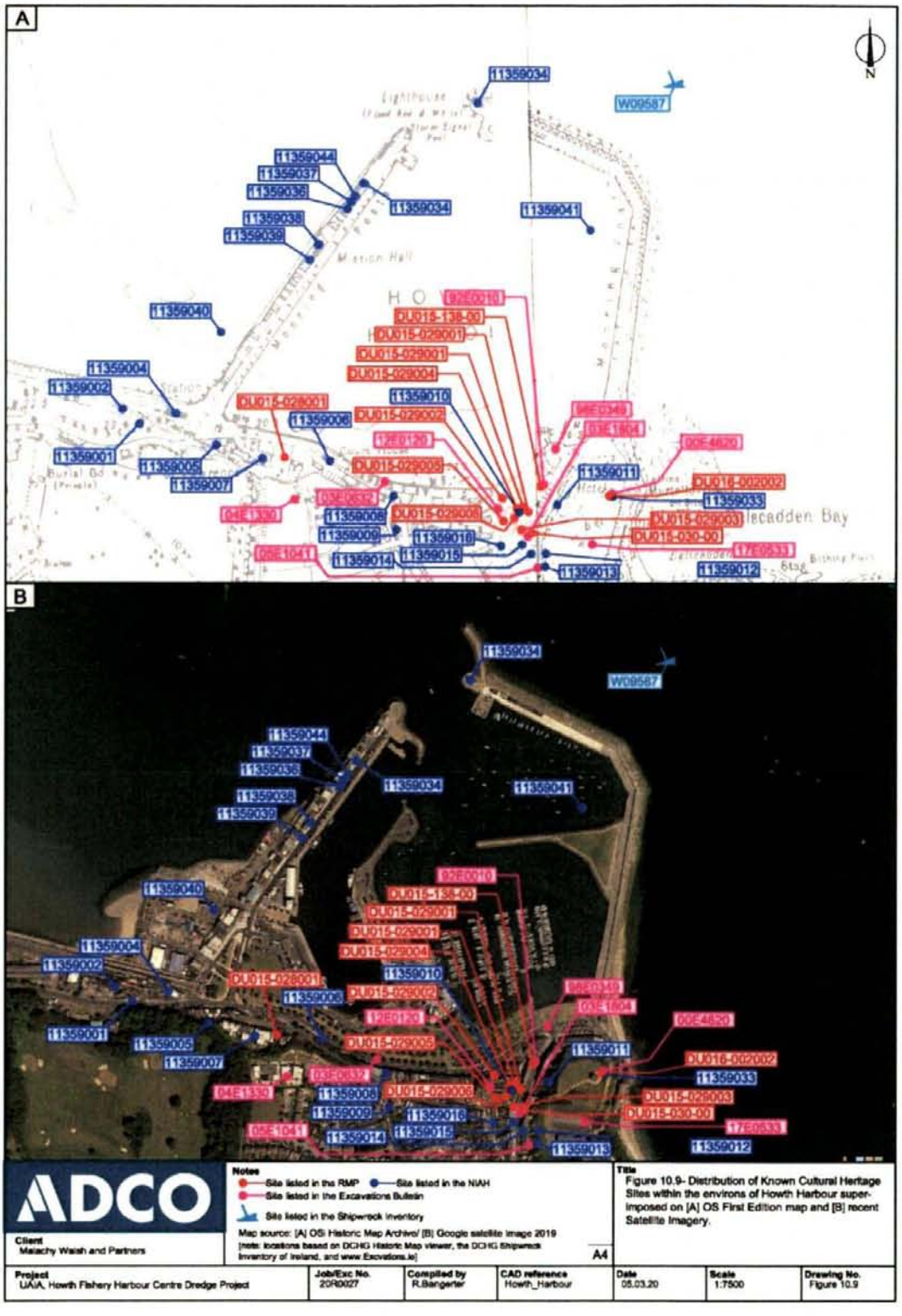


Figure 9: Distribution of known cultural heritage sites within the environs of Howth Harbour.

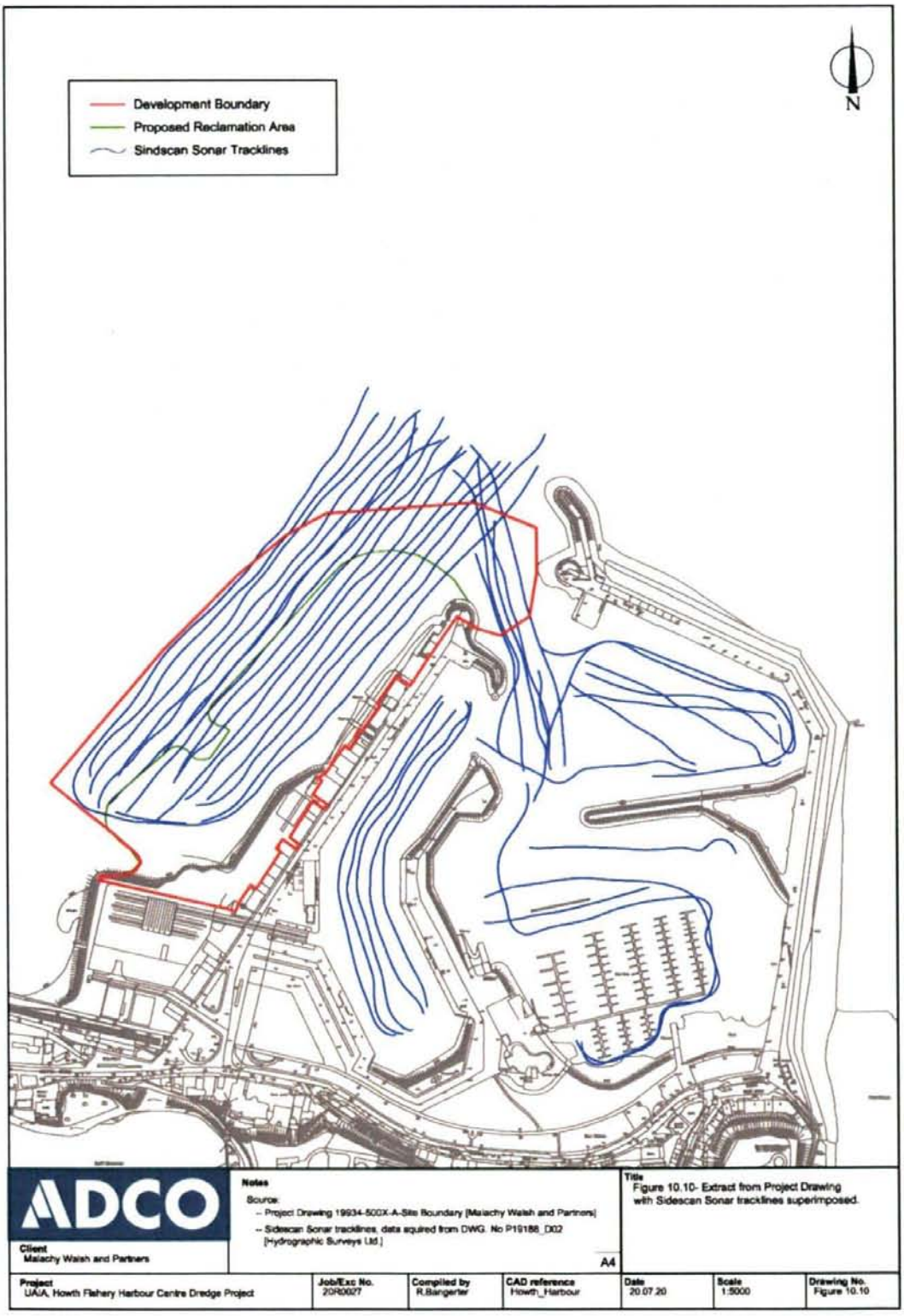


Figure 10: Extract from Project Drawing showing side-scan sonar survey tracklines.

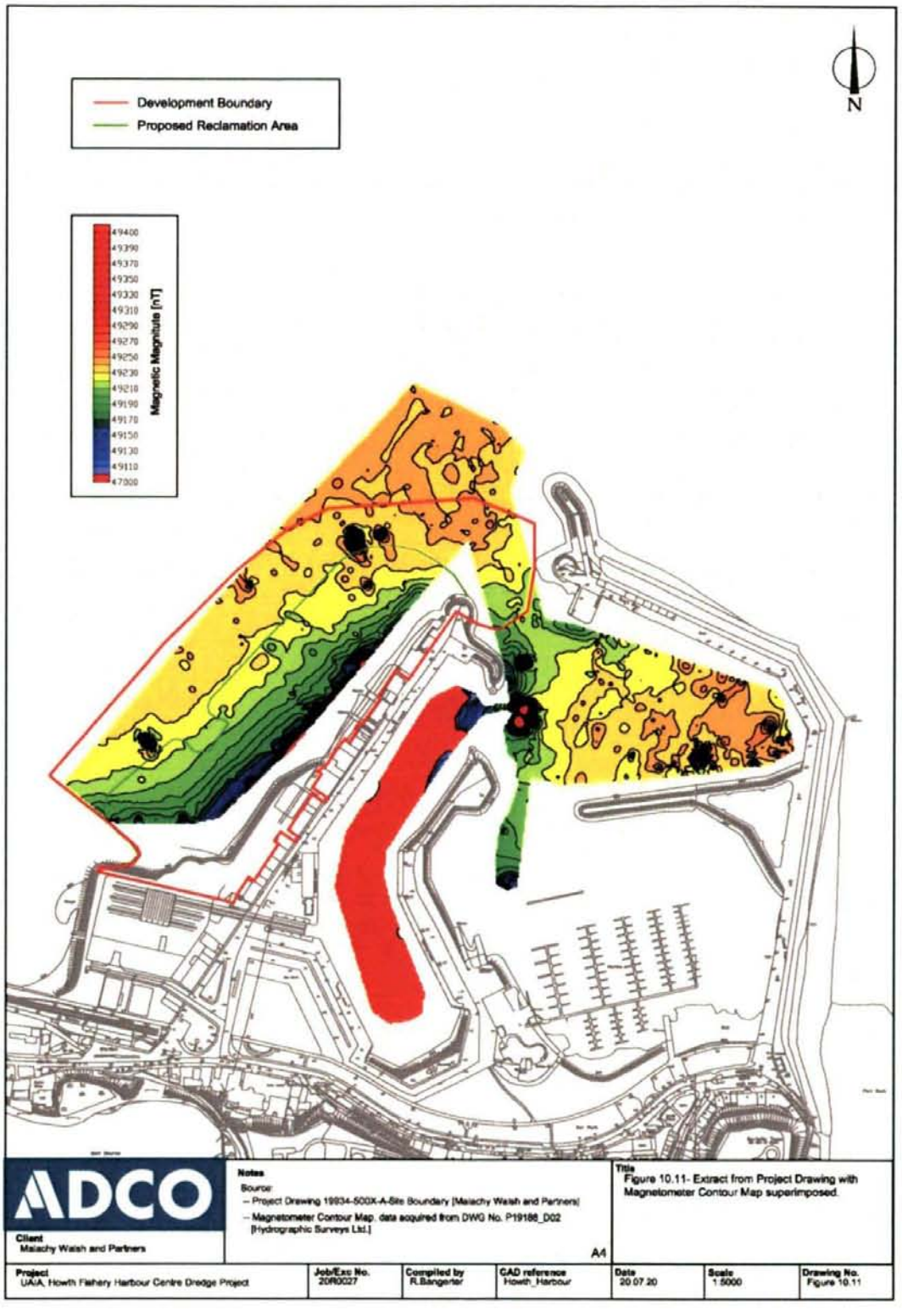


Figure 11: Extract from Project Drawing showing magnetometer contour map.

Figure 12: Extract from Project Drawing showing ADCO Underwater Survey Area, Marine Geophysical Survey dive targets, and side-scan sonar mosaic.

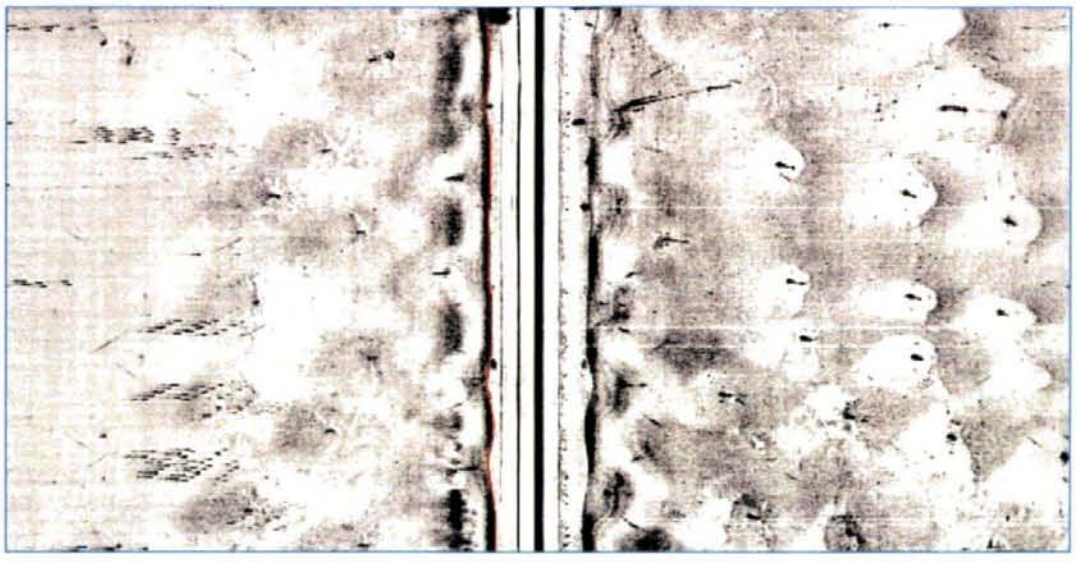


Plate 1: Side-scan sonar image showing moorings in the Mooring Basin. Survey Line 1143.

