Galway Harbour Company

Galway Harbour Extension

RESPONSE TO

REQUEST FOR FURTHER INFORMATION

OCTOBER 2014

DOCUMENT AMENDMENT RECORD

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Project: Galway Harbour Extension

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TOBIN Consulting Engineers							

Galway Harbour Company

Galway Harbour Extension

Response to

Request for Further Information

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1 INTRODUCTION

GUIDANCE ON DOCUMENTATION SUBMITTED IN RESPONE TO AN BORD PLEANÁLA REQUEST FOR FURTHER INFORMATION [RFI] OF 27TH MAY 2014-10-14

The response to the Request for Further Information [RFI] is presented in separate ring binders / volumes as follows:-

1.1 RESPONSE TO REQUEST FOR FURTHER INFORMATION.

The layout follows the sequence of issues raised in the RFI.

- Alternatives.
- Noise – Vibration.
- Marine Hydrology Issues
- Ecology Issues.

  Dr. Michelene Sheehy-Skeffington has carried out an assessment of the salt marshes and stony banks adjacent to Renmore Lough having regard to the winter storms of early 2014.

- Marine Mammals

  Kelp Marine Research, Hoorn, The Netherlands, a research organisation in cetacean behaviour and ecology were engaged to assist in:-

  (i) A desk top analysis to address harbour seal habitat, and
  (ii) A risk assessment of marine mammals in the area of the proposed development.

- Birds

  Dr. Tom Gittings, Whitegate, Cork an ecological consultant was engaged to assist in a desk study to assess the sensitivity of bird species to potential impacts from the proposed development.

1.2 APPENDICES TO RFI

This volume includes the following Appendices:

RFI 1 - **Consideration of Development in Context of Article 6[4] of the Habitats Directive as Transposed into Irish Law.**

RFI 2 - **Mammals**

RFI 2.1 - Seal Raw Data
RFI 2.2 - Kelp Report
+ Risk Assessment for all Marine Mammals
+ Aquatic Habitat Use of the Harbour Seal

RFI 3 - **Birds**

RFI 3.1 - Birds Raw Data
RFI 3.2 - Species Profiles by Dr. Chris Peppiatt
RFI 3.3 - Bird Species Assessments by Dr. Tom Gittings

1.3 NIS ADDENDUM / ERRATA

Generally, the information presented in the NIS Addendum is new information which should be considered as ADDITIONAL to that included in the NIS as submitted with the planning application originally. ERRATA will be noted specifically, in addition to sections where it is considered that the information considered in the NIS Addendum should supersede information presented in the main NIS document. Where possible, reference material which was previously presented in the EIS and has now been incorporated into the NIS Addendum is presented as Appendices, as this information is not necessarily new information. Similarly, where new information has been prepared by external consultants, relevant portions have been incorporated into the body text of the NIS Addendum, with their original report presented in an Appendix for reference. Where possible, the NIS addendum follows the same sequence and numbering system as the original NIS with notes provided to show where no additional information has been added under a heading or sub-heading.

1.4 APPENDICES TO NIS ADDENDUM / ERRATA

Chapter 1 - No Appendices

Chapter 2

- Appendix 2.1 - Lough Atalia and Renmore Lagoon Habitats
- Appendix 2.2 - Benthic Fauna
- Appendix 2.3 - Salmon Smolt Tracking and Fish Predation Surveys
- Appendix 2.4 - Otter
- Appendix 2.5 - Seal Raw Data
- Appendix 2.6 - Kelp Report
  - \+ Risk Assessment for all Marine Mammals [Excluding Otter]
  - \+ Aquatic Habitat Use of the Harbour Seal
- Appendix 2.7 - Raw Bird Data
- Appendix 2.8 - Bird Species Profiles by Dr. Chris Peppiatt
- Appendix 2.9 - Lough Corrib SPA SCI's

Chapter 3

- Appendix 3.1 - Potential Impacts and Mitigation
- Appendix 3.2 - Chapter 8 from original EIS
- Appendix 3.3 - Marine Hydrology Issues
  - 3.3.1 - Sediment Transport / Morphology Modelling
  - 3.3.2 - Potential for Transport of Sand for River Corrib
  - 3.3.3 - Modelling of Wind Waves
  - 3.3.4 - Wind Waves and Current Effects
  - 3.3.5 - Wind Waves and Coastal Areas
  - 3.3.6 - Effects of Sea Bed Roughness
  - 3.3.7 - Wind Waves and Friction
  - 3.3.8 - Outfall Dispersion Study
  - 3.3.9 - Mapping of Maximum Wave Heights
  - 3.3.10 - Mapping of Areas of Potential Flood Risk
- Appendix 3.4 - Bird Species Assessments [Dr. Tom Gittings]
- Appendix 3.5 - Oil Spill Contingency Plan
- Appendix 3.6 - The Port of Galway Marine Emergency Plan [Galfire]
- Appendix 3.7 - Environmental Management Framework

1.5 EIS ADDENDUM / ERRATA AND APPENDICES

This volume includes the following:

- Addendum to Non-Technical Summary
  [Amendments to Sect. 7.3 – Impacts]

- Addendum to Chapter 3 – Background & Alternatives

- Addendum to Chapter 7 – Flora & Fauna

- Addendum to Chapter 8 – Water
  [Marine Hydrology Issues]

- Appendices to EIS Addendum / Errata

  - **EIS[A] 1 - No Appendix**

  - **EIS[A] 2 - Mammals**
    + EIS[A] 2.1 - Seal Raw Data
    + EIS[A] 2.2 - Kelp Report
      * Risk Assessment for all Marine Mammals [except Otter]
      * Aquatic Habitat Use of Harbour Seal

  - **EIS[A] 3 - Birds**
    + EIS[A] 3.1 - Birds Raw Data
    + EIS[A] 3.2 - Species Profiles by Dr,. Chris Peppiatt
    + EIS[A] 3.3 - Bird Species Assessments by Dr. Tom Gittings

1.6 RFI FROM AN BORD PLEANÁLA

For ease of reference a copy of the RFI from ABP is included at the following pages.

Our Ref: 61.PA0033

Your Ref: JPK2139

An Bord Pleanála

John P. Kelly
Tobin Consulting Engineers
Fairgreen House
Fairgreen Road
Galway

27th May 2014

**Re: Galway Harbour Extension,
Renmore and Townparks Townlands, Galway**

I have been asked by An Bord Pleanála to refer further to the above-mentioned proposed development which is before the Board for consideration.

Please be advised that the Board, in accordance with section 37(F)(1) of the Planning and Development Act, 2000, as amended, hereby requires you to furnish the following further information in relation to the effects on the environment of the proposed development:

Alternatives:

1. The information contained in Chapter 3 of the EIS in relation to alternatives is noted. S177AA (1) of the Planning and Development Act states that the competent authority can, 'only in the absence of alternative solutions' consider that consent should nevertheless be given for the proposed development for imperative reasons of overriding public interest. EU Commission Policy (Integrating Biodiversity and Nature Protection into Port Development (2011)) notes that a plan or a project that has ignificant effects on a Natura 2000 site is to be authorised on the basis of imperative reasons of overriding public interest under Article 6.4 of the Habitats Directive, that this Directive requires a justification of such reasons as well as the absence of alternative solutions with less or no adverse effects. The Board notes that the Shannon Foynes Master Plan 2041 has been prepared. Part of the preparation involved the publication of the 'Shannon Foynes Port Company Vision 2041 Natura Impact Report'. The applicant is requested to comment on this Report as part of the evaluation of alternative sites and particularly in light of the EU Commissions Policy which requires the evaluation of alternative solutions with less or no adverse effects.

Noise and Vibration:

1. Figure 10.4.1 to Figure 10.4.14 refer to noise level in terms of dB. Please clarify whether these figures refer to L_{Aeq} or L_{90} or some other parameter.

2. Please provide details of the sound power levels emanating from the machinery involved in the a) lagoon wall and lagoon construction (b) dredging works (c) quay wall construction and pile driving (d) traffic noise construction.

3. It is noted that the EIS calculates L_{den} for construction works. It is envisaged that the vast majority of construction works will take place during normal business hours and not during the evening and night-time. The applicant is requested to clarify why construction noise levels were calculated over a 24 hour period when the major construction works are to take place during normal business hours.

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4. It is not altogether clear whether the noise prediction model used in the EIS specifically takes into consideration that the noise in question will propagate across water. The applicant is requested to comment on this.

5. Section 10.2.4.1 of the EIS states that "as traffic noise is dominant during the day time the noise due to unloading bulk cargo is not considered". The applicant is requested to elaborate further on this point, having particular regard to the fact that port related activity can give rise to tonal and impulsive noise through loading and unloading of cargoes. The applicant is requested to comment as to whether or not a noise rating penalty was incorporated into the calculations in predicting future noise levels arising from the development. In this regard the applicant should indicate whether or not a one-third octave frequency band analysis from existing noise specifically generated by port related activity was carried out as part of the noise assessment.

6. It appears that the EIS estimates sound propagation based on a point source as opposed to a line source. The applicant is asked to comment on the appropriateness of this having regard to the fact that the dredgers will not be operating on a fixed point but will be moving up and down the channel alignment.

7. Finally in relation to noise and vibration it appears that the EIS does not assess the cumulative impact resulting from construction activities where various construction works are operating simultaneously on site. The applicant is asked to clarify and comment on this point.

Marine Hydrology Issues:

(a) Sediment Transport:

1. Section 8.4.2.6 of the EIS is a discussion of changes in the sedimentation patterns. These changes are partly due to the creation of a dredged access channel, and also due to the change in the flow direction of the Corrib in-and outflow. The discussion is based on considering changes in the computed bed shear stresses for a number of different scenarios. These bed shear stresses are compared with a table (8.4.1), from which it can be evaluated whether different fractions of the bed sediment can be moved or not.

   Deposition can occur in many places on a live bed (a bed on which sediment transport occurs). In section 8.4.2.6, it is stated "the bed shear stress dictates the rate of erosion and susceptibility of a location for deposition". This may apply to cohesive sediment like clay, but not necessarily apply to fine sand, which will settle as soon as the transport capacity (or bed shear stresses) decreases. The applicant is requested to comment on this.

   According to section 8.4.2.2, the model system contains a sediment transport module SISYPHE, but whether it has been applied to account for the morphological changes within the bay is not clear. In the EIS, "Marine Ecology and Modelling", it is stated that the mathematical modelling will include "Sediment transport modelling to include erosion and deposition rates, changes to morphology etc."

   Applying the sediment transport module, as an example, the impact of the harbour extension on the morphology west of the extension should be evaluated applying all the information contained in the plots 8.4.16 to 8.4.39. Similarly, the deposition pattern from the spill from Capital Dredging should be evaluated from figures 8.4.42 to 8.4.57. Please comment on the above, and identify where deposition/erosion could cause a problem.

2. Furthermore and related to the above estimates are required for the total annual transport of fine sand from the River Corrib (section 8.4.2.7) to assist in the understanding the near harbour morphology.

(b) Wind waves:

3. The wind waves appear to be quite small in the harbor area according to the model results presented in 8.4.6, mainly due to the protective impact from the Mutton-Island causeway. The near field wave climate in this area is modelled using the ARTEMIS numerical model. For waves coming from SSW and S, wave heights up to 1.6m can be attained, Figure 8.4.135. It seems that the near field wave climate is calculated without including impact of current, unlike the spectral wave model TOMAWAC applied further away. If that is the case, the waves can actually be even higher than predicted in the EIS at a large outflow from Corrib River combined with the tidal flow due to current refraction. Please provide further justification for the large change in the flow pattern in this area being of no importance for the wave climate.

4. Please clarify whether within the area that experiences high wind waves, willÿ the wave heights be exacerbated if the current-effects are included?

5. Will the wind waves approach the breaking point and under such a scenario could the radiation stresses increase the water level further inland, thus increase the risk of flooding in coastal areas and if so which coastal areas are particularly at risk?

(c) Flow resistance:

6. As an input into the flow resistance modeling, details of the sea-bed roughness is required. Is the bed roughness kept constant in all runs, and how sensitive are the results regarding the choice of this value, say changing it by a factor of 10 and 100?

7. Has the impact of wind waves been incorporated into this friction, or is that effect negligible?

(d) Outfall Dispersion studies:

8. Dispersion studies due to tidal flow have been analyzed for the existing Mutton Island outfall and the proposed Galway East outfall, applying a depth integrated model (TELEMAC-2D). The Corrib entrance is not impacted by the proposed Harbour extension according to these simulations. However, due to prevailing wind from SSW, a wind driven surface current may transport waste water from the Mutton Island Outfall towards the Corrib entrance, and the concentrations may be impacted by the harbor extension. Since the location is quite windy, as indicated from the wind data from the Belmullet station, presented in figure 8.4.123, a number of (5-10) runs should be made using TELEMAC-3D to consider whether this will create any potential issues in the in terms of pollution.

(e) Mapping

9. In section 8.4.6.7 of the EIS reference is made to maximum wave heights within the Bay. The applicant is requested to present the maximum wave heights in the form of a map.

10. Likewise section 8.4.7.3 of the EIS makes reference to the specific locations for potential flood risk. These are merely mentioned in the form of street names in the text. The applicant is requested to present this information in the form of a map.

Ecology Issues:

Annex I Habitats:

1. As a standalone document, the Natura impact statement (NIS) lacks some detail required, much of which is included in the environmental impact statement (EIS). This is particularly notable in the case of Annex I habitats. For example:

(a) Chapter 7 of the EIS details the evidence that there is no potential for interaction of habitats within the Galway Bay complex with designated habitats in other sites. This information should be incorporated more fully in the NIS.