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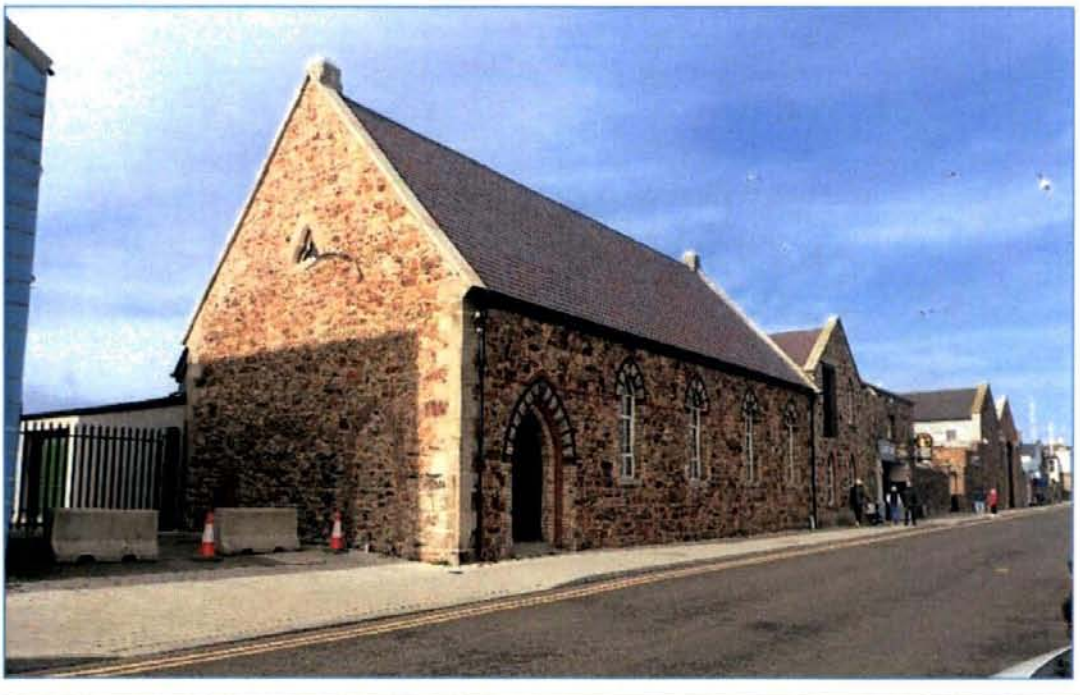

Plate 6: View of the former chapel, the 'Mariner's Hall', NIAH 11359038.

Plate 7: View of the elegant entrance to boathouse NIAH 11359044, with building NIAH 11359036 to the right (North).

Plate 7: Plate 7: View of the elegant entrance to boathouse NIAH 11359044, with building NIAH 11359036 to the right.

Plate 9: View of the former Harbour Master's building, NIAH 1139035.

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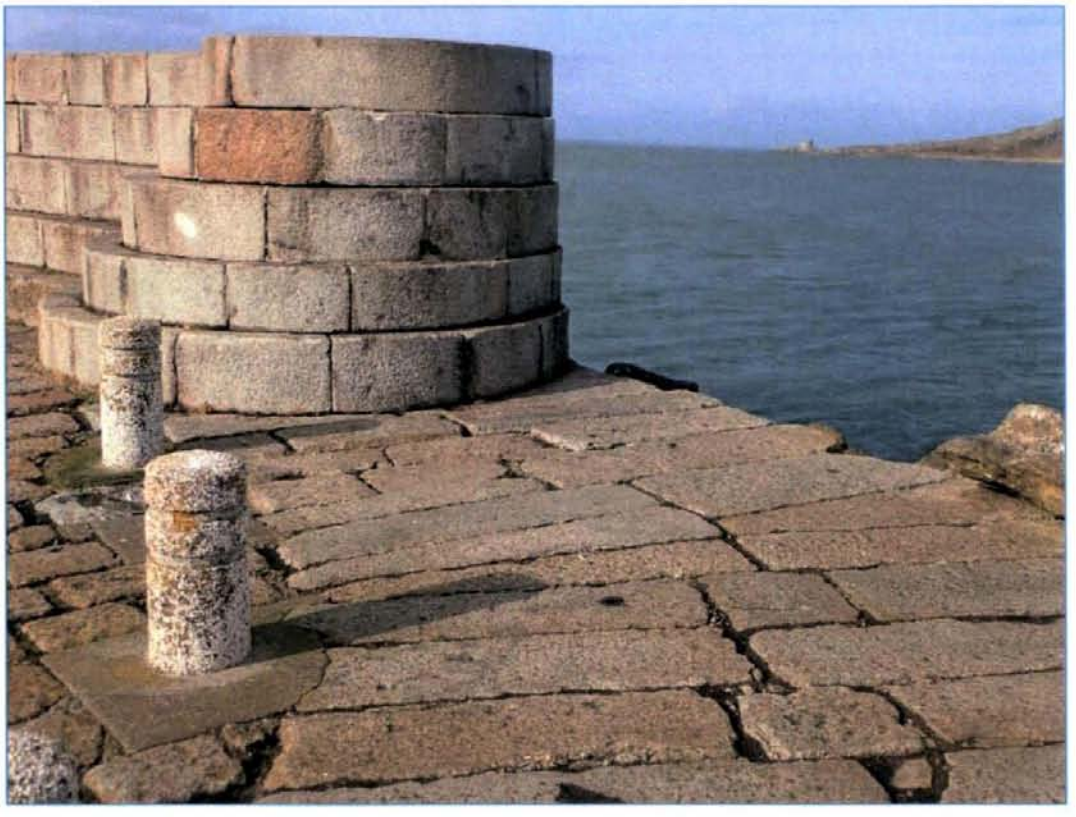

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Plate 20: View looking South from top of wave barrier on West Pier roundel.

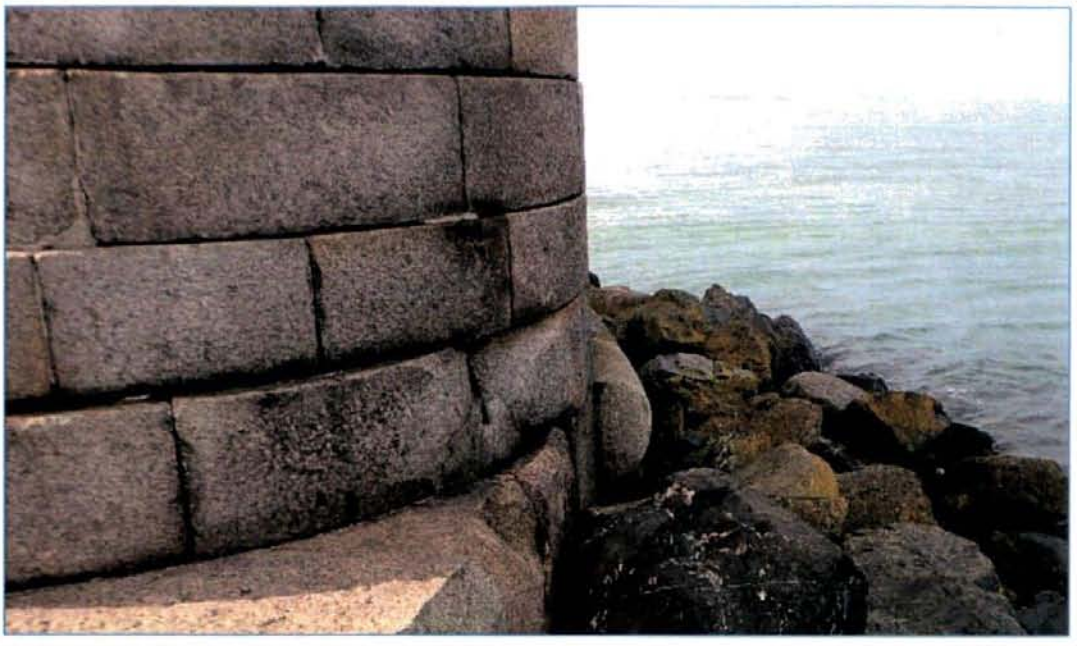


Plate 21: View focussed on rolled moulding at external base of West Pier roundel.

Plate 22: View from above looking down on rolled moulding on exterior of West Pier roundel.

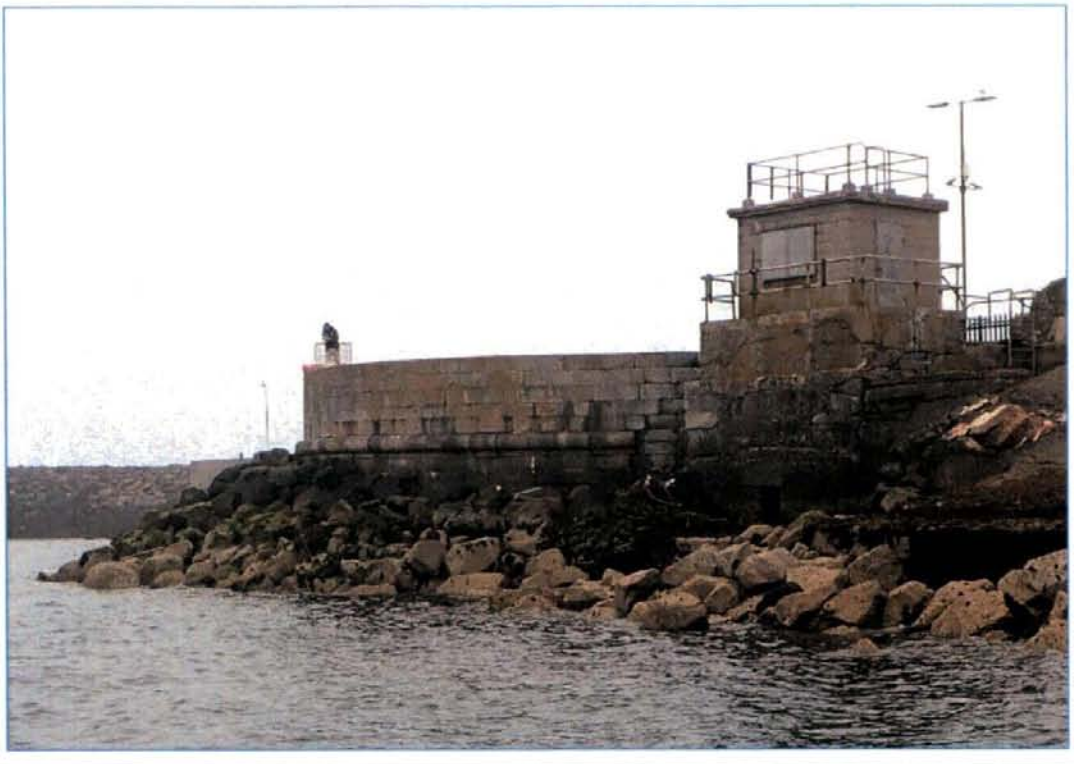


Plate 23: View from sea towards West Pier roundel, showing the rolled moulding at the base of the wave barrier. Picture includes the later observation building to the south (right) of the roundel.