(b) The EIS details mitigation measures to offset potential disturbance to Annex I habitats that should be explained in greater detail in the NIS because they are necessary to make an informed assessment of the potential operational effects of the proposed development on Annex I habitats. These include potential impactsfrom altering the local hydrography, management of invasive species, oil spill contingency plans and management plans for catastrophic events. Relevant sections within the EIS include Chapter 8, Appendix 4.2 and Appendix 4.3.

2. Detailed multivariate faunal analyses and sediment profile imagery (SPI) surveys of subtidal sediments are reported in Chapter 7 of the EIS, but the methodologies used for the assessment of sensitivity of these habitats to potential operational impacts could be improved. Many of the references quoted are very old. What is clear is that the macrofaunal communities of Inner Galway Bay are variable in composition because they are subject to frequent natural disturbance and occur on a mosaic of sediment types. Habitat quality, as a measure of conservation status (and sensitivity) should be determined using a multimetric index of the type developed for Water Framework Directive (WFD) monitoring. In Ireland, the index routinely used is the Infaunal Quality Index (IQI). This would enable the ecological status of the communities of the proposed development area to be empirically compared at different times and locations, despite the variable multivariate structure of the fauna. This may pertain particularly to the operational effects of proposed maintenance dredging. O'Reilly et al (2006) demonstrated, using a combination of SPI and faunal analyses, that habitat quality in the dredged channel approaching Galway Docks is lower than in the surrounding area. The spatial pattern of habitat quality (conservation status) should be assessed in the area to determine if the same pattern exists in the baseline data presented, and the potential impacts of maintenance dredging on Annex I habitats should be discussed. The applicant is requested to address the above points in a more comprehensive manner.

3. Appendix 7.4 of the EIS does not detail the methodology used to calculate the Benthic Habitat Quality (BHQ) index. This index has also been adapted for the purposes of the WFD, including an adjustment for the decreased expected occurrence of high BHQ values in shallow water, by Rosenberg et al (2004). The SPI data should be analysed using this methodology to support the macrofaunal data in assessing the conservation status of the Annex I habitats. The applicant is requested to address this.

4. The information provided in relation to terrestrial and coastal habitats is not sufficient to describe the structure, sensitivity, functioning and correspondence with Annex I habitats of these communities. This is of particular concern in the receiving environment to the east of the proposed development where saltmarsh and stony banks occur. The stony banks that form part of the barrier to Renmore Lough require particular study. Relevant habitats include perennial vegetation of stony banks (1220) Atlantic salt meadows (1330) and Mediterranean salt meadows (1410). The NIS states that the potential impacts on these habitats are "unlikely but must be considered to be Indeterminate". More information should be provided describing these habitats with particular reference to their structure and sensitivity to the potential impacts of the proposed development.

5. The applicant's study of coastal lagoons (1150) predates the storms of 2013-2014. A site visit by NPWS to these sites in 2014 has shown that the extent of stony banks has increased inland and into Renmore Lough. Further information is now required on the potential impacts of the proposed development on the stability of the barrier to Renmore Lough in light of these changes.

6. The first paragraph of Section 3.7 of the NIS states that an impact classified as "indeterminate" must be considered as "likely significant" when assessed with relevance to Article 6.3 of the Habitats Directive. In other words,"indeterminate" is not an acceptable classification for any potential impact.Despite this, the text of the NIS repeatedly classifies potential impacts as "indeterminate". The applicant is requested to re-evaluate the NIS with regard to these "indeterminate" classifications. You are requested to consider whether or not replacing them with "likely significant", as stated in Section 3.7, is appropriate so that the application can be fully assessed with relevance to Article 6.3. This applies to all text and tables in the NIS.

Marine Mammals:

1. The potential adverse impacts on harbour seal are described in the NIS and EIS.Given the nature of the proposed development and the importance of the development location for harbour seal, more information is required to assess the potential effects on this Annex II species. A robust and comprehensive desktop analysis is required to address harbour seal aquatic habitat use in the area and the observed impacts of similar developments and associated coastal/maritime activities on harbour seal populations in other locations. This should be done with the assistance of a suitably qualified seal ecologist and be based on international scientific research as well as information currently available from Ireland. The purpose of this analysis would be to better inform and better determine appropriate final conclusions in the relevant impact statements regarding the likelihood and significance of any adverse effect on the conservation objectives of the site arising from the proposed development.

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2. Detailed environmental impact and Natura impact statements are provided in relation to cetaceans as part of the current application. However, these do not clearly present activity-specific assessments of risk in relation to all Annex IV cetacean species likely to occur at the site. Potential adverse impacts on cetaceans that may arise from the development as it is currently described include (i) the effect of collisions with shipping and other vessels, (ii) direct disturbance and/or injury due to sound and intensified motorised vessel/plant/construction activities, and (iii) secondary impact due to localised disruption of normal ecological activity. It is the current policy of the Department of Arts Heritage and the Gaeltacht that a proposed development of this nature should undergo an appropriate and comprehensive risk assessment specific to any and all cetacean species occurring in the operational area concerned. In the context of the proposed extensive marine development, the Department's Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters (January 2014) provides instructive information such that the risk to protected marine mammal species arising from underwater sound can be characterised, assessed and managed as appropriate. This guidance and the associated risk assessment requirements were first published by the Department in public consultation form in March 2012. The risk assessment should be carried out with the assistance of a suitably qualified cetacean ecologist and be based on international scientific research as well as information currently available from Ireland.

Birds:

1. The assessment of bird distribution and behaviour in the proposed development area should be supplemented with additional data. Bird data of this type is inherently variable and it is unlikely that the duration of the proposers study would have been sufficient to characterise the birds at the site. While the proposer's assessment did incorporate data from additional sources, including bird atlases and the Irish Wetland Bird Survey (I-WeBS), these data are generally more than ten years old, and many are much older. The EIS does not cite the latest I-WeBS survey of waterbirds in Ireland (Crowe et al, 2012). This study ranks Inner Galway Bay as being 15th of Ireland's internationally important sites in terms of waterbird abundance rather than 24th as stated in the EIS. The EIS also does not report that Inner Galway Bay is currently listed as having the highest number of several species in Ireland including Great Northern Diver and Red-breasted Merganser (Boland and Crowe, 2102). While not available at the time of EIS and NIS submission, the most recent revision of Birds of Conservation Concern in Ireland (Colhoun and Cummins, 2013) is now available and pertinent information from this study should be included in the revised submission. Of particular importance is the change in status of Great Northern Diver to an amber-listed species because of Ireland's importance on a European scale in supporting significant numbers of this species in the non-breeding period.

2. The assessment of sensitivity of the listed bird species to potential impacts from the proposed development would be greatly improved by a comprehensive desk study that incorporated species specific information concerning the ecology of each species. The desk study should be carried out with the assistance of a suitably qualified waterbird ecologist and be based on international scientific research as well as information currently available from Ireland. Many species appear to have been assessed as being the same group despite having markedly different ecologies. The effects of many potential impacts on birds are listed as "indeterminate". The desk study may resolve many of the "indeterminate"classifications. As noted above, the potential impact of any activity may not be classified as "indeterminate" and should be classified as "likely significant"in the case of uncertainty.

3. There is a notable lack of proposed mitigation measures in the NIS to offset potential impacts on waterbirds. The detailed desk study requested may go some way to informing this. As for Annex I habitats, topics raised in the EIS concerning good environmental practise during construction and operation of the proposed development may partially address this issue.

4. Some potential impacts on waterbirds were not considered in the NIS. Anỷ additional impact requiring consideration is the effect of extreme weather on bird species and the interaction of the proposed development with this. There is also a potential impact to some bird species from increased recreational boating and shipping that is not associated with noise. Some species, such as Great Northern Diver, are displaced from foraging areas by the proximity of vessels at distances of more than a kilometer (Furness et al, 2012). Maintenance dredging of the turning circle may be a permanent impact of some diving species. These impacts, as with all potential impacts, should be considered separately for each species.

5. There appears to be some inconsistency in the information provided about waterbirds in the NIS. For example, Inner Galway Bay is listed for three breeding species: Cormorant, Sandwich Tern and Common Tern. For each of these breeding species, all attributes were assessed with no significant impacts predicted. However, the assessment goes on to assess the impacts separately (i.e. impacts during construction phase; impacts during the operational phase; and in-combination effects). This results in a common and repeated statement of "this impact is not likely to be significant, but is indeterminate". With no proposed mitigation stated in Table 3.11, the residual impact for all these three breeding species is considered to be "indeterminate". The applicant is required to re-evaluate the section on waterbirds contained in the NIS in the context of the above comments.

6. The applicant is requested to assess in a more comprehensive manner the 'In combination effects' of the proposed development with other developments. To clarify; the Inner Galway Bay SPA was designated in 1994 before the Port development of the 1990s. The SPA boundary was set at the high water mark. For some species such as Ringed Plover, the impact of the Port development is listed in table 3.15 as the loss of terrestrial habitat. It was in fact the loss of intertidal habitat, and should be considered so in combination with the proposed development. There is little consideration in the NIS of the effect of the loss of this habitat on waterbirds. The NIS does not go into a sufficient level of detail in relation to the likely areas associated with the take-off, landing and approach areas that are associated with the consented Galway Harbour flights operation. This is relevant in terms of assessing the in-combination disturbance levels to those birds associated with the subtidal areas of Inner Galway Bay SPA.

The further information referred to above should be received by the Board **no later than 5.30 p.m. on Monday the 1st of September, 2014.**

Please note that following its examination of any information lodged in response to this request for additional information, the Board will then decide whether or not to invoke its powers under section 37(F)(2) of the Planning and Development Act, 2000, as amended, requiring you to publish notice of the furnishing of any additional information and to allow for inspection or purchase of same and the making of further written submissions in relation to same to the Board.

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If you have any queries in relation to the matter please contact the undersigned officer of the Board. Please quote the above-mentioned An Bord Pleanála reference number in any correspondence or telephone contact with the Board.

Kieran Doherty
Executive Officer
Direct Line: 01-8737248

AHC/PA33.13.LTR

2 ALTERNATIVES:

Query:

The information contained in Chapter 3 of the EIS in relation to alternatives is noted. S177AA (1) of the Planning and Development Act states that the competent authority can, ‘only in the absence of alternative solutions’ consider that consent should nevertheless be given for the proposed development for imperative reasons of overriding public interest. EU Commission Policy (Integrating Biodiversity and Nature Protection into Port Development (2011)) notes that a plan or a project that has significant effects on a Natura 2000 site is to be authorized on the basis of imperative reasons of overriding public interest under Article 6.4 of the Habitats Directive, that this Directive requires a justification of such reasons as well as the absence of alternative solutions with less or no adverse effects. The Board notes that the Shannon Foynes Master Plan 2041 has been prepared. Part of the preparation involved the publication of the ‘Shannon Foynes Port Company Vision 2041 Natura Impact Report’. The applicant is requested to comment on this Report as part of the evaluation of alternative sites and particularly in light of the EU Commissions Policy which requires the evaluation of alternative solutions with less or no adverse effects.

Response:

The response to this section was prepared by project team ecologists Brendan O’Connor and Corina Colleran, in addition to specialist input from Tom Gittings (ornithologist) and Simon Stephenson (marine acoustics expert).

DKM Economic Consultants were commissioned to prepare both a cost benefit analysis of Galway Harbour Extension (GHE), followed by a report on the feasibility of Shannon Foynes as an alternative port location to serve Galway Ports region. The report on the Shannon Foynes alternative concludes that there are compelling reasons why the alternative solution of the port of Shannon Foynes servicing Galway Port’s region, is not feasible from a policy, socio-economic and environmental perspective and that the Applicant and the Design Team consider that there are overriding reasons of public interest why GHE should proceed.

That report entitled *“Consideration of development in the context of Article 6(4) of the Habitats Directive as Transposed into Irish Law”* is attached as Appendix RFI 1 of this Response to the Request for Further Information.

In addition the discussion on alternatives in Chapter 3 of the EIS has been expanded with the additional text included in the EIS Addendum / Errata.

The ‘Shannon Foynes Port Company Vision 2041 Natura Impact Report’ (SFPC NIR) was reviewed. The Shannon Foynes NIR is an Appropriate Assessment (AA) of a high level non-statutory Vision document which is based primarily on desk study information, with little information regarding engineering design or construction methods. In contrast, the Natura Impact Statement (NIS) for the Galway Harbour Extension project, which is a proposed project for which detailed design information is available. The AA for the Galway Harbour Extension project is based on a significant amount of field data from detailed field surveys and detailed engineering and construction information. This makes it difficult to compare the projects and their impacts on Natura 2000 sites on the basis of the information provided within the SFPC NIR document.

According to the SFPC Vision 2041, the document is non-statutory with the proposed options at this stage considered as concepts only, which may be developed should the predicted growth in tonnage envisaged over the next 30 years transpire. Options are 'not exhaustive' and not prescriptive. Technical details have not been expanded on, nor has any detailed engineering or detailed design information been provided. The description of the components of Vision 2041 provides for a number of key objectives including the provision of appropriate infrastructure and facilities to meet future demands, identification of configuration for extending berthage and storage, provision of adequate deep water berths and provision of additional warehousing and storage facilities as the need arises.

The SFPC Vision 2014 document contains a number of strategic objectives, which are listed in tables at the end of each chapter. These objectives are listed in bullet points in Section 4.2 of the NIR and linkages between the objectives and Natura 2000 sites are listed in Table 6.1 of the NIR. The latter table also gives linkages between the objectives and strategic sites identified in the Strategic Integrated Framework Plan for the Shannon Estuary (SIFP). Therefore, while the SIFP strategic sites are not explicitly referred to in the SFPC Vision 2041 document (which predates the SIFP), the NIR has interpreted the relevant strategic sites as bringing forward objectives of the SFPC Vision 2041 document and has included these sites in the assessment carried out for the NIR.

The SIFP strategic sites included in the NIR are:

- Site C - Foynes Island
- Site D - Lands to the east of Foynes Port
- Site E - Akseaton Business Park
- Site I - Limerick Docks

2.1 APPROPRIATE ASSESSMENT APPROACH

The Appropriate Assessment of plans contains an inherent degree of uncertainty because of the strategic nature of plans and the lack of detailed proposals for concrete actions that can be assessed. This is acknowledged in Scottish Natural Heritage's guidance on the *Habitats Regulations Appraisal of Plans* (David Tyldesley and Associates, 2012), which states that:
'the precautionary principle needs to be applied, in plan appraisal, in a way that recognises the more general nature of plans, and does not unnecessarily or unreasonably prevent or impede the adoption of plans. If the implications of uncertainty are taken to an extreme, it would be impossible for many plans ever to meet such an extreme test, simply because of their non-specific and more general nature.'

Therefore, it would not be reasonable to expect the SFPC Vision 2041 NIR to have the same level of detailed assessment and certainty about likely impacts as would be expected from a project-specific assessment (such as the assessment for the Galway Harbour Extension). However, for the SFPC Vision 2041 NIR to be useful in developing the SFPC strategic objectives, it needs to contain some level of assessment of likely impacts arising from specific actions connected with the objectives being assessed. While relevant guidance (David Tyldesley and Associates, 2012; Scott-Wilson et al., 2006) indicates that it is acceptable to address potential impacts through prescribing how adverse impacts will be avoided by mitigation measures in a lower tier Appropriate Assessment, the guidance emphasises the importance of identifying the specific risks arising from the objectives being assessed, prescribing explicit case-specific mitigation addressing these risks, and adding these mitigation requirements to the policy.

2.2 FUNCTION OF AA PROCESS

SFPC has undertaken AA to identify key gaps, potential impacts and threats which would need to be addressed at a later stage. Under Article 6(3) of the Habitats Directive, the AA process is required for any plan or project, and the SFPC Vision may be considered a plan rather than a project, given the conceptual nature of the document. However, the AA process should not be undertaken to identify key gaps, as EC Guidance on Appropriate Assessment states that '*where there are gaps in the information, it will normally be necessary to supplement existing data with further survey fieldwork*' (EC Guidance, 2001; Assessment of Plans and Projects Significantly Affecting Natura 2000 Sites: Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC, Office for Official Publications of the European Communities, Luxembourg).

2.3 AA SCREENING RATIONALE

SFPC Vision 2041 was screened in for immediate progression to Stage 2 Appropriate Assessment as the potential for significant negative impacts associated with the plan existed. Details of the screening process, or the screening out of a number of designated sites within a 15km radius has not been expanded upon within the document. However, given that the site is a marine setup with port operations, it is considered that mobile marine mammal and fish species from Natura 2000 sites further than 15km from the site, have potential to be impacted and should have been considered.

2.4 REQUIREMENT FOR MORE DETAILED BASELINE ECOLOGICAL INFORMATION

The SFPC NIR includes information including some more detailed analysis of impacts on cetaceans and birds, but the document also identifies that additional surveys in the following areas would be required:

- Habitat surveys to characterise the seabed and identify sensitive habitat and species within strategic sites
- Detailed surveys to examine the marine mammal (primarily Bottlenose Dolphin) distribution and use around, and within, the strategic site if not already known or insufficient research exists for the area in order to fully understand and mitigate for this risk
- Detailed otter surveys to fully mitigate for risks to this species
- Site specific surveys for birds to identify the presence of key foraging hotspots and/or resting areas and to aid site selection within the strategic site
- As part of proposed monitoring, a survey for the presence of Salicornia, spot bird counts and continued Static Acoustic Monitoring of cetaceans are proposed.

On the basis of this admitted lack of information in relation to the existing baseline condition of the site, upon which the assessment of significance of impacts was based, it is difficult to identify how the conclusion of no significant impacts was formed beyond reasonable scientific doubt.

2.5 AA CONCLUSIONS AND MITIGATION MEASURES

The SFPC NIR concludes that '*the proposed Vision will avoid significant negative impacts to key sensitive receptors and qualifying features of the SAC and SPA*', but recommends that '*mitigation measures detailed herein are developed further with National Parks and Wildlife Service and Inland Fisheries Ireland*'.

'*Effective mitigation of adverse effects on Natura 2000 sites can only take place once those effects have been fully recognised, assessed and reported*'. (EC Guidance, 2001 Assessment of Plans and Projects Significantly Affecting Natura 2000 Sites: Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC, Office for Official Publications of the European Communities, Luxembourg).

The conclusion checklist within the SFPC NIR outlines that no Environmental Management System has been included as part of the assessment (either as a mitigation measure or otherwise) and that SFPC are in the process of developing such a plan. It could therefore be assumed that current activities are not being undertaken in line with any formal Environmental Management System, and no such document is available on the SFPC website. In the absence of such a system, it is difficult to identify how a conclusion of no likely significant effects on Natura 2000 sites or their conservation objectives has been reached.

2.6 IMPACTS ON HABITATS

The document also concludes that dredging activities '*aim to achieve the least impact on Natura 2000 conservation objectives'*, but does not conclude that no likely significant impacts will arise as a result of such activities, as is required to proceed under Article 6(3). Current maintenance dredging activities have a current Dumping at Sea licence from the Environmental Protection Agency, which was the subject of a separate Appropriate Assessment, but similarly relied on a lack of detailed survey information with particular regard to birds, habitats and otter. The locations within which the current dredge material is disposed are within the River Shannon and River Fergus Estuaries SPA and Lower River Shannon SAC. It is considered that alternative locations for disposal of maintenance dredging material outside Natura 2000 sites (as is proposed for the Galway Harbour Extension project) could have been identified and considered as suitable alternative solutions with less or no adverse effects.

'*As no areas of inter-tidal mudflats, saltmarshes or habitats of a similar nature are located within the dredge or dump sites, this is not considered to have a significant effect on the integrity of the SAC or SPA as no loss of potential bird feeding areas will occur*' (from Table 4-1 of SPFC Maintenance Dredging Appropriate Assessment document)

While it is acknowledged that inter-tidal mudflats, saltmarsh and similar habitats are important habitats for the bird species for which the SPA is designated, the AA fails to identify what habitats are present within the dredge and dump sites and fails to present bird survey data to identify the use of the proposed dredge and dump sites by bird species. In the absence of such data, it is difficult to identify how the above conclusion was formed beyond reasonable scientific doubt.

'*Physical damage such as siltation and smothering may occur from the disposal of dredged material at sea. This can cause smothering of benthic communities which the birds feed on and cause disturbance*.' (from Table 4-1 of SPFC Maintenance Dredging Appropriate Assessment document). The SFPC NIR mentions that new shore facilities will be required to cater for increased shipping. However, the area that this new working space will require is not given in the document. New quay walls will by their nature be required to be built in the sea and this will involve the loss of qualifying interest habitats such as intertidal muds and sands and shallow bays and inlets.

2.7 ORNITHOLOGICAL INFORMATION INCLUDED IN THE SFPC VISION 2014 NIR

Section 6.2.2.3 of the NIR describes the results of a desk review of waterbird count data for the River Shannon and River Fergus Estuaries SPA. This appears to be abstracted from the analysis carried out for the SIFP NIR.

The information in Section 6.2.2.3 is based on the results of the NPWS BWS counts carried out in the winter of 2010/11. This data was used to rate the 66 subsites according to two criteria: the number of SCI species recorded within the subsites, and the sum of the maximum counts for all waterbird species in the subsites. Each subsite was then given an overall importance value of high, medium or low, based on the combined rating across both criteria.

Section 6.2.2.3 of the NIR also refers to I-WeBS counts, and to other "sites within the estuary for which bird data exists" (e.g., swan sites, geese sites, etc.), but does not present any information from these sources. However, the document states that most of these latter sites are "outside of the priority development areas", and brief details of these sites are presented in the SIFP NIR.

In addition to the information presented in Section 6.2.2.3, some comments on bird distribution are included in the assessments of strategic sites in Appendix B of the NIR.

2.7.1 Impact assessment

2.7.1.1 Potential impacts

Section 6.3 of the NIR identifies potential effects that may arise from the SFPC Vision 2041. This is divided into four sectors: Renewable Energy, Marine-related Industry, Shipping and Navigation and Archaeology and Cultural Heritage. For each sector, links to SFPC objectives and to SIFP strategic sites are listed, and the potential effects of activities associated with the sector are tabulated. However, the potential effects are not explicitly linked to the SFPC objectives. The tables of potential effects provide a checklist of potential impacts but do not provide any assessment of the likely magnitude or significance of the impacts.

Section 6.4 of the NIR describes potential effects "emanating from the implementation of the Vision at project level". This provides a more detailed discussion of some of the potential effects listed in the tables in Section 6.3. Again, the potential effects are not explicitly linked to the SFPC objectives. The discussion provides some context that may help to evaluate some of the potential effects, but does not provide any explicit assessment of the likely magnitude or significance of the impacts in relation to specific objectives of the SFPC Vision 2041.

2.7.1.2 Detailed assessment

Section 6.5 of the NIR is entitled *Detailed Appropriate Assessment of Significant expansion opportunities*. This refers to the development of the lands in Sites D and E. In addition this section refers to the potential development of deep water berthage at Foynes Island and states that "this area relates to Site C". Section 6.5 does not provide any actual assessment of these sites but refers to the AA tables in Appendix 2. The latter includes tables for the above sites, as well as Site I, which is not mentioned in Section 6.5. These tables appear to have been reproduced from the SIFP NIR.

For each site, Appendix 2 contains separate tables for the SAC and SPA assessments. The SPA tables consider all the SCIs together. They list the SCI species recorded in the relevant subsites[1]. They describe the potential impacts, the likely potential impacts, mitigation measures and residual impacts.

The potential impacts are described primarily in terms of the importance rating of the relevant subsite. In addition, reference is also made to NPWS BWS roost data, where relevant.

The assessment of likely potential impacts for each site identifies disturbance as the main potential impact, although, for Sites C, D and E, the assessment also states that “there is very moderate” (Site C) or “low” (Sites D and E) “potential for direct impact to feeding areas of loss of habitat”.

The Mitigation section of the tables (called *Detailed Assessment* in the table for Site D) mainly contains generic text on mitigation that is identical in each table. However, some site-specific comments are included for Site C:

- No important bird wintering areas identified to the north and north east of the island.
- Areas of deep water in the Shannon Estuary including Foynes Island are described as being “relatively unimportant for waterbirds” (based on consultation with one of the main waterbird counters).
- The main feeding areas for waders and gulls are described as occurring on the east side of Foynes Island and the southern shore opposite the jetty is described as only being used by a small number of birds.

The Residual Impacts section of the tables contains a generic statement on alternatives and IROPI that is identical in each table.

2.7.2 Mitigation

Section 7 of the NIR deals with mitigation. It presents four tiers of mitigation:

- Use of AA criteria in site selection during the SIFP process.
- AA of the strategic sites as presented in Section 6.5 and Appendix 2 of the NIR (see above).
- Overarching mitigation arising from the AA of the general objectives of the SFPC Vision 2041.
- General mitigation measures per sector.

The overarching mitigation includes three measures focusing on ecological assessment and mitigation requirements during project level AA, one measure specifying a “no nett loss” principle and four measures dealing with potential water-related impacts.
The general mitigation measures per sector include a number of measures focused on birds. These measures address potential impacts from *direct physical damage to mobile species*

[1] The table for Site C also lists Black-necked Grebe, which is not a SCI species

and *indirect disturbance or loss of species*. These are generic mitigation measures and these measures are reproduced identically in each of the assessment tables in Appendix 2.

2.7.3 Monitoring

Section 8 of the NIR deals with monitoring. It includes an *Environmental Monitoring Programme* that focuses on using existing datasets and monitoring programmes, including the *Atlas of breeding birds in Ireland* (sic). However, the I-WeBS monitoring programme is not included, despite its more direct relevance.

The NIR does include one specific monitoring requirement aimed at birds:

Spot bird counts should be undertaken to the north and north west of Foynes Island throughout the year to establish if suitable foraging habitat is present/absent or whether birds are in fact utilising this part of the Island. This would eliminate any uncertainty in terms of potential impacts.

2.7.4 Conclusions

Section 9 of the NIR presents the conclusions of the assessment. The main content of this section is a table dealing with maintenance and capital dredging, which appears to be of limited relevance to the rest of the assessment.

The NIR concludes that "following the implementation of the mitigation described in this Appropriate Assessment it is expected that the proposed Vision will avoid significant negative impacts to key sensitive receptors and qualifying features of the SAC and SPA both alone and in-combination with the other elements identified in this report".

2.8 OTHER SPECIES

For fish and other freshwater species a mitigation measure to avoid siting structures in particularly sensitive sites (e.g. migratory routes, feeding and breeding areas) has been specified, although the details of these sites may not be known at this time. Similar mitigation is proposed for bat species, although detailed survey information is not referred to within the text. Mitigation to consider timing of dredge to avoid sensitive periods for benthic communities has also been specified, although details of the communities are not provided. It is understood that dredging is currently completed on a continuous basis and therefore mitigation regarding timing of dredge is not undertaken.

Mitigation measures are incorporated into the SFPC Vision 2041 NIR, including statements regarding mitigation which 'should' be undertaken at project assessment stage. The assessment has been concluded on the basis that these additional surveys will be completed as mitigation and/or monitoring and as part of the assessment process at project stage, but at this point significant negative impacts have been ruled out. There are references to uncertainties in terms of impacts to qualifying interests, but these uncertainties will be dealt with through research and monitoring schemes.

2.9 SUMMARY

It is acknowledged that there are significant limitations to the level of assessment that can be undertaken at plan or vision stage, but the document is heavily reliant on the implementation of mitigation and monitoring of qualifying interests in the absence of assessment based on survey based data.