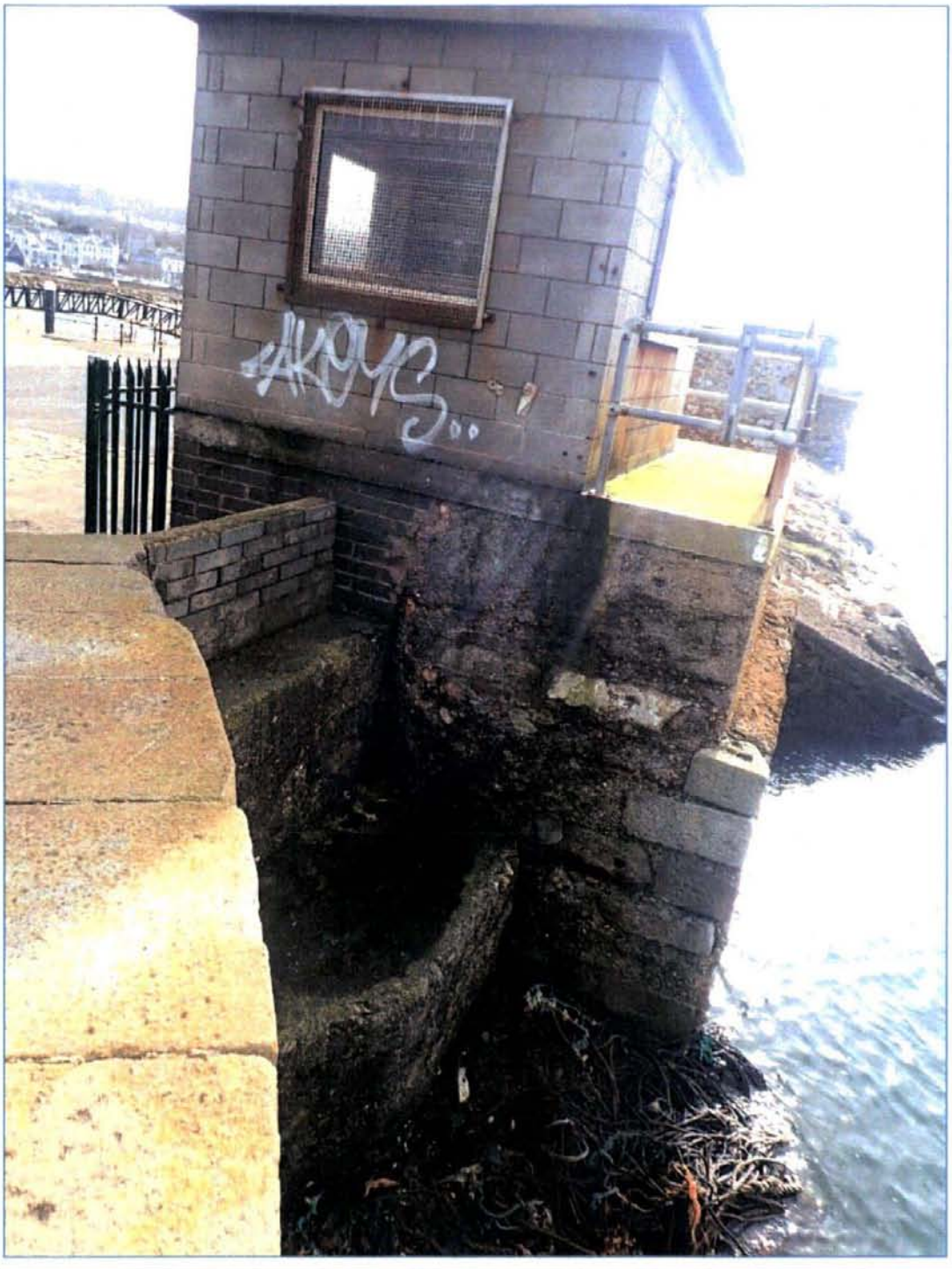
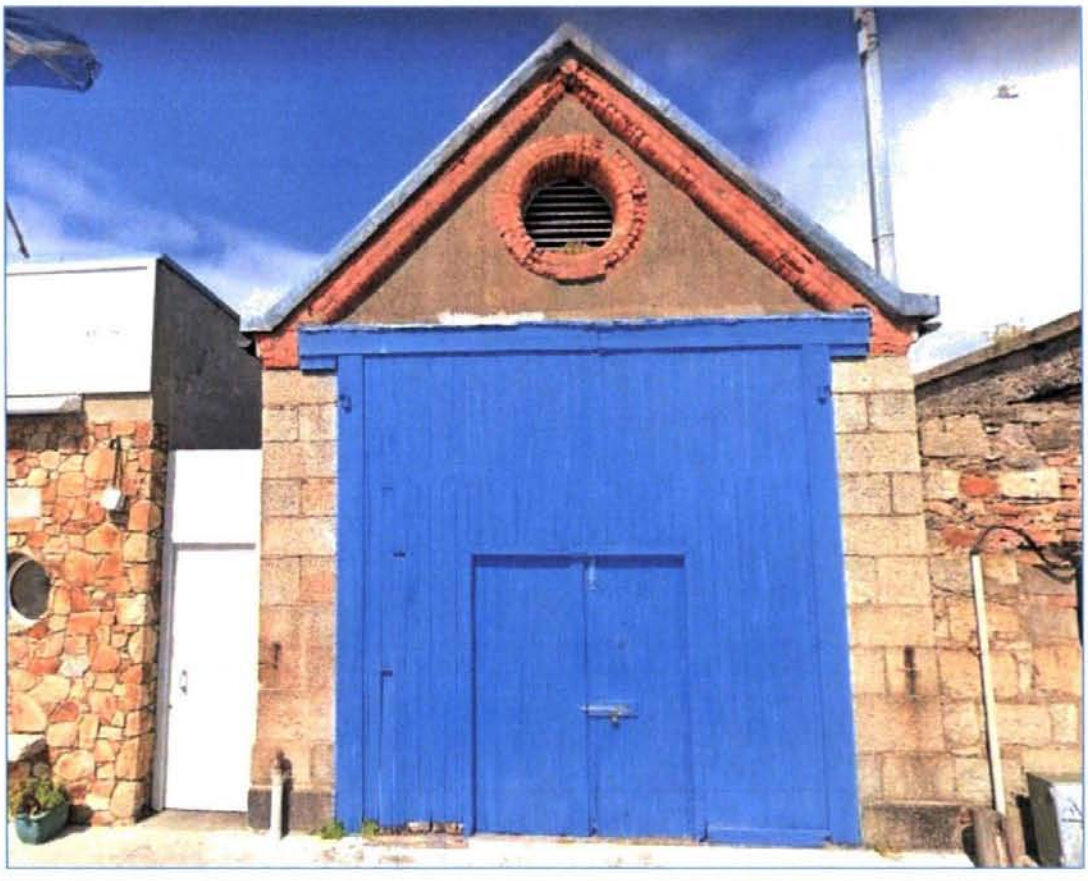


Plate 24: View looking South from roundel showing the non-uniform nature of the integration with the West Pier. The picture also shows the later observation building and its construction of earlier foundations.



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Source: Google Maps/Street View.

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Source: Google Maps/Street View.

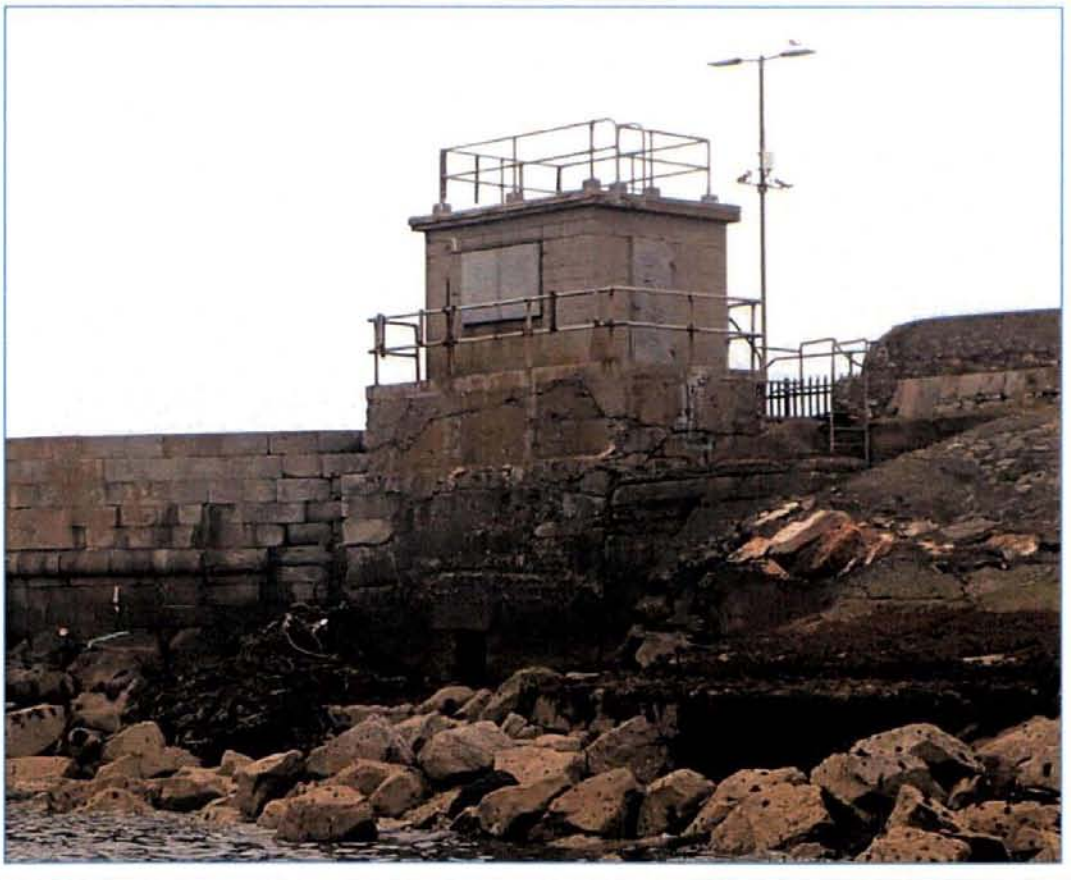

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Plate 30: View looking South along glacis.

Plate 31: View looking South showing detail of stonework along glacis.

Plate 32: View looking North along glacis.

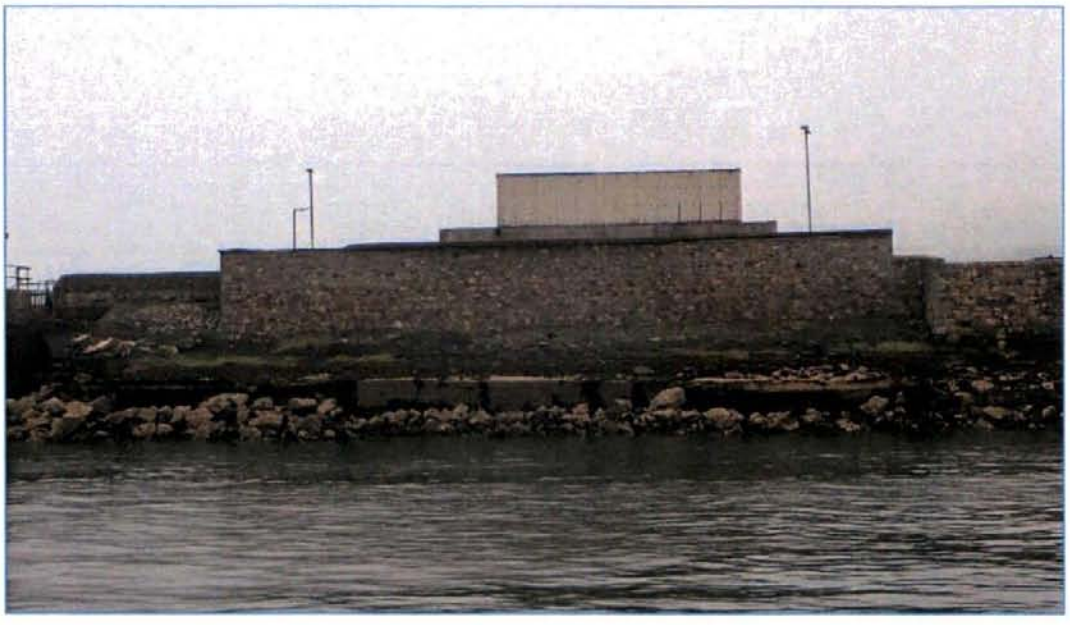

Plate 33: Stone retaining wall with granite employed as cornerstones.

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Plate 35: Detail of Plate 34 highlighting a pair of the lintelled culverts that have been blocked up.

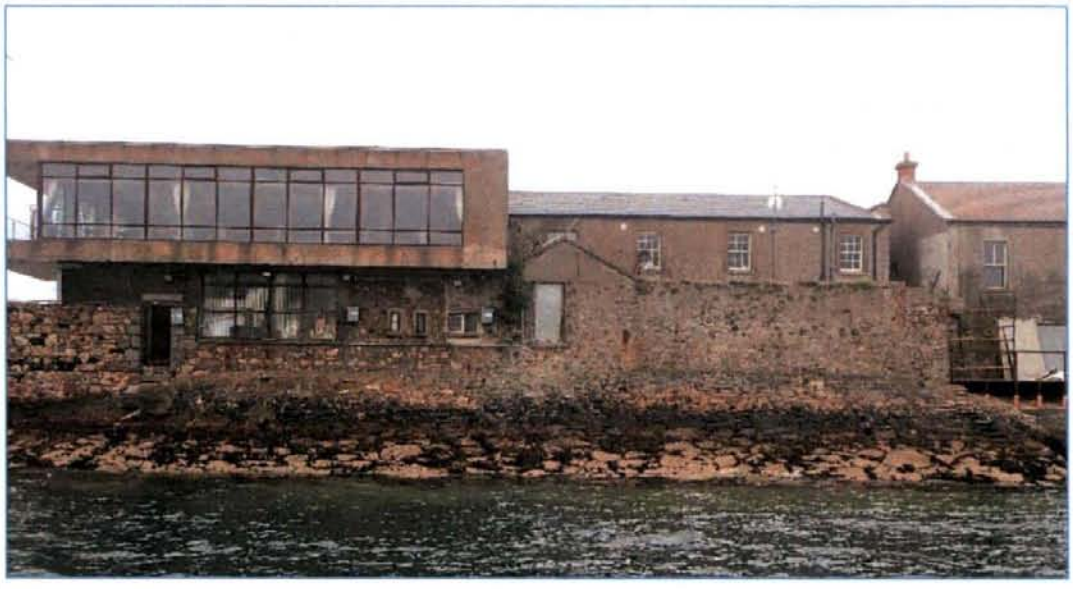

Plate 36: Sea view looking at rear of Clubhouse and details embedded in retaining wall.

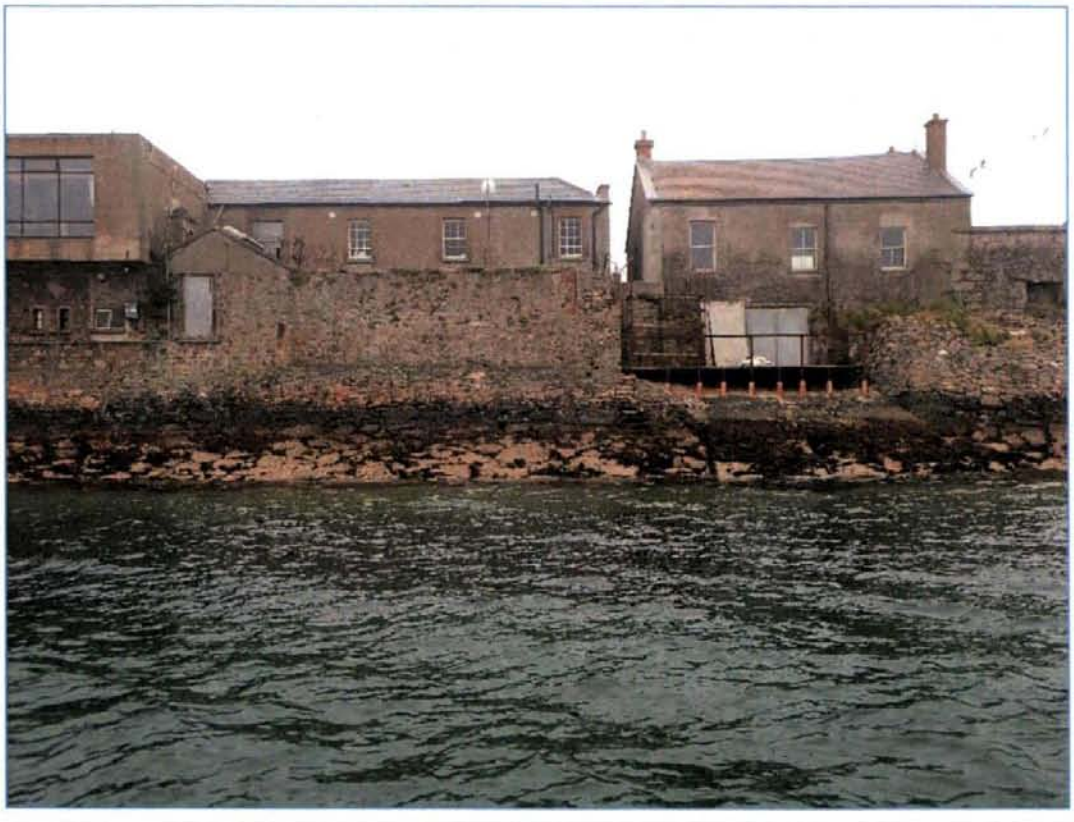

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Plate 42: Detail view of one of the tracklines, with a piece of light rail still embedded in it.