For these reasons, it is not considered that the conclusion of the SFPC Vision 2041 NIR that significant negative impacts to key sensitive receptors and qualifying features of the SAC and SPA both alone an in-combination with other described elements, can be compared with the outcome of the NIS for the proposed Extension to Galway Harbour.

2.10 COMPARISON OF ECOLOGICAL RECEPTORS AT GALWAY BAY AND SHANNON FOYNES AREA

In the absence of detailed information regarding ecological receptors in the Shannon Foynes Area within the SFPC NIR document, and taking into consideration the request by An Bord Pleanala to comment on the report in light of the evaluation of alternative solutions with less or no adverse effects, an attempt has been made to compare the two development areas in terms of their ecological receptors, under a number of headings as outlined below:

- Designated Sites
- Protected Species

2.10.1 Designated Sites

At a high level, both development areas are located within and SAC and SPA. In both cases (for SACs and SPAs) the sites on the Shannon are larger in area. The Lower River Shannon SAC is significantly larger in area, but takes in a large freshwater component of the Shannon and tributaries, which could be compared to the Corrib in the case of Galway.

Designated Site	Area (in hectares)
Inner Galway Bay SPA (Site Code 0004031)	12,456.6ha
River Shannon and River Fergus Estuaries SPA (Site Code 0004077)	16,908.78ha
Galway Bay Complex SAC (Site Code 0000268)	14,408.98ha
Lower River Shannon SAC (Site Code 0002165)	68,329.57ha

2.10.1.1 Qualifying Interests of the Designated Sites

	Lower River Shannon SAC	Galway Bay Complex SAC
Annex I Priority Habitats	Coastal lagoons* [1150]	Coastal lagoons* [1150]
		Turloughs* [3180]
		Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco Brometalia)(*important orchid sites) [6210]
		Calcareous fens with (Cladium mariscus) and species of the Caricion davallianae* [7210]
Annex I Habitats	Mudflats and sandflats not covered by seawater at low tide [1140]	Mudflats and sandflats not covered by seawater at low tide [1140]
	Large shallow inlets and bays [1160]	Large shallow inlets and bays [1160]
	Reefs [1170]	Reefs [1170]
	Perennial vegetation of stony banks [1220]	Perennial vegetation of stony banks [1220]
	Salicornia and other annuals colonizing mud and sand [1310]	(Salicornia) and other annuals colonizing mud and sand [1310]
	Atlantic salt meadows (Glauco-Puccinellietalia maritimae) [1330]	Atlantic salt meadows (Glauco-Puccinellietalia maritimae) [1330]
	Mediterranean salt meadows (Juncetalia maritimi) [1410]	Mediterranean salt meadows (Juncetalia maritimi) [1410]
	Vegetated sea cliffs of the Atlantic and Baltic coasts [1230]	
	Spartina swards (Spartinion maritimae) [1320]	
	Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation [3260]	
	Molinia meadows on calcareous, peaty or clavey-silt-laden soils (Molinion caeruleae) [6410]	
	Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae) [91E0]	
	Sandbanks which are slightly covered by sea water all the time [1110]	
	Estuaries [1130]	
		(Juniperus communis) formations on heaths or calcareous grasslands [5130]
		Alkaline fens [7230]

Table 2.10.1Designated Sites – Qualifying Interests and Special Conservation Interests

	Lower River Shannon SAC	Galway Bay Complex SAC
Annex II Species	Otter (Lutra lutra) [1355]	Otter (Lutra lutra) [1355]
	Freshwater pearl mussel (Margaritifera margaritifera) [1029]	
	Sea lamprey (Petromyzon marinus) [1095]	
	Brook lamprey (Lampetra planeri) [1096]	
	River lamprey (Lampetra fluviatilis) [1099]	
	Salmon (Salmo salar) [1106]	
	Bottle-nosed dolphin (Tursiops truncatus) [1349]	
		Common seal (Phoca vitulina) [1365]

Table 2.10.1 contd/. Designated Sites – Qualifying Interests and Special Conservation Interests

2.10.1.2 Priority Habitats

Both designations have priority habitats present within the SACs; both have Coastal Lagoons as priority habitat. Galway has three additional priority habitats within the SAC – turloughs, orchid rich grasslands and cladium fen. The Galway Harbour Extension project NIS has included significant data and assessment with regard to coastal lagoons at Lough Atalia and Renmore, with a confident conclusion that the development will not result in impacts to any of the other priority habitats for which Galway Bay Complex SAC is designated.

2.10.1.3 Annex I (non-priority) Habitats

The sites share seven common qualifying Annex I habitats; Shannon has seven additional habitats and Galway has one additional habitat. So in all, Shannon is designated for 14 Annex I habitats and Galway is designated for 13. Galway has more priority habitats; both include non-marine habitats and both include Coastal Lagoons as a priority habitat.

2.10.1.4 Annex II Species

Shannon is designated for seven species in total; Galway is designated for two. Otter is common to both SACs. Shannon is designated for Salmon and lamprey species, in addition to freshwater pearl mussel. These species are protected as part of the Lough Corrib SAC however, which is within proximity to the Galway Harbour extension site. As part of the EIS and NIS for the Galway Harbour Extension project, an assessment including tracking and analysis of salmon smolt and migration patterns was undertaken, allowing for a conclusion that no significant impact to this species is considered likely to arise as a result of the proposed works. Bottlenose Dolphin is designated in Shannon which is a significant difference to the Galway site. Common seal is not a qualifying interest for Shannon, however.

2.10.2 Special Protection Areas

The special conservation interests of the relevant SPAs are outlined in Table X.X below. Shannon is designated for 21 species while Galway is designated for 20. Thirteen species are common SCIs for both designations. Galway has five Annex I bird species as part of the SCIs, while Shannon has three.

	Shannon Fergus Estuaries SPA	Inner Galway Bay SPA
Annex I Bird Directive Species	Dunlin *(Calidris alpina schinzii)*	Dunlin *(Calidris alpina schinzii)*
	Bar-tailed Godwit *(Limosa lapponica)*	Bar-tailed Godwit *(Limosa lapponica)*
	Whooper Swan *(Cygnus cygnus)*	
		Great Northern Diver *(Gavia immer)*
		Sandwich Tern *(Sterna sandvicensis)*
		Common Tern (*Sterna hirundo*)
Common SCIs	Cormorant (*Phalacrocorax carbo*)	Cormorant (*Phalacrocorax carbo*)
	Light-bellied Brent Goose (*Branta bernicla hrota*)	Light-bellied Brent Goose (*Branta bernicla hrota*)
	Wigeon (*Anas penelope*)	Wigeon (*Anas penelope*)
	Teal (*Anas crecca*)	Teal (*Anas crecca*)
	Shoveler (*Anas clypeata*)	Shoveler (*Anas clypeata*)
	Ringed Plover (*Charadrius hiaticula*)	Ringed Plover (*Charadrius hiaticula*)
	Golden Plover (*Pluvialis apricaria*)	Golden Plover (*Pluvialis apricaria*)
	Lapwing (*Vanellus vanellus*)	Lapwing (*Vanellus vanellus*)
	Curlew (*Numenius arquata*)	Curlew (*Numenius arquata*)
	Redshank (*Tringa totanus*)	Redshank (*Tringa totanus*)
	Black-headed Gull (*Chroicocephalus ridibundus*)	Black-headed Gull (*Chroicocephalus ridibundus*)
Other SCIs	Shelduck (*Tadorna tadorna*)	Common Gull (*Larus canus*)
	Pintail (*Anas acuta*)	Grey Heron (*Ardea cinerea*)
	Scaup (*Aythya marila*)	Red-breasted Merganser (*Mergus serrator*)
	Grey Plover (*Pluvialis squatarola*)	Turnstone (*Arenaria interpres*)
	Knot (*Calidris canutus*)	
	Black-tailed Godwit (*Limosa limosa*)	
	Greenshank (*Tringa nebularia*)	
	Wetlands & Waterbirds	Wetlands & Waterbirds

Table 2.10.2 SPA Special Conservation Interests Comparison

2.11 CONCLUSION

In conclusion, the following ecological issues have been arrived at based on the NIR :

1. The bottle nosed dolphin (which is a qualifying interest species for the Lower Shannon cSAC), a highly mobile and gregarious species, could be impacted by the increased shipping through greater disturbance (including noise) and physical damage (collision).

2. The proposed expansion of port facilities will require the destruction of qualifying interest habitats such as intertidal muds and sands and shallow bays and inlets.

3. Operational maintenance of the ports in the Shannon Estuary requires regular dredging within the cSAC which gives rise to permanent increases of levels of suspended sediments in the water column.

The proposed expansion of facilities in the Shannon Estuary is therefore considered to have greater ecological impacts than the planned Galway Harbour Extension project. Due to the lack of information in the SFPC Vision 2041 NIR, but nevertheless based on the precautionary principle, the level of impact of the proposed expansion of shipping in the Shannon Estuary must be considered as being significant.

3 NOISE AND VIBRATION

3.1 NOISE LEVEL PARAMATER

Query:

Figure 10.4.1 to Figure 10.4.14 refer to noise level in terms of dB. Please clarify whether these figures refer to L_{Aeq} or L_{90} or some other parameter.

Response:

The noise levels reported in Figure 10.4.1 to Figure 10.4.14 refer to LAeq.

In the interests of clarity, the following are the relevant definitions:-

dBA	A-weighted Sound Pressure level in decibels with a reference level of 20 □Pa
HF	High Frequency
L_pA	LpA (max) refers to a maximum A weighted sound pressure level, to correlate with that sound which a person would actually hear. Sound Pressure (A-weighted) is in dB re 20 μPa. L_{Aday}, L_{Aeq}, L_{Aden}, etc below are similarly weighted where indicated.
L_{day}	The noise indicator for annoyance during the day period. (07:00 to 19:00).
L_{den}	The 24 hour Leq calculated for an annual period, but with a 5 dB weighting for the evening and a 10 dB weighting for night. Directive 2002/49/EC.
L_{eq}	Shorthand for ‘equivalent continuous noise level’, which is a parameter that calculates a constant level of noise with the same energy content as the varying acoustic signal being measured. The Leq is an energy mean of the noise level averaged over the measurement period and often regarded as an average level. It is good practice to state the time period over which measurements were taken.
$L_{evening}$	The noise indicator for annoyance during the evening period, (19:00 to 23:00)
LF	Low Frequency
L_n	Typically L10 or L90, A noise descriptor based on the % of the measurement period for which a particular value was exceeded. L90 is typically reported as the background noise level, whereas L10 was used in the past as an indicator for traffic noise. As with Leq it is good practice to state the time period over which measurements were taken.
L_{night}	The night time noise indicator for sleep disturbance during the night. (23:00 to 07:00)
P_{ref}	Reference sound pressure used to calculate a level in decibels, for air the value is 20μPa and for underwater noise the value is 1μPa.
P_{rms}	Root Mean Square, the RMS value of a fluctuating quantity
PTS	Permanent Threshold Shift, the component of hearing absolute threshold shift for a given listener is increased through noise

	exposure that shows no recovery with time after the apparent cause has been removed.
SEL	Sound Exposure Level, a measure of the sound exposure in decibels. On this scale 0db corresponds to a steady sound pressure whose root mean square frequency-weighted sound pressure equals the reference pressure (1µPa underwater), persisting for a reference time of 1 second. Sound Exposure level can be applied to single events, as well as to noise of a continuing character.
SPL	Sound Pressure Level, at a given point is defined as SPL = $10\log10(p_{rms}/p_{ref})2$
TTS	Temporary Threshold Shift, the component of hearing absolute threshold shift for a given listener is increased through noise exposure that shows a recovery with time after the apparent cause has been removed. Recovery usually occurs within a period ranging from seconds to hours.
µg/L	Preferred dimension for microgram per litre.
µPa	micro Pascals

3.2 SOUND POWER LEVEL EMANATING FROM MACHINERY

Query:

Please provide details of the sound power levels emanating from the machinery involved in the (a) lagoon wall and lagoon construction (b) dredging work (c) quay wall construction and pile driving (d) traffic noise construction.

Response:

(a) The lagoon wall and lagoon construction data is based on a selection of equipment items from Tables D.3, D.8 and D.9 of BS 5228-1:2009 Code of practice for noise and vibration control on construction and open sites – Part 1: Noise.

Construction noise sources on a large site such as this will be dispersed over a large area and will operate intermittently on various duty cycles. In order to replicate this dispersal a range of equipment noise sources were analysed based on the quantities set out in section 4.5.2.21 of the EIS. As outlined in section 10.4.2.1 noise levels from this level of activity at 5 locations dispersed around the site is in the order of 45 dBA at the site perimeter.

The sound power level is based on an average level (LWA) of 15 items including Dozers, Tracked Loaders, Dump Trucks, Vibratory Rollers Lorries and Tracked Excavators. The average source level was corrected in accordance with Annex F - Estimating Noise from Sites. The resulting source level (LWA) of 97 dBA was placed at five separate source points around the site and noise level contours were calculated on that basis.

Source Data		Description	Sound Power Level L_{WA}
Table	Item	D3 Site Preparation	
D.3	27	Dozer	109
D.3	59	Tracked Loader	105
D.3	59	Lorry	105
D.3	52	Dump Truck	109
D.3	114	Road Roller	108
D.3	113	Tracked Loader	112
D.3	110	Dumper	102
D.3	115	Vibratory Roller	102
D.3	116	Vibratory Roller	106
D.8	16	Excavator Loader plus Lorry	108
D.3	117	Dozer plus Roller	114
D.3	118	Compactor Rammer	108
D.8	25	Road Roller plus Lorry	96
D.9	40	50T Dump Truck	104
D.3	109	Tracked Excavator	108
		Arithmetic Average	106.4
		KT adjustment (Figure F.5)	-10
		Composite Sound Power Level	97

The arithmetic average figure was used in the model, had the maximum value been used the noise level would equate to 51 dBA at the site boundary based on the conditions. Applying no KT adjustment would elevate this to 61 dBA. Section 10.2.4.1 outlines the extreme worst case scenario requiring several items of equipment to be operating simultaneously at the site boundary. At various stages of construction some noisy equipment will need to operate close together and in some cases at the site boundary. In these limited instances noise levels at the site boundary could reach 70 dBA (as stated in section 10.4.2.1). The separation distances to the nearest properties/amenity areas are set out in Table 9.4.1 of the EIS and exceed 480m in all cases.

Any elevated construction noise will be limited to the levels set out in Table 10.2.1 of the EIS.

(b) The sound power level for dredging activities was taken from publicly available data on dredging activities. The sound power levels used in the model calculations were 122 dBA for the backhoe dredger and 112 dBA for the Trailer Suction Hopper Dredger (TSHD). Typically backhoe dredgers emit more noise than TSHD dredgers, as stated in Section 10.4.2.4 of the EIS. Tobin Consulting Engineers has recently provided more specific information on the dredgers that may be used on the project which include the D.V Manu Pekka. This backhoe dredger has a sound power level of 110 dBA (12 dB lower than the EIS model). On that basis the sound power level used in the EIS is likely to be overestimated and dredging noise levels will be lower than those predicted in the EIS.

(c) The sound power level used for quay wall construction and pile driving was 126 dB based on 1.2m diameter king piles which form part of the structure. The majority of the piles are sheet piles which will be driven using vibratory driving, which results in significantly lower noise levels. This figure was based on the average of two values of sound power level for 1.07m dia. tubular casing piles being driven by a double acting diesel hammer piling rig given in Table D.4 of BS 5228-1:2009 Code of practice for noise and vibration control on construction and open sites – Part 1: Noise. The value is comparable to that used on large diameter impact piling operations. Piling noise from hydraulic powered sheet piling works is normally of the order of 100 dBA, which is considerably quieter.

(d) The construction traffic noise sound power level is based on 800 vehicle passes per day with a 50% contribution from Heavy Goods Vehicles.

3.3 RATIONALE FOR L_{DEN} FOR CONSTRUCTION WORKS

Query:

It is noted that the EIS calculates L_{den} for construction works. It is envisaged that the vast majority of construction works will take place during normal business hours and not during the evening and night-time. The applicant is requested to clarify why construction noise levels were calculated over a 24 hour period when the major construction works are to take place during normal business hours.

Response:

All of the noise prediction maps, with the exception of piling, are presented as L_{DEN} for assessment purposes. The piling map as presented showed levels as L_{night} and demonstrated that the levels, if piling was to be carried out at night time would be likely to have a significant adverse noise impact. As a result a decision was made that piling at night would not be carried out (and this is confirmed at section 10.7.2 of the EIS). The noise impacts associated with piling during daytime are the same as those shown on Figure 10.4.4 in the EIS on a L_{Aeq} basis.

Dredging works are proposed as 24 hour operations and the other construction activities will be carried out during the day-time. There may be some limited requirements due to tidal operations to operate outside 'normal' construction hours, so a worst case scenario was presented.

By presenting the results as L_{DEN}, the model output is approximately 6dB higher than if the results were presented as 'Day', 'Evening' or 'Night' results. This presents a worst case scenario and provides a margin of safety to the noise levels presented in the EIS.

3.4 NOISE PROPAGATION ACROSS WATER

Query:

It is not altogether clear whether the noise prediction model used in the EIS specifically takes into consideration that the noise in question will propagate across water. The applicant is requested to comment on this.

Response:

When calculating noise models the ground absorption factor G can be defined ($0 \le G \le 1$). A value of 0 is used for propagation over water or hard ground and a factor of 1 is used for porous soil. All of the models presented in the EIS are prepared using a universal ground absorption factor of 0 (propagation over water or hard ground). This means the model does take into consideration that the noise will propagate across water.

3.5 NOISE IMPACTS FROM LOADING & UNLOADING ACTIVITIES

Query:

Section 10.2.4.1 of the EIS states that "as traffic noise is dominant during the day time the noise due to unloading bulk cargo is not considered". The applicant is requested to elaborate further on this point, having particular regard to the fact that port related activity can give rise to tonal and impulsive noise through loading and unloading of cargoes. The applicant is requested to comment as to whether or not a noise rating penalty was incorporated into the calculations in predicting future noise levels arising from the development. In this regard the applicant should indicate whether or not a one-third octave frequency band analysis from existing noise specifically generated by port related activity was carried out as part of the noise assessment.

Response:

Section 10.2.4.1 refers to the modelling parameters. In the 'do something' scenario the loading and unloading of bulk cargo will relocate to the new berthage area which is considerably removed from noise sensitive properties in comparison to existing activities. Bulk loading and unloading of dry cargo such as limestone, coal, etc. is presently carried out around the clock when tidal conditions require but is generally confined to day-time.

Attended measurements taken at the port included in the EIS at Table 10.2.2 (2004), Table 10.2.3 (2007), Table 10.2.4 (2011) and Table 10.2.5 (2013) have indicated that loading of metal onto ships gives rise to impulsive noise. Third octave measurements taken at the same time demonstrate that there are no significant tonal noise components recorded at the port. Should the project be granted permission, it is not anticipated to result in any significant changes to the nature of the noise generated from the present port.

Loading of metal into ships has been recognised as a particularly noisy activity and is carried out during the day-time only. Section 10.2.3.2 of the EIS refers to this as follows: *The loading/unloading of scrap metal results in noise levels in the order of 70 to 75 dBA with noise peaks in excess of 90 dBA. (as measured 24/11/2010).* Noise levels of 70 to 75 dBA can arise in the existing docks area due to traffic noise.

In the context of a 'do something' scenario the loading and unloading activities will be relocated further away from noise sensitive properties. The impact arising from impulsive noise arising from loading metal into ships is restricted to day-time operation. The noise assessment was based on octave band analysis in the absence of any significant tonal noise from operations.

3.6 SOUND PROPAGATION FROM DREDGERS

Query:

It appears that the EIS estimates sound propagation based on a point source as opposed to a line source. The applicant is asked to comment on the appropriateness of this having regard to the fact that the dredgers will not be operating on a fixed point but will be moving up and down the channel alignment.

Response:

The dredgers will indeed move over the extent of the area to be dredged. The speed at which the dredgers will move is such that at any time the dredger will act as a point source. This is particularly the case of the backhoe dredger, which is the louder of the two operations.

The location of the source used in the model is the innermost point at which dredging will be required, i.e. worst case as outlined in section 10.4.2.4 of the EIS.

3.7 CUMULATIVE NOISE LEVELS FROM CONSTRUCTION WORKS

Query:

Finally, in relation to noise and vibration it appears that the EIS does not assess the cumulative impact resulting from construction activities where various construction works are operating simultaneously on site. The applicant is asked to clarify and comment on this point.

Response:

The construction period for the project is multi-year with different activities taking place in ‘blocks’ as set out in the stages of construction set out in the EIS. While some construction activity will be taking place in parallel with dredging for example, the individual activities are separated geographically. The overall site area is such that activities can be carried out in parallel provided there is a reasonable separation distance between them. When the noise level from one activity is 10 dB lower than the other no cumulative effect arises. Due to the scale of the site, activities will take place in ‘pockets’. The separation distance between activities such as the backhoe dredging, unloading the barge and lagoon formation will not result in any significant cumulative impact.

The EIS sets out Construction Noise Limits as presented in Section 10.2.2.3 of the EIS. Appendix 4.2 – Environmental Management Framework adopts these limits (refer Section 5.6.2.4) and proposes on-going monitoring during construction (refer Section 6.2 of Appendix 4.2). Monitoring of noise levels at the nearest sensitive receptors (which will include sensitive ecological receptors) will be carried out during the construction phase. In the event of cumulative noise levels in excess of those assessed being detected, corrective measures such as removing, reducing the operating time, screening or not using one or more plant items in order to reduce noise levels to those set out in Table 10.2.1 will be carried out.

4 MARINE HYDROLOGY ISSUES

4.1 SEDIMENT TRANSPORT:

Query:

4.1.1 Morphology Modelling

Section 8.4.2.6 of the EIS is a discussion of changes in the sedimentation patterns. These changes are partly due to the creation of a dredged access channel, and also due to the change in the flow direction of the Corrib in-and outflow. The discussion is based on considering changes in the computed bed shear stresses for a number of different scenarios. These bed shear stresses are compared with a table (8.4.1), from which it can be evaluated whether different fractions of the bed sediment can be moved or not.

Deposition can occur in many places on a live bed (a bed on which sediment transport occurs). In section 8.4.2.6, it is stated "the bed shear stress indicates the rate of erosion and susceptibility of a location for deposition". This may apply to cohesive sediment like clay, but not necessarily apply to fine sand, which will settle as soon as the transport capacity (or bed shear stresses) decreases. The applicant is requested to comment on this.

According to section 8.4.2.2, the model system contains a sediment transport module SISYPHE, but whether it has been applied to account for the morphological changes within the bay is not clear. In the EIS, "Marine Ecology and Modelling", it is stated that the mathematical modeling will include "Sediment transport modeling to include erosion and deposition rates, changes to morphology etc.".

Applying the sediment transport module, as an example, the impact of the harbour extension on the morphology west of the extension should be evaluated applying all the information contained in the plots 8.4.16 to 8.4.39. Similarly, the deposition pattern from the spill from Capital Dredging should be evaluated from figures 8.4.42 to 8.4.57. Please comment on the above, and identifying where deposition / erosion could cause a problem.

Response:

4.1.1 Introduction

In order to address the issues raised in Item 1 above a number of morphological modelling simulations using the SISPHYE sediment transport and bed evolution model were run. These simulations attempt to quantify the longer term depositional and erosional characteristics in the vicinity of the Harbour area and the potential impact of the proposed development over the existing case.

SISYPHE is a sediment transport and morphodynamic model which is part of the TELEMAC System. In SISYPHE, sediment transport rates, split into bedload and suspended load, are calculated at each node as a function of flow (velocity, depth, wave height, etc.) and sediment (grain diameter, relative density, settling velocity, etc.) parameters. The bedload and suspended load are calculated separately, bed load using a choice of classical relationships and suspended load using transport equations for depth-averaged suspended sediment concentration. The bed evolution is determined by solving the Exner equation. The sediment transport processes also include the effect of bottom slope, rigid beds (non-erodible) and a bed roughness predictor. To include hydrodynamics the SISYPHE model is dynamically coupled with the TELEMAC Hydrodynamic Model and wave conditions can be imposed in the model from formatted wave climate model output file.

As directed the impact of capital dredging was evaluated from the combined capital and maintenance dredge simulations presented in the EIS Figures 8.4.42 to 8.4.57.

4.1.2 Sediment Transport Simulations

In the EIS in Section 8.4.2.6 use was made of the bed shear stresses to identify locations where erosion / resuspension are likely to take place for different sediment sizes. The magnitude of shear stresses presented for various spring-neap and river flow conditions indicate that the potential erosive areas for fine sands are associated with the Corrib outflow velocities with very little potential outside of this area in respect to tidal flow velocities.

The SISYPHE model was ran to examine the sediment transport and evolution of the sea floor in the vicinity of the proposed development. This model used the same refined mesh as the hydrodynamics for both existing and proposed models.

The SISYPHE simulations indicated that under spring – neap tides and without river inflows the hydrodynamics were unable to mobilise sands from the sea bed in the vicinity of the proposed Harbour development and the existing navigation channel. For simulations with river flows median and winter flood flows, significant scouring of the Claddagh river channel and Lough Atalia inlet channel takes place when modelling coarse silts and fine sands. In reality these sections of river bed behave as rigid (non-erodible) beds as they already have been eroded free of these sediment fractions sizes.

Depending on the Corrib flow magnitude the scouring of the navigation channel for both existing and proposed cases extend seaward of the Corrib Entrance (at Nimmo's Pier) for silt and fine sediment fractions. At the lower summer flows of say 30cumec the Corrib sediment when present will temporarily settle inside the Corrib Entrance but will be flushed seaward once river flow increases.

4.1.3 Dredging History of Channel

The dredging History of the existing navigation channel is c. 63,000m^3 in 1978, 70,000m^3 in 1990 and 65,000m^3 in 2001 and has not been dredged since 2001. It is expected that the existing Navigational Channel will require maintenance dredging in 2016, which represents a gap of 15years. The above volumes equate to 100,170 tonnes, 111,300tonnes and 103,350 tonnes respectively based on a porosity of 40% and a grain density of 2650 kg/m^3 (equates to between 8,300 and 9,300 metric tonnes per annum). Based on the 2012 and 2014 HSL Bathymetry survey the deposition volume over the two year period between surveys is 18,200 m^3 (9,100m^3 per annum) and this includes the severe wave climate tidal flooding of January 2014. The main deposition area is just to the south of the Corrib entrance off Nimmo's Pier. This would agree with the winter flow conditions in the Corrib described in Figures 4.1.14 to 4.1.17 for sand (i.e. where it would drop the sand if present). At the end of January 2012 and 2014 the date of the two channel surveys, the River Corrib would have been in winter flow conditions and suggests that the sediment deposition observed from the difference in surveys is most likely sand as opposed to river silt.

Based on the low sediment yield characteristics of the Corrib it is considered that the majority of the deposition (possibly up to 80%) is from littoral deposition under wave action being swept in around Mutton Island and settling in the deeper channel and the remainder from the Corrib.

These figures indicate that the dredging requirement for the existing case is quite low requiring dredging on average every 12years at approximately 9,000tonnes per annum.