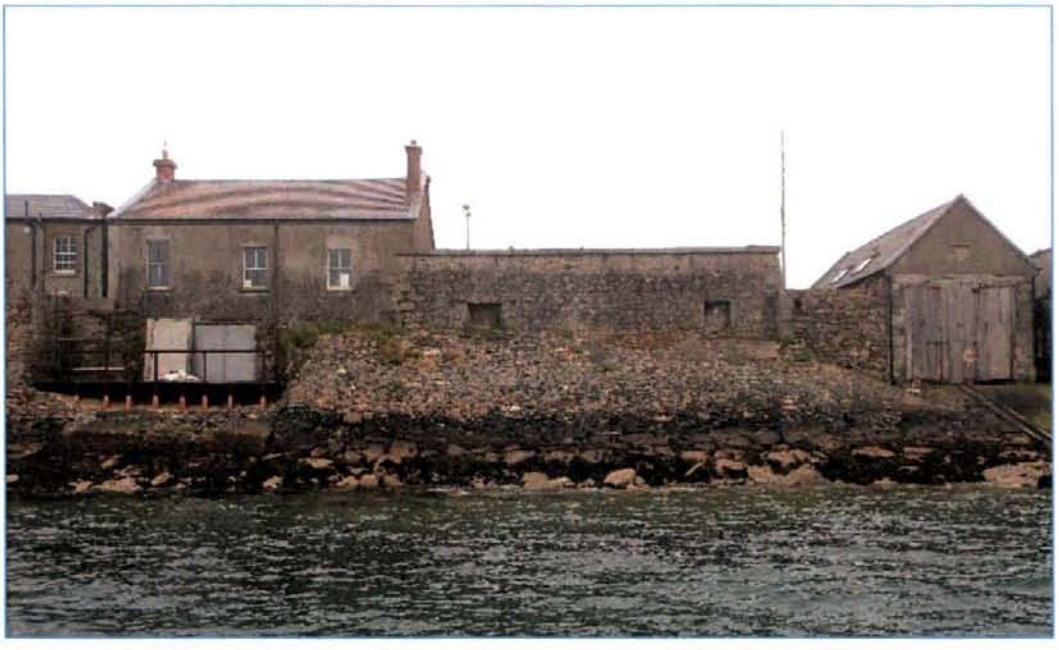

Plate 43: View from the sea, showing the rear of boathouse NIAH 1359044, and the elevated nature of the glacis constructed across it, effectively blocking any access to a boathouse entrance.

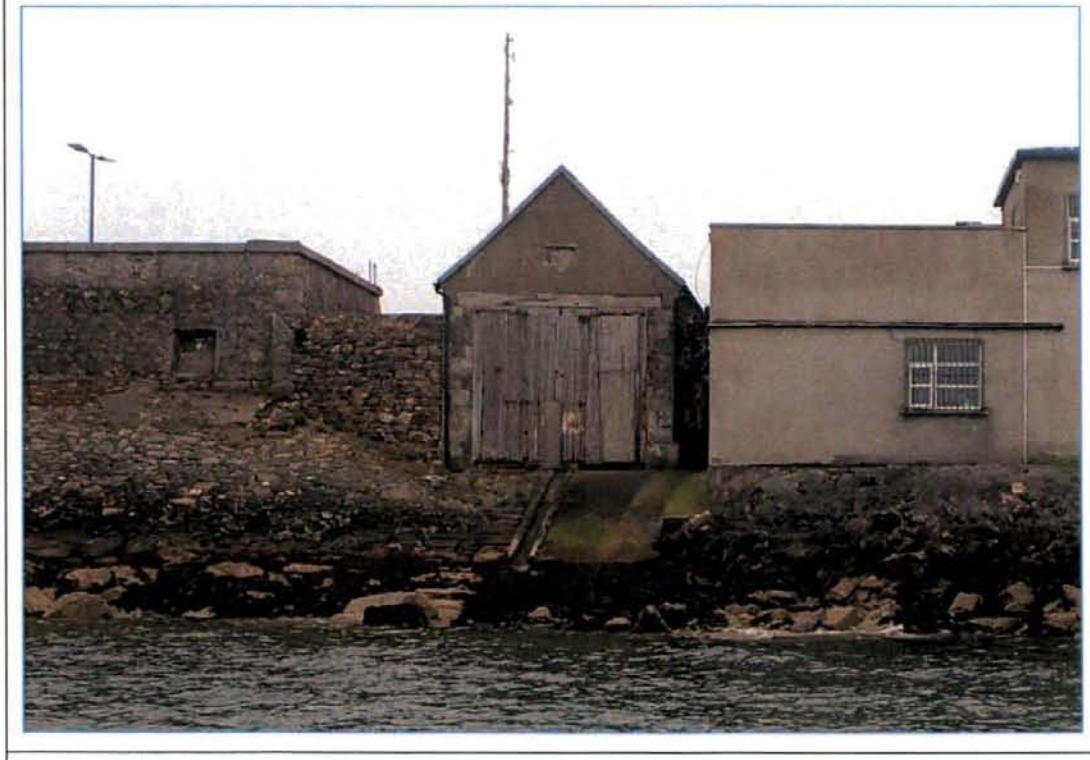

Plate 44: View from the sea towards the rear of the coastguard boathouse and slipway, NIAH 11359037.

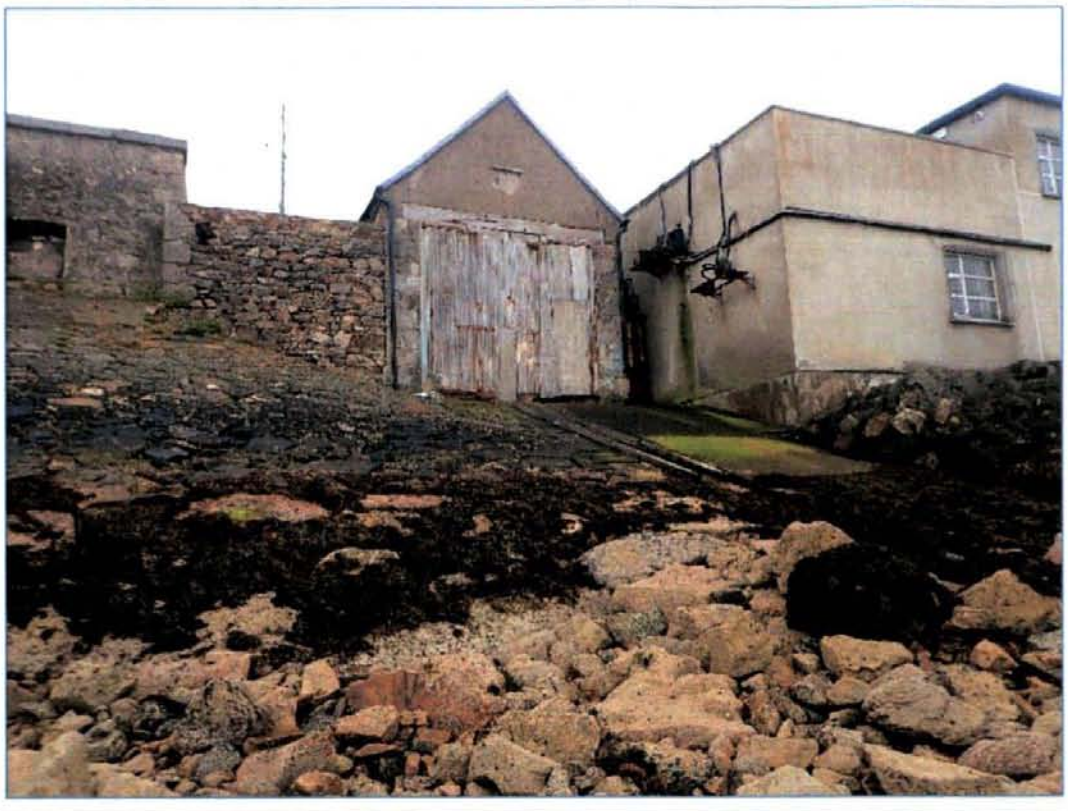

Plate 45: View across glacis to rear of the coastguard boathouse and slipway, NIAH 11359037.

Plate 46: View across glacis to rear of the coastguard boathouse and slipway, NIAH 11359037.

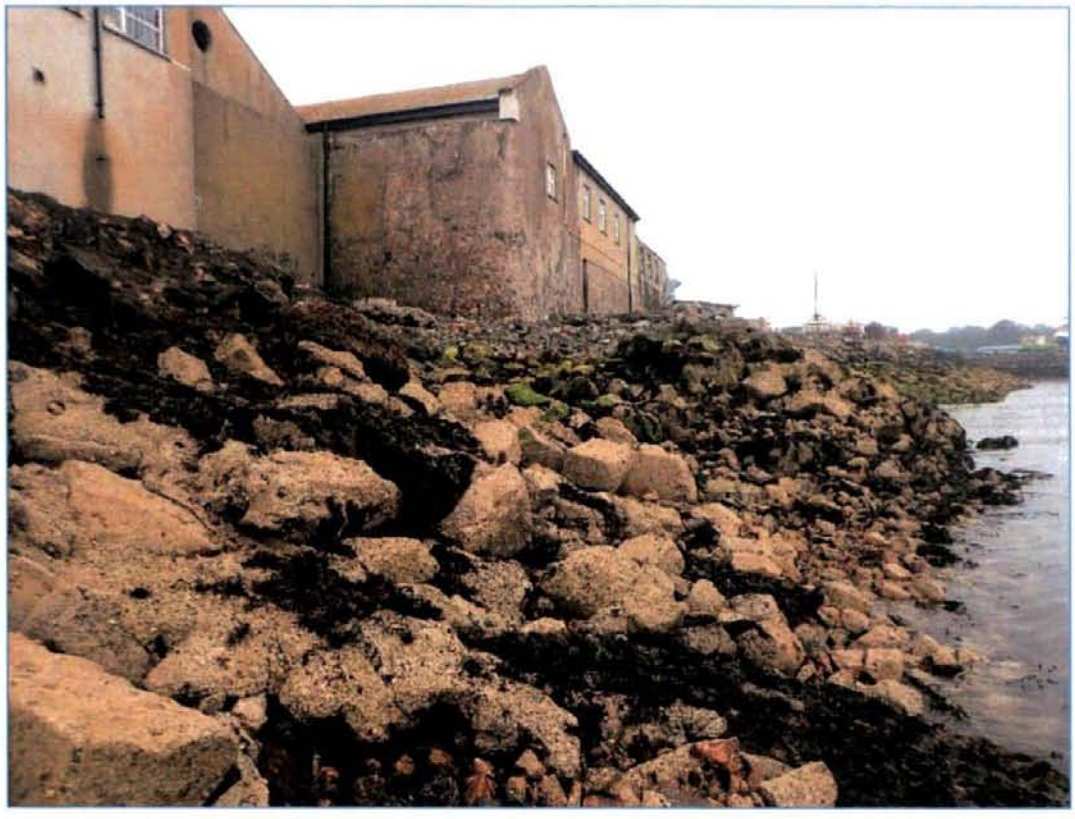

Plate 47: View looking South from the slipway at the coastguard slipway along rock armour that has been added, effectively burying the glacis.

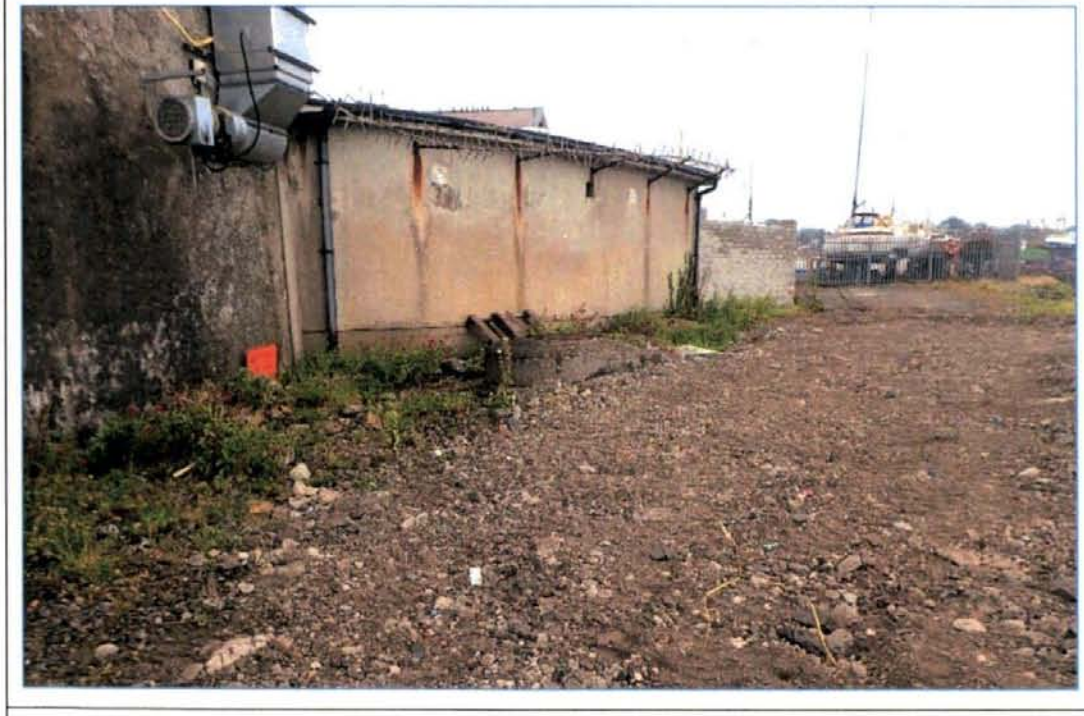

Plate 48: View of rear of buildings showing the incremential infill that is creating a new working surface.

Plate 49: View looking South along the reclaimed land and modern rock armour defining the current shore in the southern half of the West Pier.

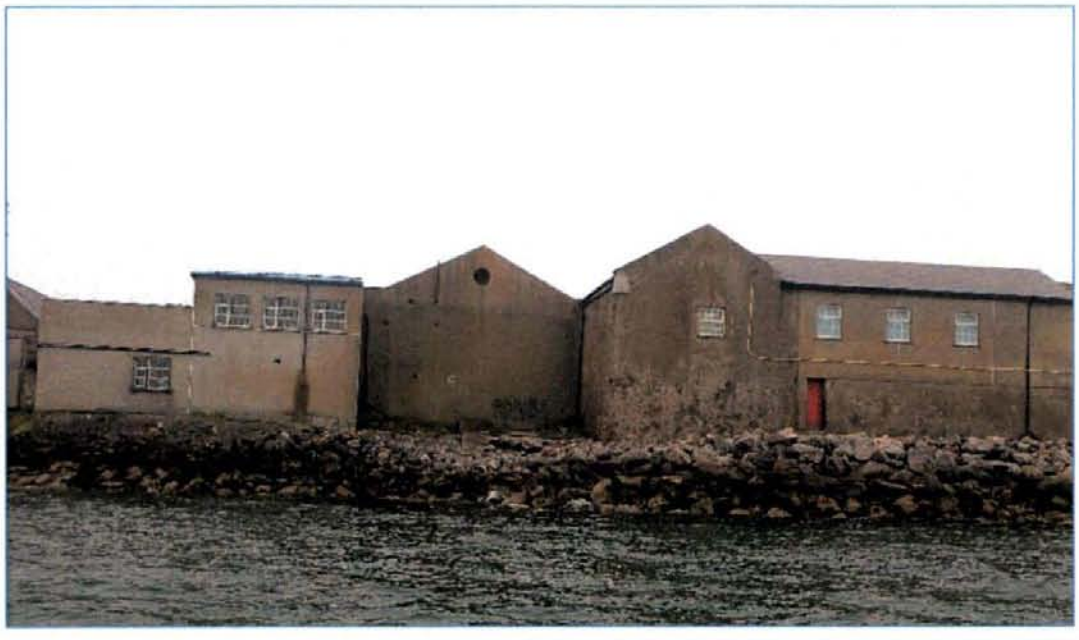

Plate 50: View from the sea showing the modern rock armour that forms the current shoreline along the southern half of the West Pier.

Plate 51: Detail view showing the rounded corner of the rear of the one of the buildings that lead on to the reclaimed area. The rounded corner is a tell-tale feature of nineteenth-century construction, employed to facilitate the movement of horse-drawing vehicles around a corner by avoiding the sharp edge of a squared corner.

Appendix 4

Hydrodynamic and sediment regime assessment

Malachy Walsh and Partners
Engineering and Environmental Consultants

Hydrodynamic and Sediment Regime Assessment
Howth FHC Dredging EIAR

ISSUE FORM	
Project number	19934
Document number	6023
Document revision	A
Document title	Hydrodynamic Assessment
Document status	Final
Document prepared by	PP
Document checked by	DOD

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4 HYDRODYNAMIC AND SEDIMENT REGIME ASSESSMENT

4.1 INTRODUCTION

4.1.1 General

The Howth Fishery Harbour Centre (Howth FHC) dredge project involves the dredging of the inner harbour followed by the reuse of the material to reclaim land to the west of the west pier. Refer to the Environment Impact Report (EIAR) chapter 2 for a full description of the project. This hydrodynamic and sediment regime assessment describes the potential impacts of the proposed project on hydrodynamic and coastal processes. The coastal processes include tides / erosion / wave action / water levels / sediment transport and sediment released during dredging operations.

Numerical modelling of hydrodynamic and coastal processes was undertaken to assist in assessing potential impacts of the proposed development. This assessment report describes the key findings of the modelling and the implications of these findings.

Modelling was undertaken by Dr. Michael O'Shea of MaREI in University College Cork. This description of the modelling output was undertaken by Pat Parle of Malachy Walsh and Partners.

4.1.2 Scope of Assessment

Hydrodynamic and sediment regime issues relating to the development include:

- Tide levels and currents.
- Wave action.
- Sediment deposition and concentrations during dredging operations.
- Changes to sedimentation patterns during construction and operational phases.

A review of bedrock and drift geology and of the material types to be dredged is covered in the Land and Soils chapter of the EIAR. Some of this information is used in this assessment. A summary of relevant information is reproduced in this assessment.

This assessment deals with the above issues and assesses the impact on the hydrodynamic and sediment regime of the proposed development.

4.1.3 Methodology

The methodology used in this chapter includes:

- A review of existing surveys and investigations undertaken at Howth in relation to the hydrodynamic and sediment regime. The investigations include:
    - Hydrographic surveys undertaken by Hydrographic Surveys Ltd. during late 2019 for this EIAR. The surveys include wave measurements, tide level and current measurements, seabed sediment sampling and analysis.
    - Geotechnical investigations undertaken in 2015 within the harbor area; and geotechnical investigations undertaken in the reclamation area during late 2019 for the EIAR.
    - Wave and tidal current modelling undertaken by MaREI for the EIAR.

- Modelling of wave propagation into the vicinity of the proposed development, of tidal currents, of the dredge plumes and suspended sediment concentrations during dredging operations. The hydrodynamic and sediment transport modelling for this EIAR was undertaken by MaREI of University College Cork. The models used are from Danish Hydraulic Institute's MIKE21 suite relating to nearshore wave propagation; hydrodynamic modelling; and the modelling of tidal current driven sediment transport for fine sand silt and clay material (sediment deposition and concentrations of suspended sediment during dredging). A brief description of the models used is given below:
    - **The Hydrodynamic Module (MIKE21 Flow Model FM)** This software is a 2D modelling system for estuaries, coastal waters and open seas. It simulates the water level variations and flows due to different forcing functions.
    - **MIKE 21 SW (Spectral Waves)** is a 3rd generation spectral wind-wave model that simulates the growth, decay and transformation of wind-generated waves and swell in offshore and coastal areas.
    - **MIKE 21 MT (Mud Transport)** is a combined multi-fraction and multi-layer model that describes erosion, transport and deposition of mud or sand/mud mixtures under the action of currents and waves.

- Assessment of the potential impact of the development in terms of:
    - Coastal processes, tide levels and currents, waves and erosion accretion;
    - Dredging operations, suspended sediment deposition and concentrations
- The assessment includes a discussion of mitigation measures and residual impacts.
- Geotechnical investigations and granulometric analysis of seabed samples are used to inform the description of the dredge material within Howth. These findings are summarised in chapter 6 of Vol 2.

4.2 DREDGE MATERIAL AND RECLAMATION SUBSOIL

4.2.1 General

The development includes the removal of some 240,000m^3 of dredge material, 90% of which consists of a mix of sand, silts, and clays with some gravels. This material will be removed by dredger to the treatment area, treated and transferred to the proposed reclamation area. The type of material is common and its removal from this area is not considered to have a significant impact. Indirect impacts on water quality due to the dredging operations are dealt with in Chapter 7 of the EIAR.

The proposed development is located on the north side of the Howth Peninsula. The Harbour (and its immediate vicinity) is sheltered to some degree from waves from the south by Howth Head. However, it is directly exposed to waves from the east and north sectors, with some shelter provided by Irelands Eye and Lambay Island to the north. The shoreline to the east of the harbour consists of rock cliffs. To the west the shoreline has an east west orientation and consists of sandy beaches and intertidal areas extending west to Baldoyle before turning north towards Portmarnock and beyond.
The total volume of material to be dredged is 240,000m^3. All but 10% of this is overburden material consisting of gravel to clay sized material. The majority of the overburden is fine sand, silt and clay.

With the exception of some dredging undertaken in the Marina Area the proposed dredging is the first campaign in the harbour since the early 1980s.

4.2.2 Bedrock Geology (see chapter 6 EIAR)

Geotechnical investigation at Howth indicates that rock within much of the new harbour area is likely to be at or below the proposed dredge levels. Some 10% of the volume of material to be dredged will be rock.

The rocks immediately to the south of the site at Howth and extending west towards Dublin city are mostly sedimentary in nature, dominated by limestone and shale. The Howth peninsula itself is dominated by Cambrian greywacke, slate and quartzite, which forms to the east of a north-west diagonal fault line. There is an igneous intrusion to the north at Donabate and Lambay Island. (GSI).

Rock cores obtained as part of recent ground investigations in the harbour and reclamation area described that a medium strong to strong, fine to medium grained fossiliferous limestone and occasional mudstone was encountered. Limestone was occasionally not noted as fossiliferous and was described typically as medium strong to strong, dark grey/grey, fine to medium grained, thinly laminated to thinly bedded limestone with some interlaminated mudstone. In some locations a greater presence or thickness of mudstone was found.

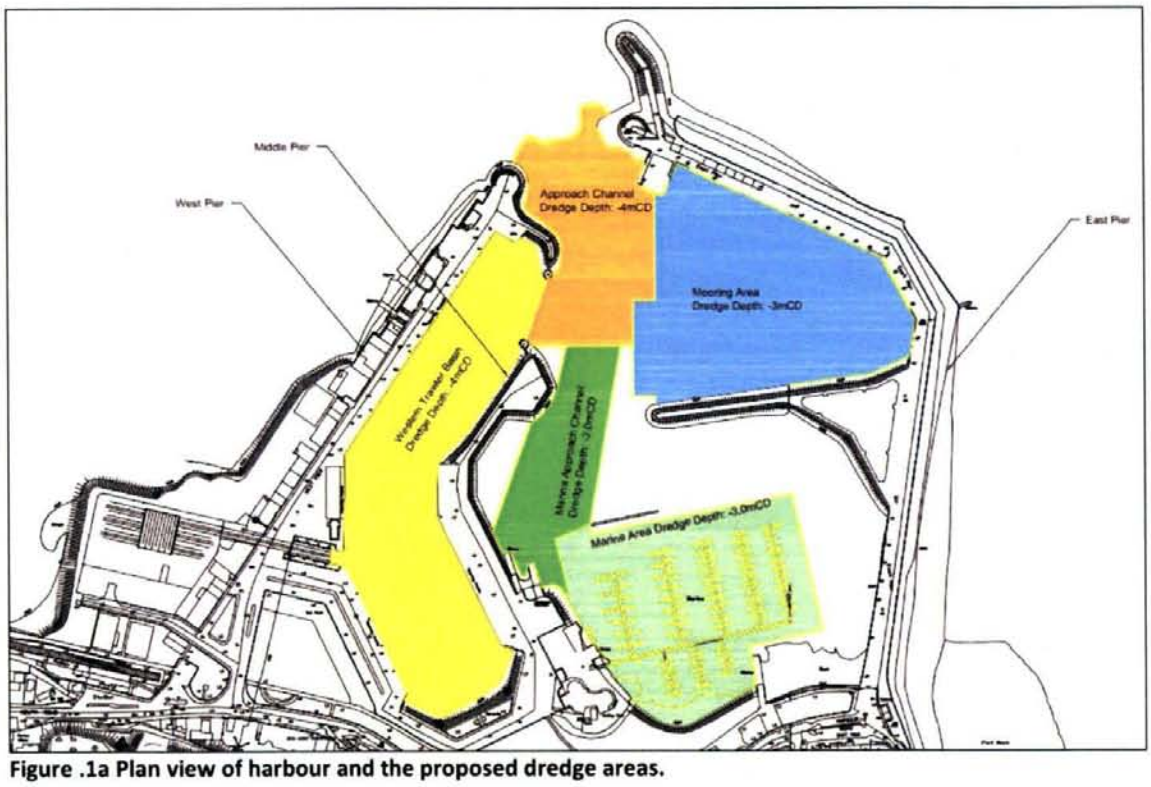

Figure .1a Plan view of harbour and the proposed dredge areas.

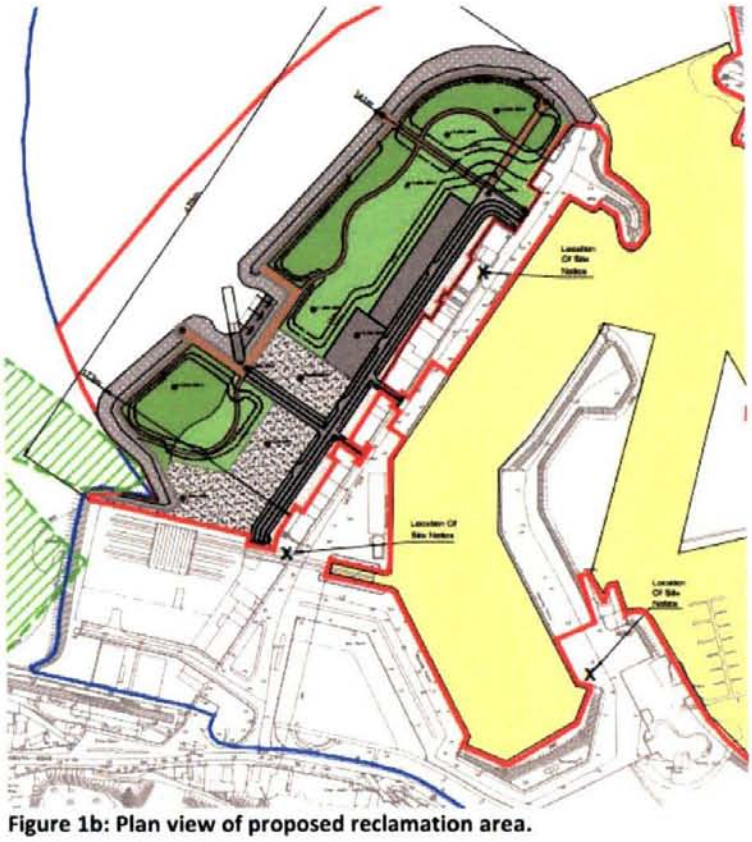

Figure 1b: Plan view of proposed reclamation area.