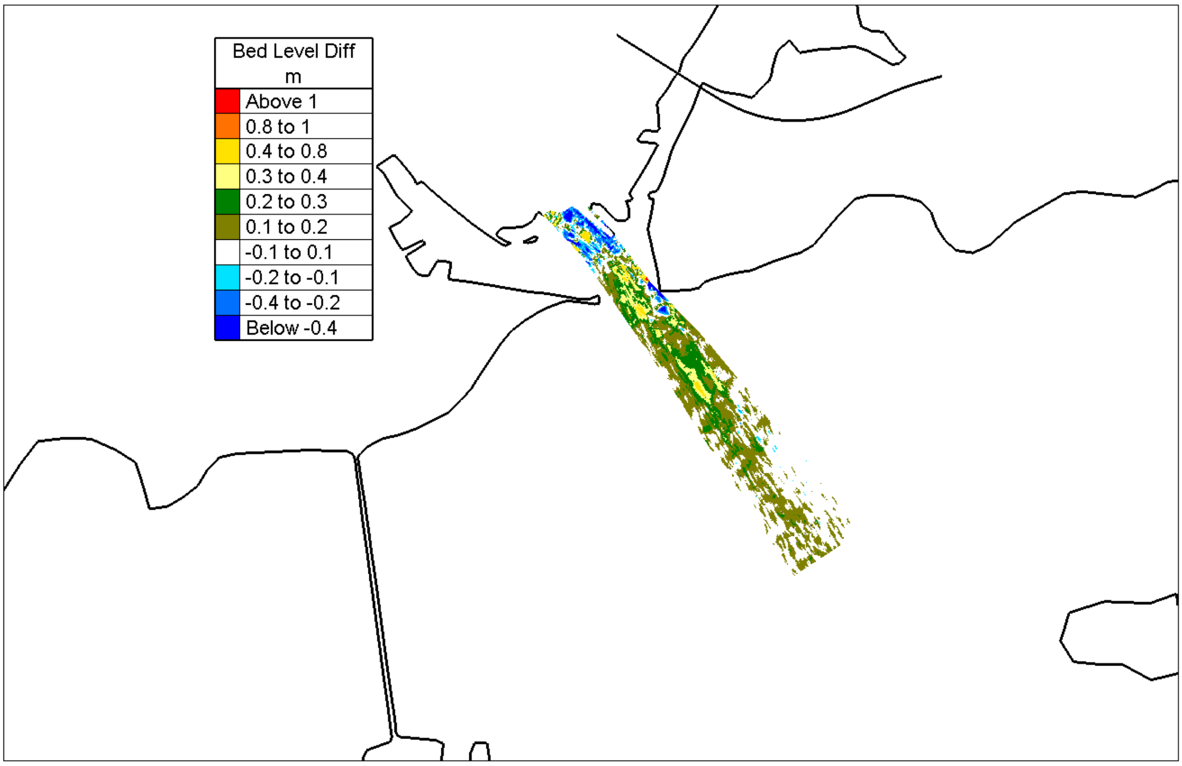

Figure 4.1.1 Difference plot of existing navigation channel HSL Survey - January 2014 and January 2012 showing principal deposition over 2 year period occurring primarily at and near the Corrib entrance.

4.1.4 River Corrib Sediment Deposition

In order to assess the contribution of the River Corrib sediment load on the Local morphology SISYPHE analysis was carried out using a rigid bed option so as to isolate the Corrib sediment input over ambient erosion and deposition features. Simulations were carried out modelling median river flow of 82cumec and 1% winter flow of 272cumec for a silt with d_{50} = 20microns and a fine sand/coarse silt with a d_{50} of 60microns. These were modelled as non-cohesive sediments. The Corrib inflow suspended sediment concentration was set at 10 mg/l (0.01kg/m^3). Based on Corrib sediment load assessment in Section 4.2 the average concentration is likely to be 3 to 4 times lower at 2 to 4 mg/l.

The simulations were run for 15day spring-neap-spring simulation with the evolution determined each time step and the bathymetry updated in the hydrodynamic model. The evolution results for a 20micron silt load from the Corrib under median (82cumec) flow conditions are presented in Figure 4.1.2 and 4.1.3 for the existing and proposed harbour cases and as depositional rates (mm per day) in Figures 4.1.4 and 4.1.5 respectively. The corresponding fine sand/coarse silt simulation results are presented in Figures 4.1.6 to 4.1.9.

As expected under median river flows for both existing and proposed cases the fine sand settles out near the Corrib entrance once velocities reduce, whereas for the smaller silt fraction (20 microns) this settles out more gradually over a larger footprint area. For both cases local elevated deposition is found adjacent to the New Pier to the east of the Docks gates. For the proposed case elevated local deposition is found at the proposed Marina entrance.

The sediment transport results for the larger Corrib winter flows are presented in Figures 4.1.10 to 4.1.17. These show similar pattern to the previous silt simulation results except that the deposition in the navigation channels occurs further seaward for both existing and proposed cases.

The Corrib flow magnitude dictates the extent that sediment is transported along the navigation channel. In low flow periods sediment is dropped inside the Corrib entrance and under median flows at the Corrib entrance and under winter flood flows seaward of the entrance. This depositional pattern is also evident from a comparison of the bathymetric surveys of the existing navigational channel between 2012 and 2014, refer to Figure 4.1.1.

The River Corrib simulation shows for the silt fraction under median (average) flows and suspended sediment concentration of 10mg/l that the Claddagh channel is self cleansing as far as the deeper water in the Corrib entrance adjacent to the Dock Gates. The depositional pattern shows settlement of silt within the length of the Channel and further south towards Mutton Island and also some settlement coming around into the new commercial Port (refer to Figures 4.1.2 to 4.1.5). Under typical winter flood conditions the simulations show that the proposed channel is self cleansing for virtually its entire length (4.1.10 to 4.1.13). The simulation shows the depositional pattern to be well spread out to the south, east, and west of the Harbour development and Mutton Island. The figures presented in the EIS 8.4.16 to 8.4.39 support the above findings in terms of the critical self cleansing velocities achieved in the proposed channel and the less efficient existing channel.

The simulation indicates that the silt fraction is well dispersed under winter flows and that a potential sediment bar towards the end of the navigation channel will not form under both existing and proposed cases.

A fine sand simulation modelling again a suspended sediment concentration in the Corrib of 10mg/l under median and winter flows shows that fine sand will settle out under median flow conditions (Figure 4.1.6 to 4.1.9). Under typical winter flows the sand is cleansed as far as the Marina Entrance where downstream of this (south) deposition is shown (Refer to Figure 4.1.14 to 4.1.17).

Based on the catchment characteristics of the Corrib and its sediment yield discussed in the Section 4.2, it is unlikely that persistent sediment concentrations of 10mg/l or higher will occur under median or Corrib flood flow conditions (with concentrations of 2 to 4mg/l being recorded) and that the sediment fraction being mobilised is a fine silt as opposed to sand and less likely to settle out in the immediate receiving waters of Galway Bay. Under these conditions the majority of the Corrib sediment will be dispersed as suspended sediment and will not settle.

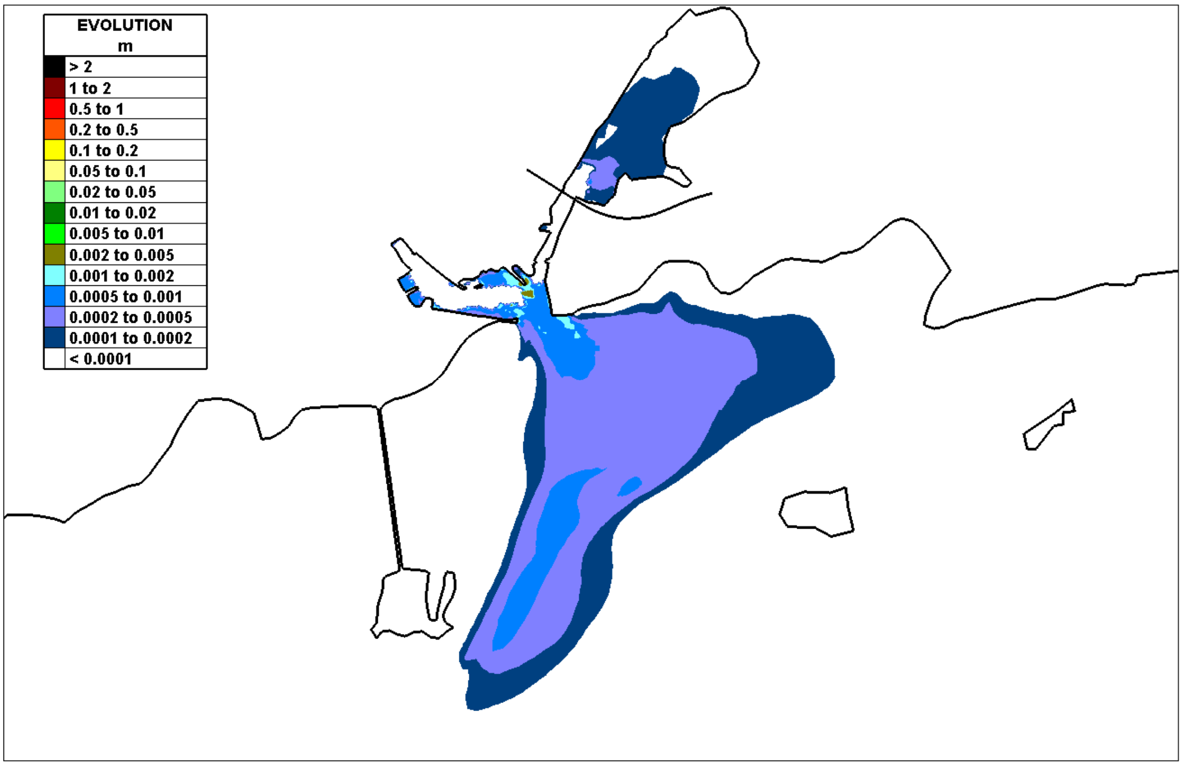

Figure 4.1.2 Deposition of a Corrib silt under median flows at the end of 15 days - Existing Case (the white area within the Claddagh Basin and Lough Atalia channel is self-cleansing.

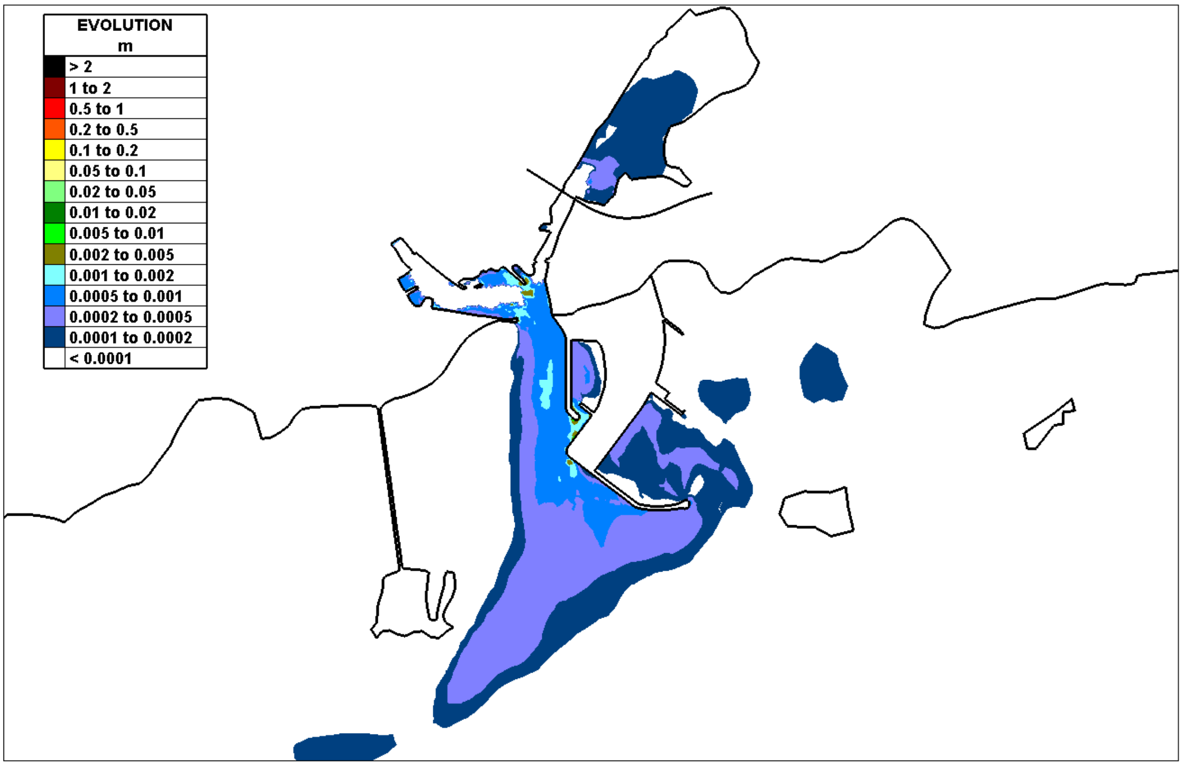

Figure 4.1.3 Deposition of a Corrib silt under median flows at the end of 15 days - Proposed Case (the white area within the Claddagh Basin and Lough Atalia channel is self-cleansing).