4.2.3 Drift Geology

4.2.3.1 Material to be dredged

Geotechnical investigations were undertaken in 2015 and 2019. A recent site investigation was undertaken by Priority Geotechnical at the proposed development site in December 2019. Previous site investigations were undertaken within the harbour in 2015. The investigation in 2015 related to the material to be dredged within the harbour whereby 29 no. marine boreholes were drilled within the proposed dredge area. The 2019 ground investigation relates primarily to the proposed reclamation area, and consisted of three boreholes within the footprint of the proposed reclamation, in addition to samples of sediment both within the reclamation footprint and within the harbour: and, the analyses of these samples for contaminants. See Appendix 2.1 of the EIAR.

The 2015 site investigation was used to recover soil, subsoil and bedrock cores within the dredge area. Deposits described as very soft or soft, dark grey or black sandy and occasionally gravelly clay/silt comprising occasional shell fragments were encountered in the majority of boreholes.

Some stiff deposits described as stiff brown or black sandy gravelly clay comprising some cobbles and boulders were encountered above the bedrock in isolated areas within the harbour. Other deposits encountered also consisted of light brown gravel sized mudstone.

The 2015 investigation included grain size analysis on 27 samples taken from the proposed dredge material. The results of this analysis were used to evaluate the proportion the coarser fraction, fine sand, silt and clay fractions to be dredged. Dredge volumes have been estimated for various areas within the harbour, such as the Marina Area, the Trawler Basin and the Moorings. Grain size distribution data from each of these areas was combined with the dredge volumes in these areas to estimate the total volumes of each fraction to be dredged.

The analysis of the grain size data split the overburden into the above and below fine sand fractions as an assessment of tidal currents within the harbour and of settling velocities for each grain size indicated that material that escapes into the water during dredging operations will fall to the seabed within the harbour area whereas the fine sand, silt and clay fractions might be carried outside the harbour.

The results of the assessment of the grain size of the dredge material are given in the tables below. The tables show that much of the material is in the silt clay range; and, that the material potentially able to exit the harbour if it is lost into the water column during the dredging operation is approximately 60% of the material lost.

Table 1 Dredge Material Grain Size and Volume Overburden

Grain size	Volume m3	%
Gravel and coarse sand >0.6mm	77,767	36.6
Medium sand 0.2 to 0.6mm	8,829	4.2
Fine sand	19,187	9.0
Silt	48,902	23.0
Clay	57,663	27.2

Table 2 Dredge Material: Proportion of Finer Material

Grain size	Volume m3	%
Total medium sand and larger >0.6mm	86,597	40.8
Total fine sand, silt and clay	125,753	59.2

Table 3 Dredge Material: Breakdown of Finer Fraction

Grain size	Volume m3	%
Fine sand	19,187	15.2
Silt	48,902	38.9
Clay[1]	57,663	45.9

1 Clay forms 46% of the fraction of dredge material that is considered fine enough to exit the harbour on an ebb tide.

4.2.3.2 Reclamation Area

The 2019 ground investigation found the soil in the reclamation area comprised a top layer of fine to medium brown sand with underlying fine to course grey, silty gravelly sand. Below this was found material described as grey, slightly gravelly clay overlying bedrock. Some cobble and shell content was encountered.

Three boreholes sunk within the footprint of the reclamation area indicated that the seabed subsurface material consists of a silty sand material overlying a layer of glacial till overlying rock. The proportion of silty sand in the top layer varied over the footprint being sandier towards the south of the area and having slightly more silt towards the northern end. The thickness of the sand layer is approximately 3m towards the south reducing to 1m towards the north. The thickness of the underlying clay layer varies from 1.3 to 2.1m.

The rock is within 2.7 to 4.4m of the seabed surface.

4.2.3.3 Nature of Adjacent Shoreline

See Figures 2, 3 and 4 below showing the shoreline to the west of the harbour. Figure 5 shows the shoreline to the east of the harbour.

The shoreline to the east of the harbour is a rocky shoreline backed by high cliffs. There is a small sandy beach in the Ballyscadden area to the south east of the harbour. There are rock outcrops into the intertidal area north and south of this beach. The shoreline east of the beach is formed by rock cliffs of Howth Head.

On the north west side of the boatyard area at the southern end of the west pier a shingle spit extends west and south from the north west corner of the boatyard area. South of this is a short length of sandy beach backing on to the boatyard area. This area has at times contained embryo dunes.

The shoreline to the west is backed by low lying land and is fronted by a sandy beach with a wide intertidal area. The DART line runs along the shoreline for some 500m west of the harbour. There is some shingle at the top of the beach which is more evident at the western end of this section. The shoreline moves north away from the DART line and is consists of a small area of sand dunes fronted by a sandy beach, just east of the Quarry where rock outcrops on the beach. Along the frontage west of this the shoreline orientation for the most part east west to the Burrow at Cush Point and consists of a sandy beach with a wide intertidal area.

West of Cush Point the shoreline returns south to be formed again by the DART line before it turns north fronting Strand Road into the Baldoyle Estuary.

Figure 2: Cush Point and Burrow Beach

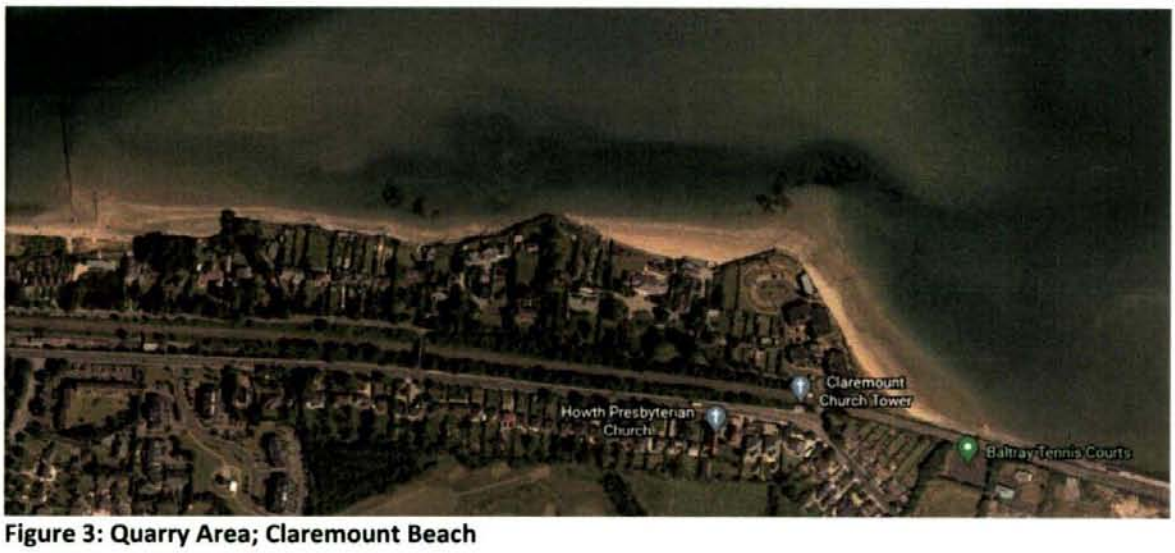

Figure 3: Quarry Area; Claremount Beach

Figure 4: Boatyard west to Quarry

Figure 5: Shoreline to the East.

4.3 TIDE AND EXTREME WATER LEVELS

4.3.1 Tide Levels

Tides drive water currents into and past the mouth of the Harbour at Howth. These currents themselves drive the movement of finer sediment, which can be enhanced by wave action which can also drive the movement of coarser sediments in the intertidal and above tide areas. Normal tides are driven by astronomical forces. However, meteorological conditions can cause tides to be higher and lower than "astronomic" tides. Table 4 below gives characteristic tide levels for the Howth Harbour area. Extreme tide levels have been estimated as part of the Irish Coast Protection Strategy Study, and the results for the Howth area are given in Table 5 below.

Table 4 Howth Tide Levels

Description	Level m Chart Datum[1]	Level m ODM
Highest Astronomic Tide	4.5	1.98
Mean High Water Spring[2]	4.1	1.59
Mean High Water Neap[3]	3.3	0.79
Mean Tide Level	2.3	-0.21
Mean Low Water Neap	1.3	-1.21
Mean Low Water Spring	0.5	-2.01
Lowest Astronomic Tide	-0.37	-2.88

1 *0.0m Chart Datum is –2.51mODMalin at Howth.*
2 *Spring tide range is 3.6m*
3 *Neap tide range is 2.0m*

These tides drive water past Howth during a 12.4hr tidal cycle and dictate the currents in the water surrounding the site. Tidal inflows and outflows to and from the Baldoyle estuary also have an impact on currents in the vicinity of the harbour.

Extreme high water levels in the vicinity of Howth have been extracted from the Irish Coastal Protection Strategy Study point NE_18, updated by ICWWS 2018 and are given in Table 4 below.

Table 5 Extreme Tide Levels

Annual Exceedance Probability %	**Level mODM OSGM15**
50	2.61
20	2.70
10	2.76
5	2.83
2	2.91
1	2.98
0.5	3.04
0.1	3.19

Tide levels within the Harbour area are dictated predominantly by tide levels in the sea away from the vicinity of the harbour and, to a much lesser degree, by water depths and the plan shape of the coastal area in the vicinity of the harbour. The proposed reclamation is within the lee of the West Pier, and tidal currents west of this area are likely to be the same with or without the development. In addition, the scale of the proposed development is considered too small to have a significant impact on tide levels.

4.4 WAVE CONDITIONS

4.4.1 General

The largest waves in the vicinity of Howth Harbour propagate from the Irish sea. Smaller shorter waves are locally generated by westerly winds blowing over the area of water to the west of the harbour. The waves from the east are considerably changed as they propagate towards the shore, the smaller shorter locally generated waves less so.

4.4.2 Offshore Waves

Offshore wave data was obtained from the M2 buoy. The impact of the proposed development on the larger waves was assessed using numerical modelling of the propagation of the waves towards and west of the harbour.

Offshore wave data has been obtained from the M2 buoy for the period 2001 to 2020. A frequency distribution table of these offshore waves is given in Table 6 for waves when the wind direction was in the sector 345 to 195°N. An extreme analyses of these waves was undertaken and the results are given in Table 7. The frequency table and extreme analysis indicates that the largest waves at the M2 buoy are most likely to come from the southerly sector, though the largest recorded wave during the period is a 9.5 to 10.0m Hs from 90°N – occurring during the "Beast from the East" storm.

Table 6
Frequency Distribution of Waves M2 Buoy

Wave height intervals	Directions ◦ N						
	345-15	15-45	45-75	75-105	105-135	135-165	165-195
0-.5m	670	925	791	903	948	811	1582
.5-1m	1724	1836	1491	1729	1309	1599	4228
1-1.5m	963.0	861	793	993	652	939	2599
1.5-2m	637	606	527	734	456	782	2144
2-2.5m	268	304	234	505	222	505	1191
2.5-3m	192	140	138	258	131	338	877
3-3.5m	91.0	85	59	141	53	160	474
3.5-4m	43	48	44	67	23	104	331
4-4.5m	14	21	28	44	16	62	215
4.5-5m	6	5	16	19	6	20	118
5-5.5m	9	2	12	16	6	10	67
5.5-6m	3	0	4	13	0	4	32
6-6.5m	2	0	1	7	0	2	14
6.5-7m	0	0	1	6	1	3	9
7-7.5m	0	0	1	9	0	1	9
7.5-8m	0	0	0	3	0	0	7
8-8.5m	0	0	0	2	0	0	7
8.5-9m	0	0	2	3	0	0	2
9-9.5m	0	0	0	0	0	0	1
9.5-10m	0	0	0	1	0	0	0

Table 7
Extreme Waves M2 Buoy

Return Period Years	Directions ◦N						
	345-15	15-45	45-75	75-105	105-135	135-165	165-195
1	4.2	4.2	4.3	4.9	4.0	4.8	5.9
10	5.9	5.7	6.0	6.7	5.6	6.6	7.8
20	6.4	6.2	6.5	7.3	6.1	7.2	8.4
50	7.0	6.9	7.1	8.0	6.7	7.9	9.1
100	7.5	7.3	7.7	8.6	7.2	8.4	9.7
200	8.0	7.8	8.2	9.1	7.7	8.9	10.2

4.4.3 Wave Modelling/ Nearshore Waves

Wave modelling was undertaken by the MaREI centre of University College Cork using the Danish Hydraulic Institute's MIKE21 SW wave module for the modelling of the propagation of waves from offshore to nearshore. Wave action at the site consists of waves propagating from the Irish Sea, in addition to much smaller and shorter waves locally generated over the short fetch from the Baldoyle Portmarnock areas. Figures 6 and 7 show plots of an 8m wave from the 30° and 60° North direction during MHWS in the vicinity of the site. These are the offshore conditions likely to give the largest

waves in the vicinity of the harbour and reclamation area. While the extreme offshore waves from the south east sector are larger, the harbour is protected to a degree from such waves by Howth Head.

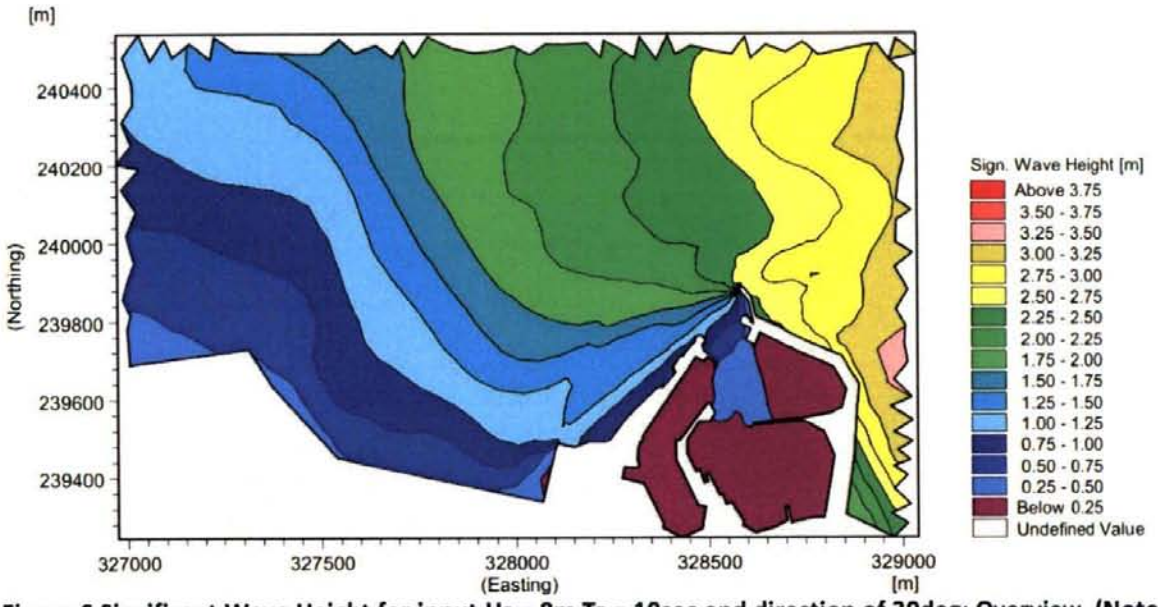

Figure.6 Significant Wave Height for input Hs = 8m Tz = 10sec and direction of 30deg: Overview. (Note Hs: Significant Wave Heights, and Tz: Mean Wave Periods.)

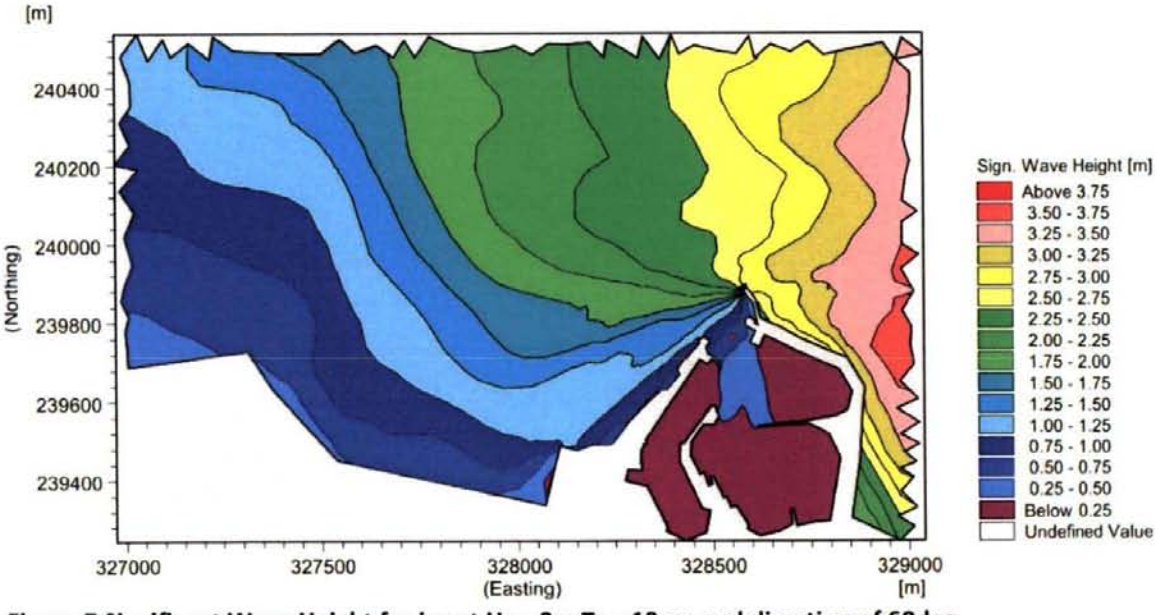

Figure 7 Significant Wave Height for input Hs = 8m Tz = 10sec and direction of 60deg.

The above Figures show the considerable attenuation of the offshore waves as they propagate into the vicinity of the harbour.

Wave modelling runs undertaken for the study included waves:

- Directions 360, 30, 60, 90, 120, 150 and 180°N
- Three tide levels, MHWS, MTL and MLWS
- Offshore significant wave heights of 1, 2, 4 and 8m

- Existing situation and with reclamation in place.

Wave data was measured at a point south east of Ireland's Eye for 9 days during January 2020 in order to calibrate the modelling of wave conditions as they propagate from the location of the M2 buoy to the vicinity of the harbour. Modelling of wave conditions is undertaken for two purposes. 1. To provide wave data for use in design and 2. in order to inform an assessment of the potential impact of the proposed development on the wave conditions in the area. Recorded wave data is given in Appendix A of this assessment.

A number of plots of the significant wave heights in the vicinity of the harbour have been produced. Two have been reproduced as Figures 6 and 7 above. These are for the existing situation. To get a clearer comparison between the existing situation and that with the proposed structure in place, wave conditions at six locations on the west side of the Harbour were obtained. These six locations are shown in Figure 8 below. The locations are positioned:

- Two in the vicinity of the northern extremity of the proposed reclamation area
- One in the vicinity of the mid-point of the west side of the proposed reclamation area
- Three along the shoreline immediately west of the harbour, between the boatyard and the quarry area, i.e. Claremont beach.

Output for the MHWS wave runs are given below in Figures 9, 10, and 11, for the existing situation and with the reclamation in place, for the 6 locations, from Point 1 just west of the Bullnose on the West Pier to Point 6 the west beach point. The plots from left to right represent significant wave heights at the point for offshore wave conditions 8, 4, 2 and 1m Hs from 360°N, followed by waves for offshore conditions 8, 4, 2 and 1m Hs from 30°N, and so on to waves from 180°N.

The plots show that there is little change in wave conditions at the output points. The largest wave difference is for the east beach location which would be the lee-most position with regard to the proposed structure. In this case the waves from the 360° (N) to 180° (S) sector are slightly reduced by the proposed development. However, the difference is less than 10% for the largest offshore waves and is approximately 10 to 15% for the smaller offshore waves. In these cases, the wave conditions on the beach are small having significant wave heights in the range 0.15 to 1m Hs.

In this area of the east beach the largest waves will be those that are locally generated over the fetch from the west to north sector and will have a Hs of greater than 1m. Locally generated waves from the North West are smaller and shorter than the offshore waves but they undergo little attenuation as they approach the beach. The largest locally generated waves in the Claremont Beach area are estimated to be 1.6m Hs. These waves would however be much shorter than the Irish Sea waves with a Ts in the order of 4.5s.

These waves are not impacted by the proposed development.

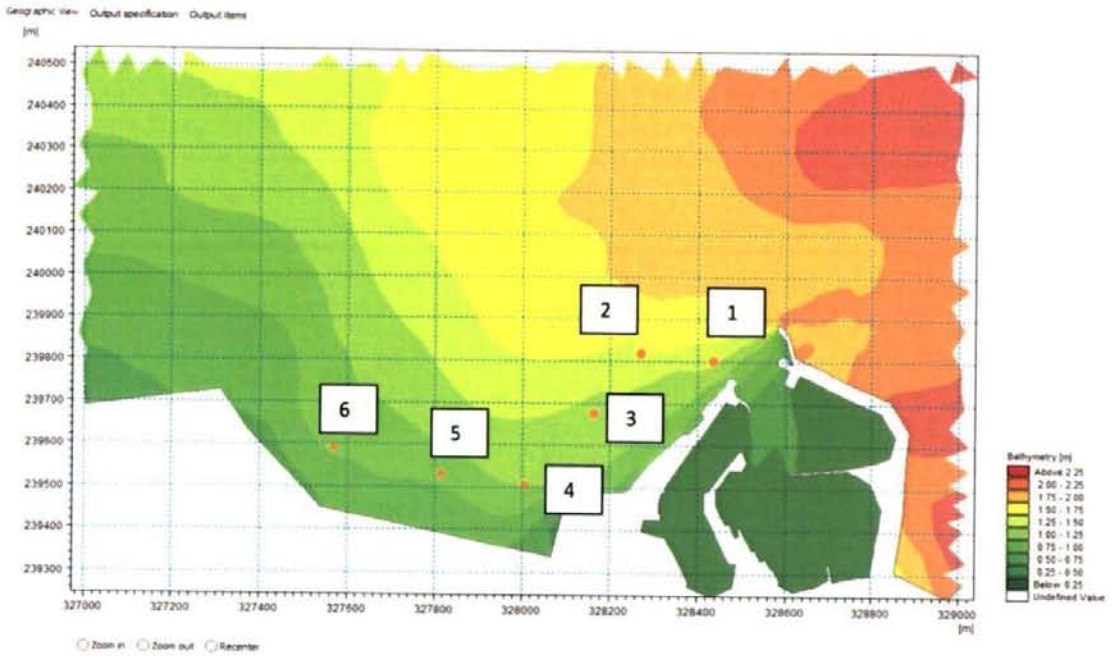

Figure 8 Location of wave condition output for modelling runs.

Point 1	West of Bullnose
Point 2	North of proposed revetment
Point 3	West of revetment
Point 4	East Beach
Point 5	Mid Beach
Point 6	West Beach

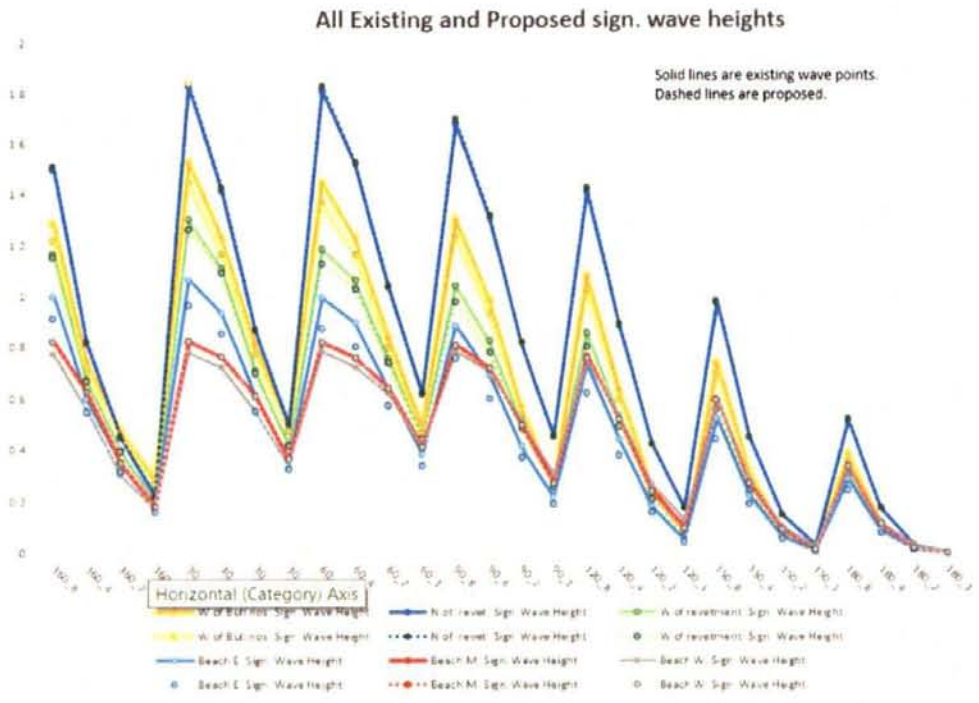

Figure 9: Hs at locations 1 to 6 for existing situation and with the proposed development

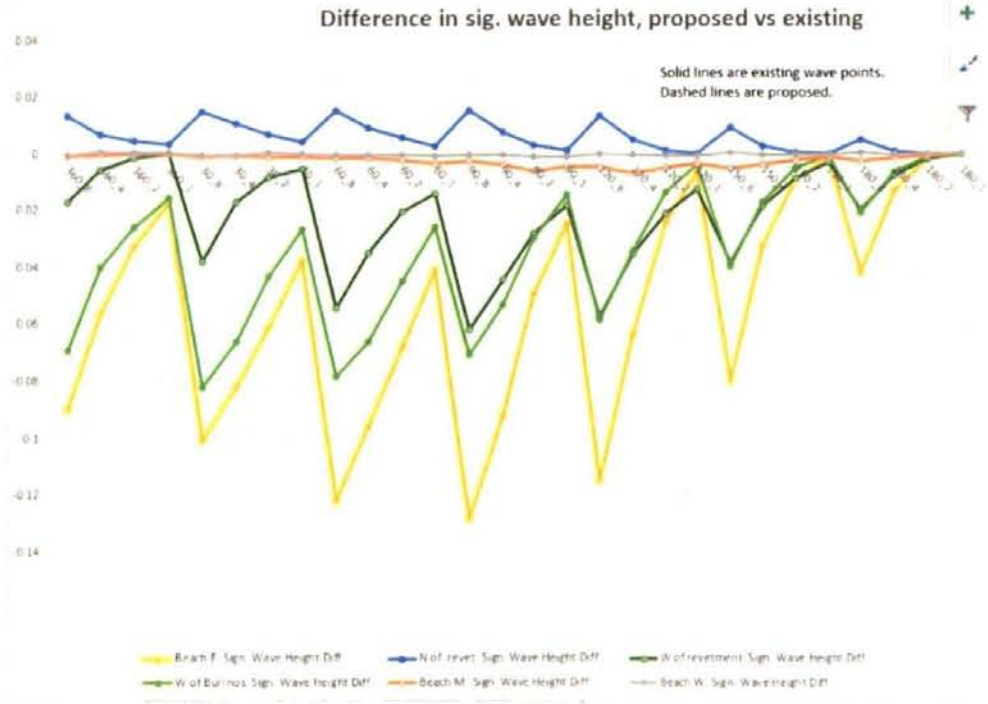

Figure 10: Differences in Hs at locations 1 to 6 between existing situation and with the proposed development