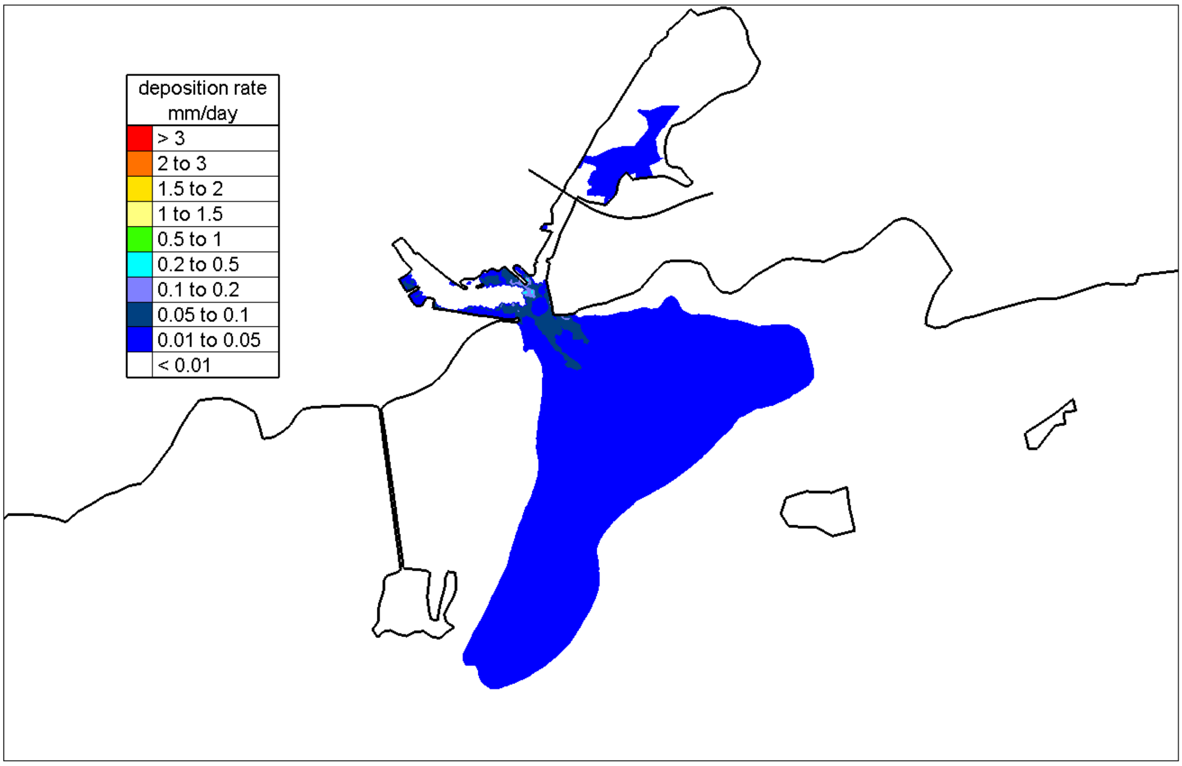

Figure 4.1.4 Computed Depositional Rates of a River Corrib fine silt under median flows for Existing Case

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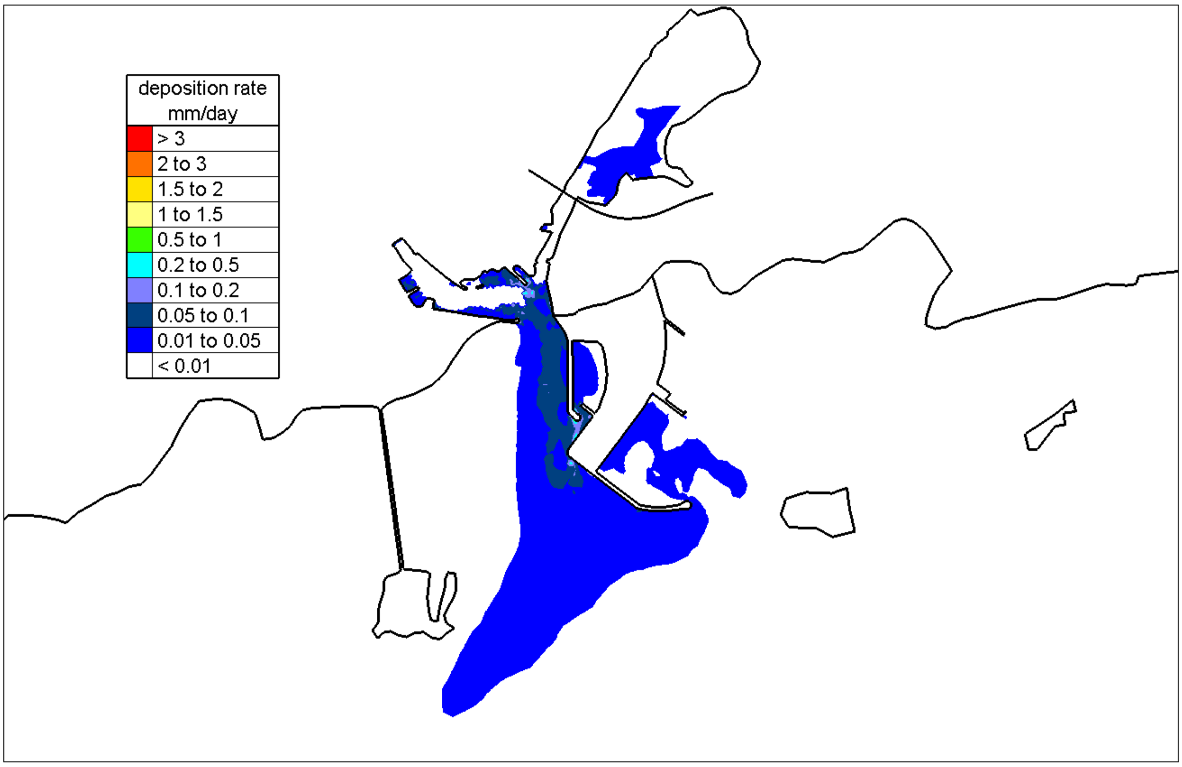

Figure 4.1.5 Computed Depositional Rates of River Corrib fine silt under median flows for Proposed Case.

Figure 4.1.6 Deposition of Corrib fine sand under median flows at the end of 15 days - Existing Case

Figure 4.1.7 Deposition of a Corrib fine sand under median flows at the end of 15 days - Proposed Case

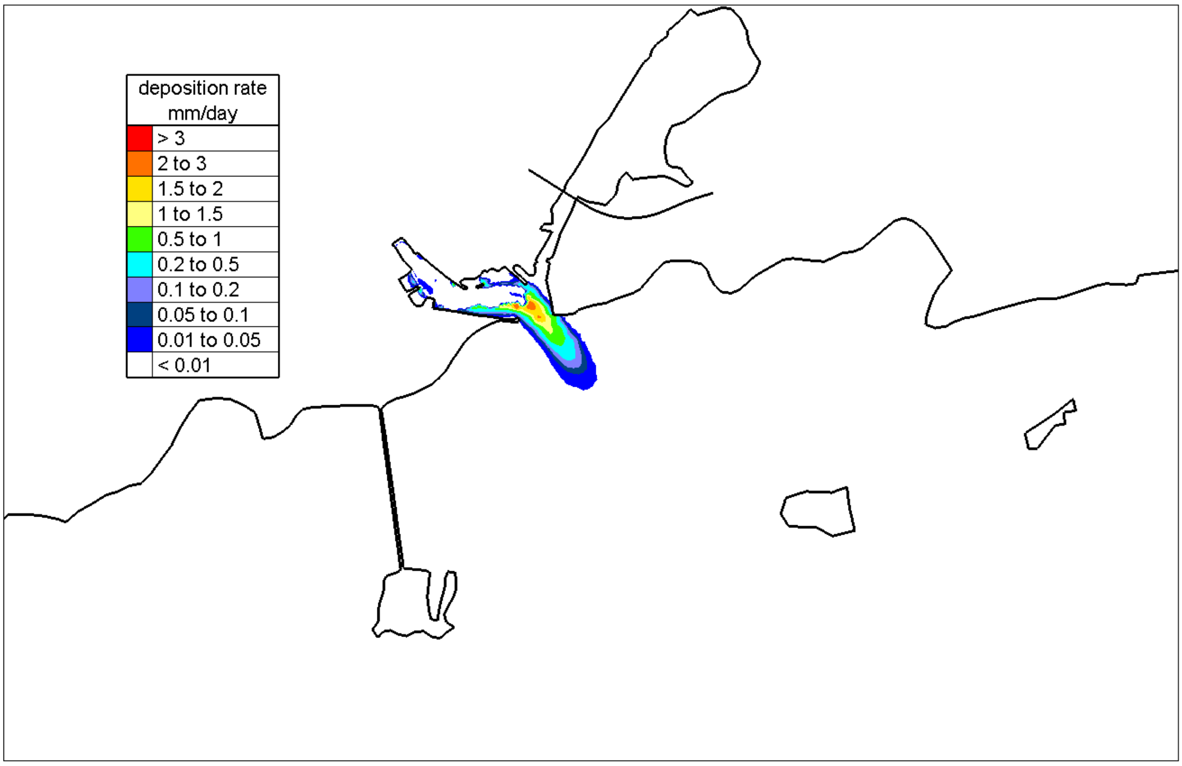

Figure 4.1.8 Computed Depositional Rates of a River Corrib fine sand under median flows - Existing Case

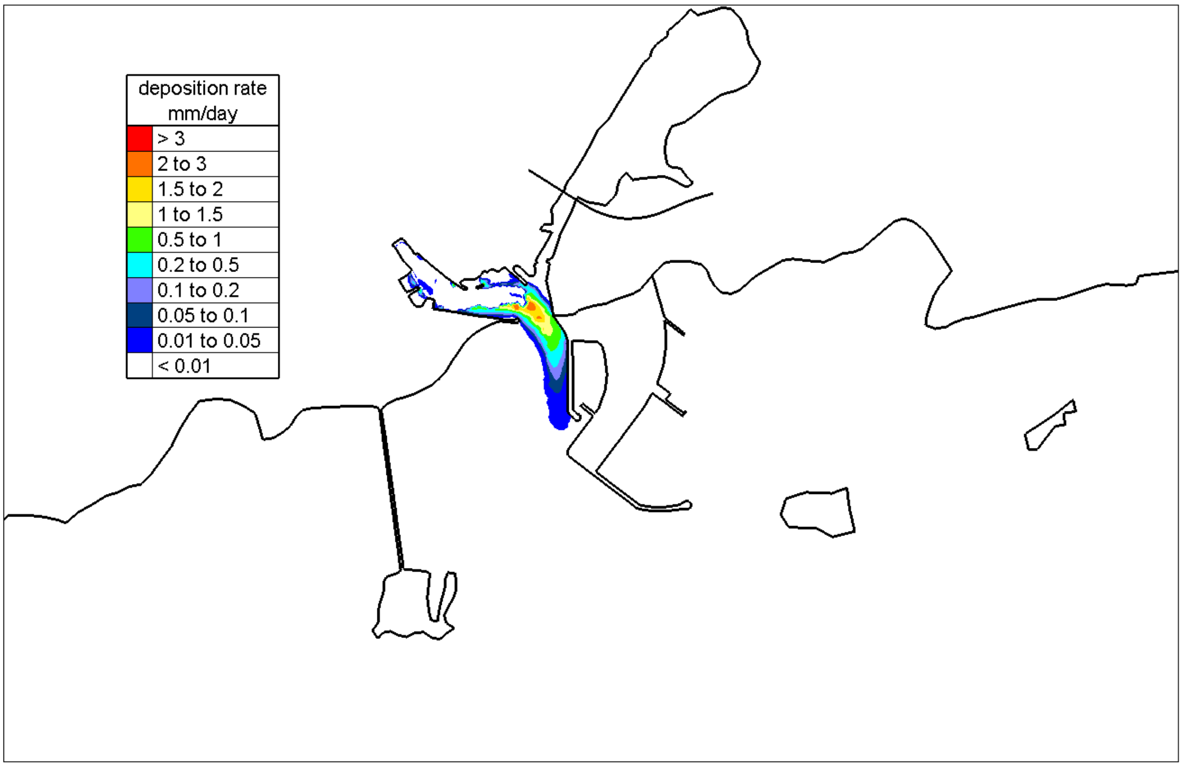

Figure 4.1.9 Computed depositional rates of a River Corrib fine sand under median flows - Proposed Case

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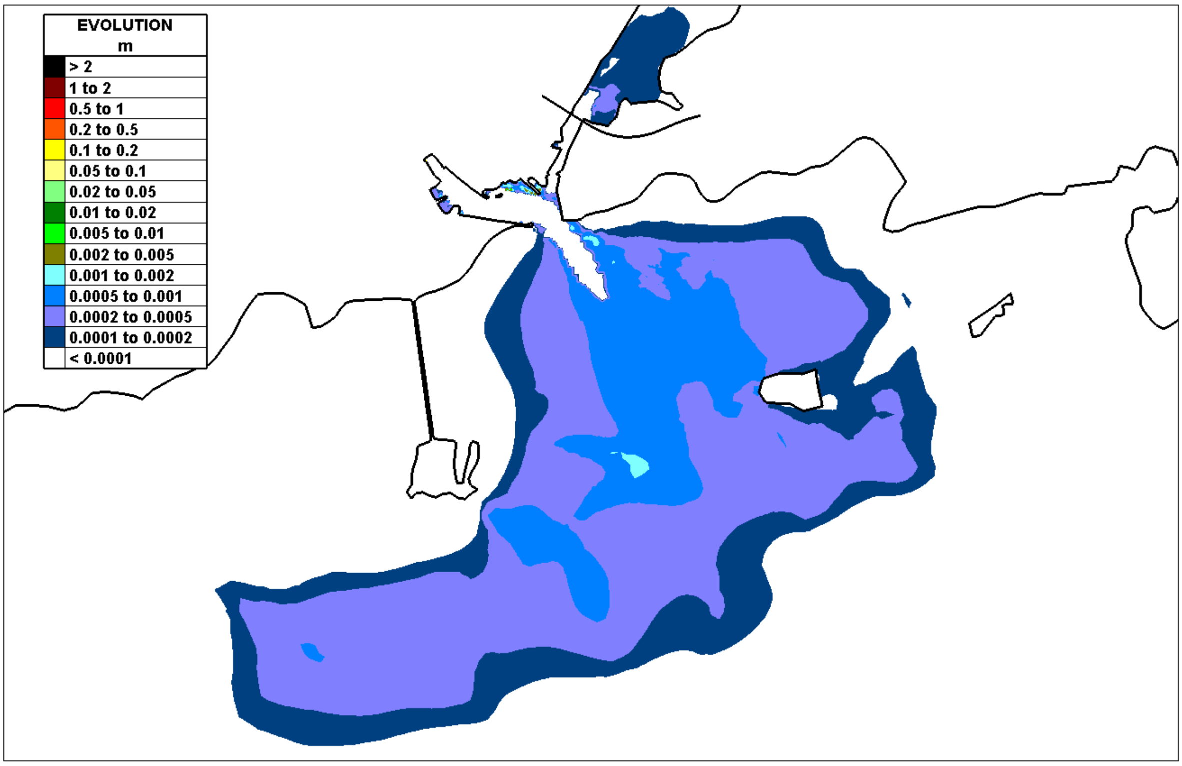