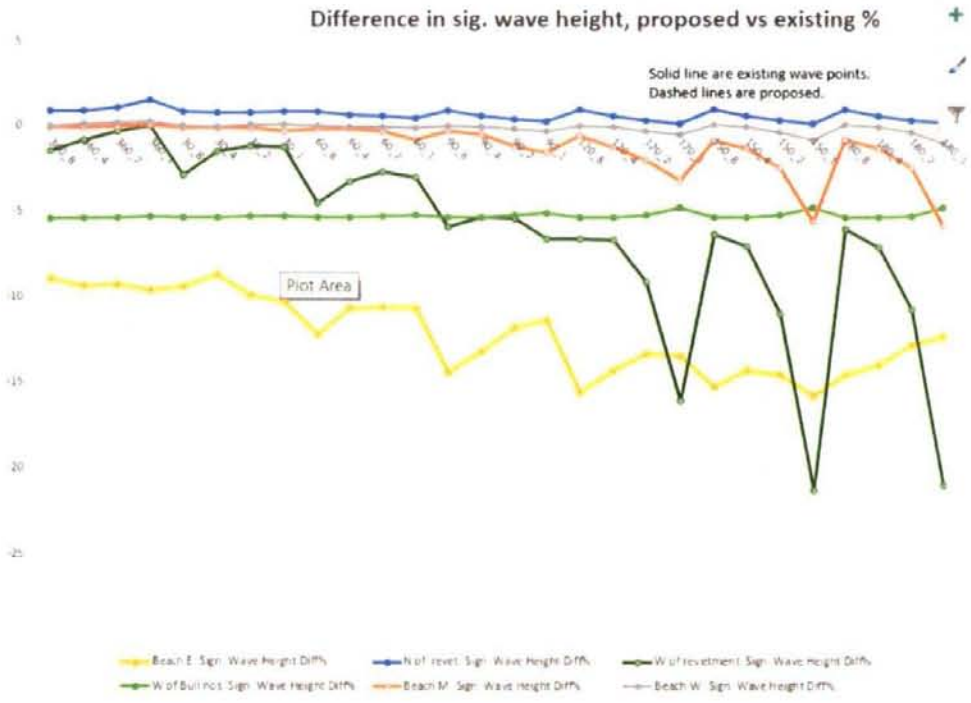

Figure 11: % Differences in Hs at locations 1 to 6 between existing situation and with the proposed development

4.4.4 Impact of Proposed Development on Wave Action

Modelling of wave action indicates that while in the immediate lee of the reclamation works there may be a reduction in wave conditions from the east, such a reduction is considered to be slight and most of the existing wave conditions will remain much as before. Locally generated waves from the north west and waves propagating from the north will be as before with a slight change in the immediate vicinity of the perimeter revetment due to a small change in reflection characteristics. The change in reflection characteristics will only impact on waves from the west to north sector. Waves from a more easterly direction will diffract around the harbour piers and the northern section of the reclamation and run along the perimeter with little impact.

The oblique angle of the waves combined with the relatively low wave reflectivity of the breakwater will mean that the structure will reflect little wave action towards the Portmarnock shoreline. In extreme wave conditions, wave heights at the location of the perimeter of the reclamation area breakwater are estimated to be in the order of 1.5m Hs. Wave reflection would be in the order of 20 to 30%, i.e., less than 0.5m Hs. The existing profile of the seaward face of the west pier presents a smooth face to the waves and would have a similar reflection characteristic. The proposed structure is considered unlikely to impact significantly on reflected waves.

At present, waves from the east propagate through the open water within 100m from the line of the west pier to the area just west of the syncrolift. When the reclamation is in place there will be a certain amount of energy loss in waves in the vicinity of the rock armour revetment due to energy losses in the rock armoured perimeter. This reduces slightly wave conditions in this area for waves from the east. Waves from the west into this area will be as before. The waves action in this area prevents the deposition of silt sized material in the upper shore area of this shoreline and results in the existing mix of

sediment sizes in this area. This will not be impacted upon significantly by the small changes that occur in wave conditions due to the proposed development.

There are embryo dunes in this area, resulting from a mix of the sediment supply, wave action and Aeolian transport. The wind-blown sand collects in this area due to winds from the west during low tides. Such winds and sediments will not be impacted by the development and the potential for embryo dunes to occur remains. It is unlikely also that such embryo dunes will develop into larger dunes in this area because of the frequency of wave action and the infrastructural constraints in this area.

4.5 TIDAL CURRENTS

4.5.1 Measured Currents

Tidal currents have been measured, as part of an oceanographic survey undertaken in December 2019 by HSL, for this study at three locations: one within the harbour (1), one west of the harbour mouth just off the head of the west pier (2), and a third slightly east of the harbour mouth halfway between the harbour and Ireland's Eye (3). Measurement locations are shown on Figure 12 below.

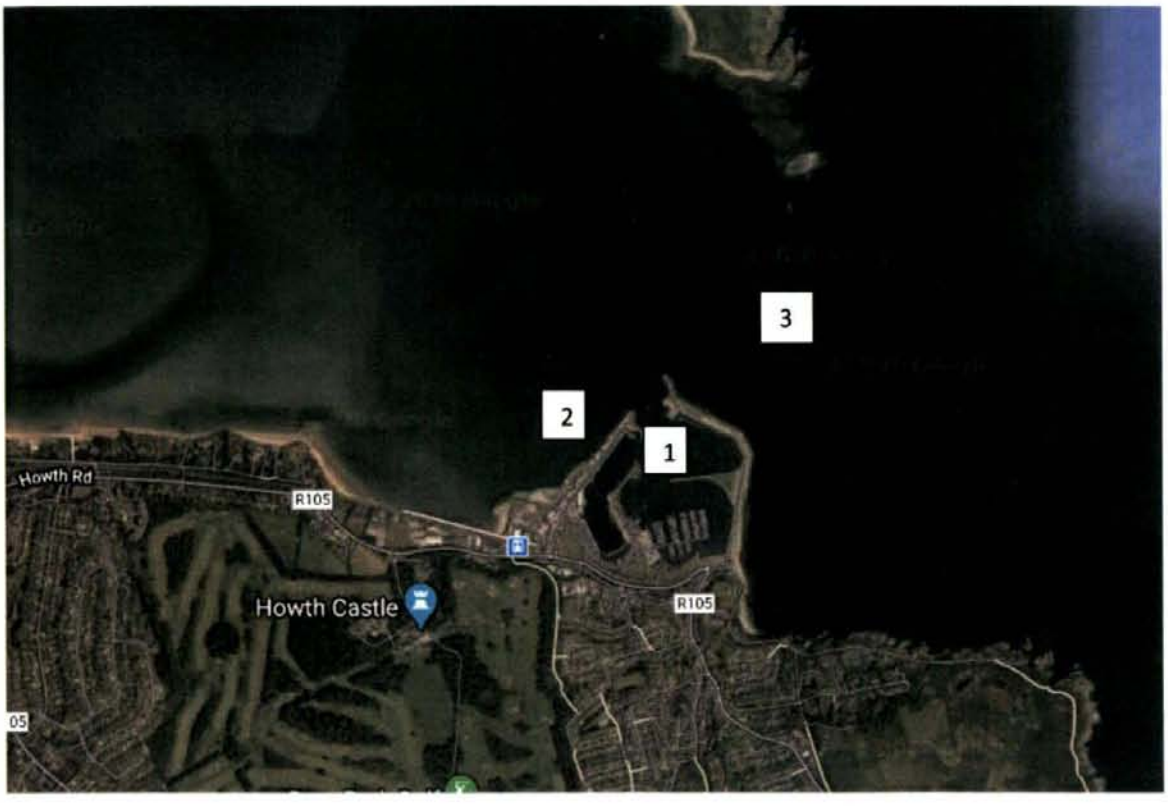

Figure 12 Location of Current Measurements

Measurements were taken at a number of water depths, approximately 1m below the surface, mid-depth and approximately 1m above the seabed. Measurements were taken over a 14 hour period on each of three days (the 3rd, 12th and 17th of December 2019) in an attempt to capture tidal currents over spring, neap and medium tides. The tidal ranges on those days were 2.33m, 3.41m, and 3.33m respectively i.e., slightly more than the neap range of 2m, and two approximately halfway between medium (2.8m) and spring (3.6m) tidal ranges.

Maximum and average tidal currents are given in the Table 8 below.

Table 8 Tidal Currents m/s - Recorded

		Location					
Date	**Tidal Range m**	**1 Within Harbour**	**1 Within Harbour**	**2 Off West Pier**	**2 Off West Pier**	**3 East Pier to Ireland's Eye**	**3 East Pier to Ireland's Eye**
		Max[1]	Average	Max	Average	Max	Average
3rd Dec19	2.33	0.233	0.049	0.271	0.109	0.584	0.283
12th Dec19	3.41	0.209	0.070	0.350	0.137	0.804	0.353
17th Dec19	3.33	0.183	0.051	0.348	0.157	0.79	0.37

1 Maximum tidal current recorded.

2 Average tidal current magnitude over the 14hour recording period.

The measurements showed that currents within the harbour are low, with a maximum recorded value over the three tidal cycles of 0.233 and an average less than 0.07m/s.

Tidal currents just west of the harbour mouth are also low, with a maximum recorded value over the three tidal cycles of 0.38m/s, and an average less than 0.16m/s.

Tidal currents north east of the harbour are higher, with a maximum recorded value over the three tidal cycles of 0.80m/s, and an average of up to 0.37m/s.

The outside harbour tidal current measurements together with tide level measurements at Howth were used to calibrate a hydrodynamic model in the vicinity of the harbour. The full domain of the model covered from Dun Laoghaire in the south to north of Drogheda. However, calibration efforts concentrated on the vicinity of the Harbour area.

4.5.2 Tidal Current Plots

Model runs were then made showing tidal currents in the vicinity of the harbour and surrounding area for a spring tide and a neap tide, both with and without the proposed development.

Model plots have been produced at hourly intervals from 0400 to 1900 on the 14/12/19. Low water occurred at approximately 0600 and 1830 on that day, mid flood at 0900 and mid ebb at 1500. Plots for the mid flood and mid ebb for the existing situation and with the proposed works in place are given below in Figures 13 to 16. They show little change in tidal currents due to the works.

A number of plots are reproduced below, in figures 13 to 16.

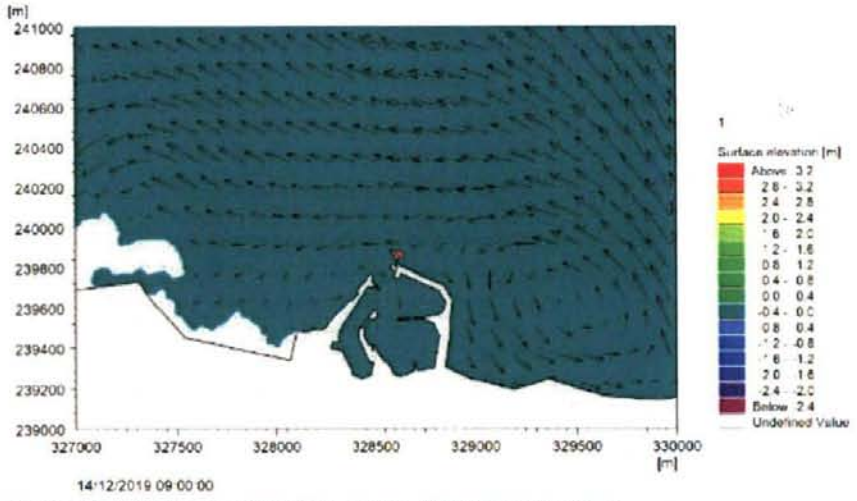

Figure 13: Mid Flood Tidal Currents, Existing Situation

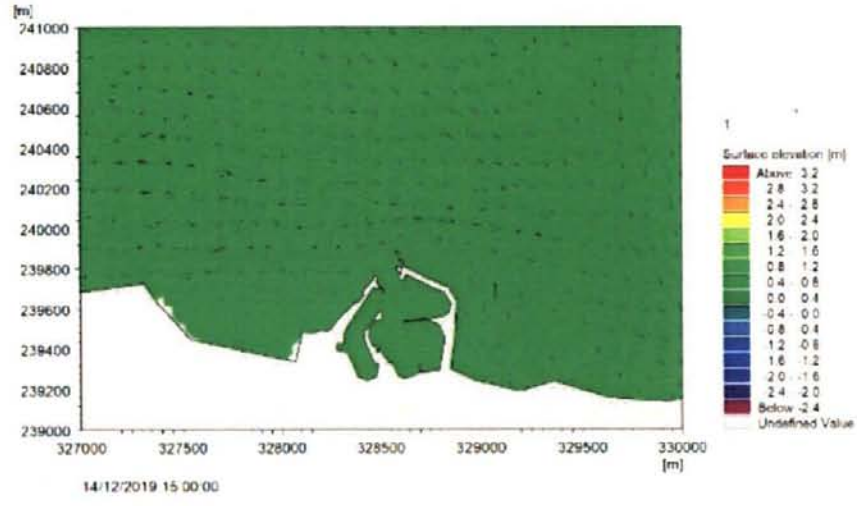

Figure 14: Mid Ebb Tidal Currents, Existing Situation