Figure 4.1.10 Deposition of a Corrib fine silt under winter flows (272cumec) at the end of 15 days Simulation - Existing Case

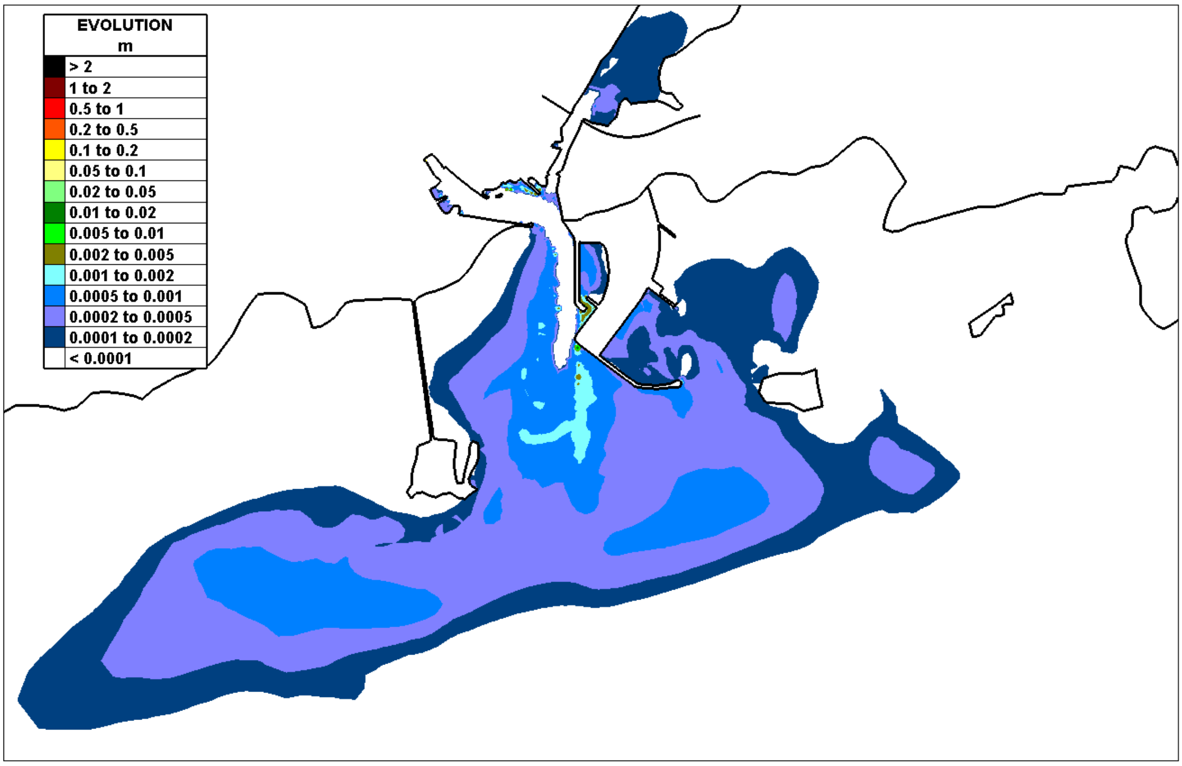


Figure 4.1.11 Deposition of a Corrib fine silt under winter flows (272cumec) at the end of 15 days Simulation - Proposed Case

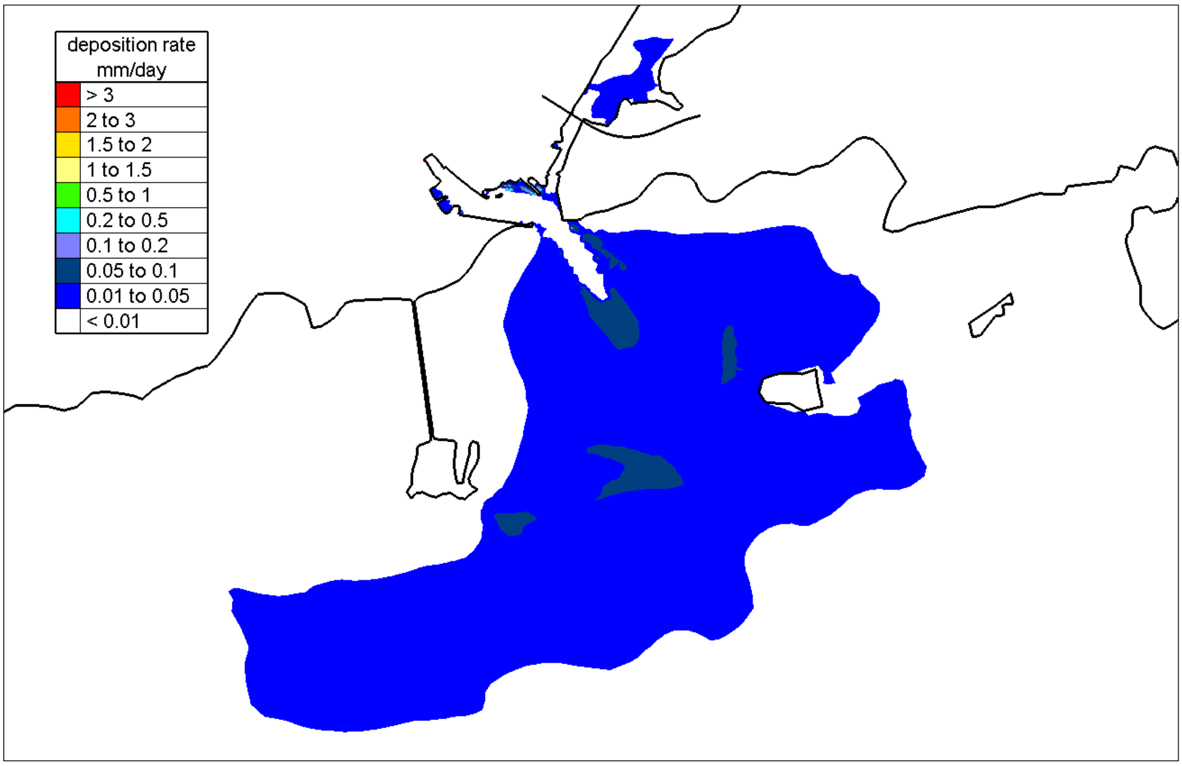


Figure 4.1.12 Computed depositional rates of a River Corrib fine silt under Winter flood flows (1-%ile 272cumec) - Existing Case.

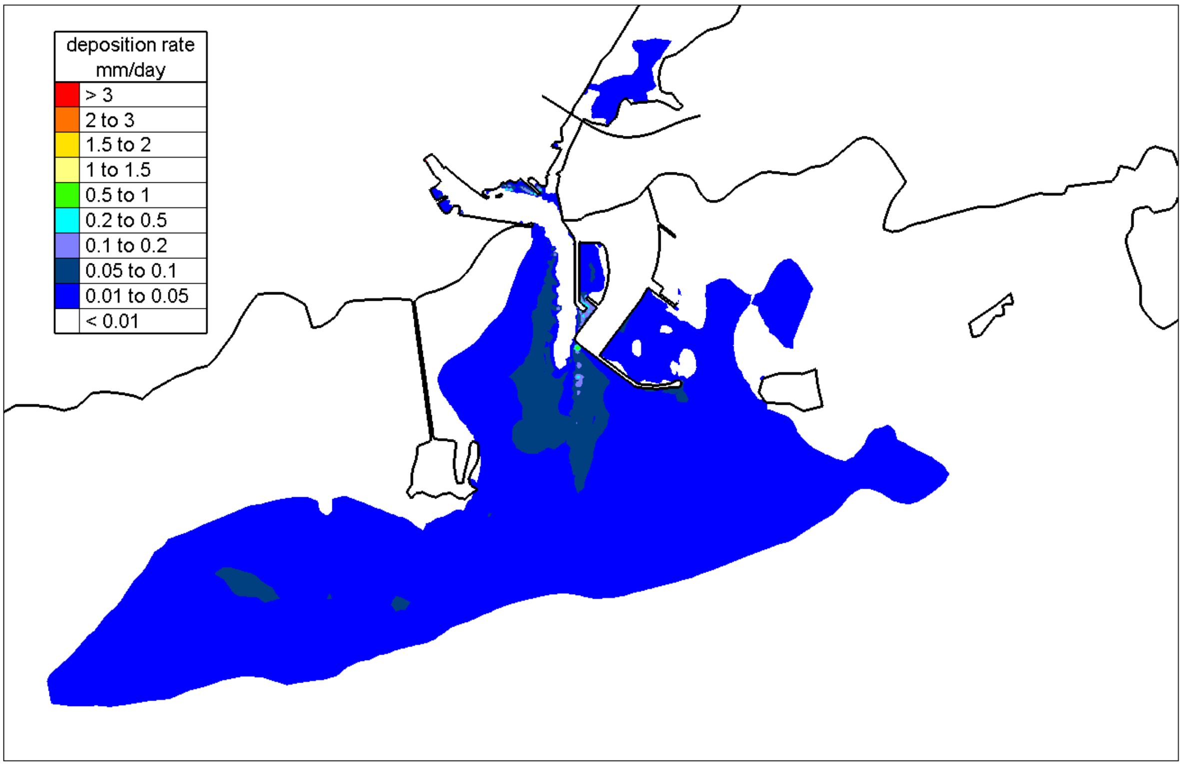


Figure 4.1.13 Computed depositional rates of a River Corrib fine silt under Winter flood flows (1 %ile 272cumec) - Proposed Case.

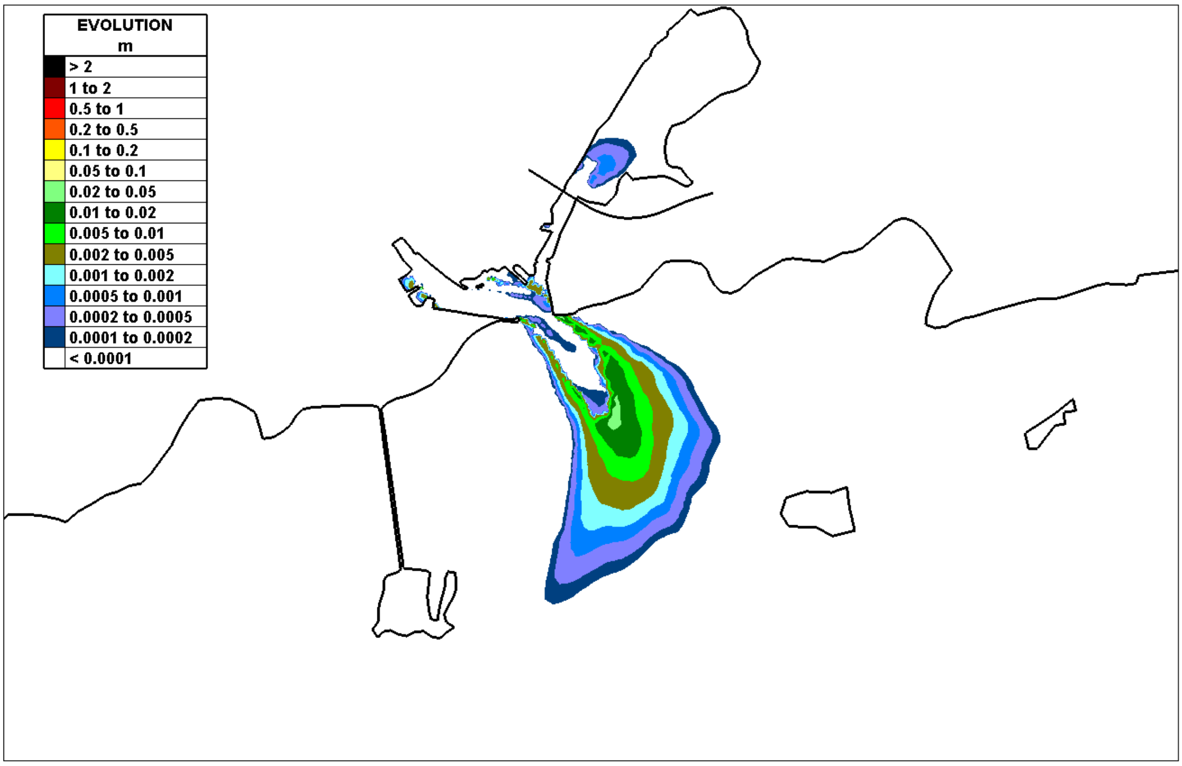


Figure 4.1.14 Deposition of a Corrib fine sand under winter flows (272cumec) at the end of 15 days Simulation - Existing Case

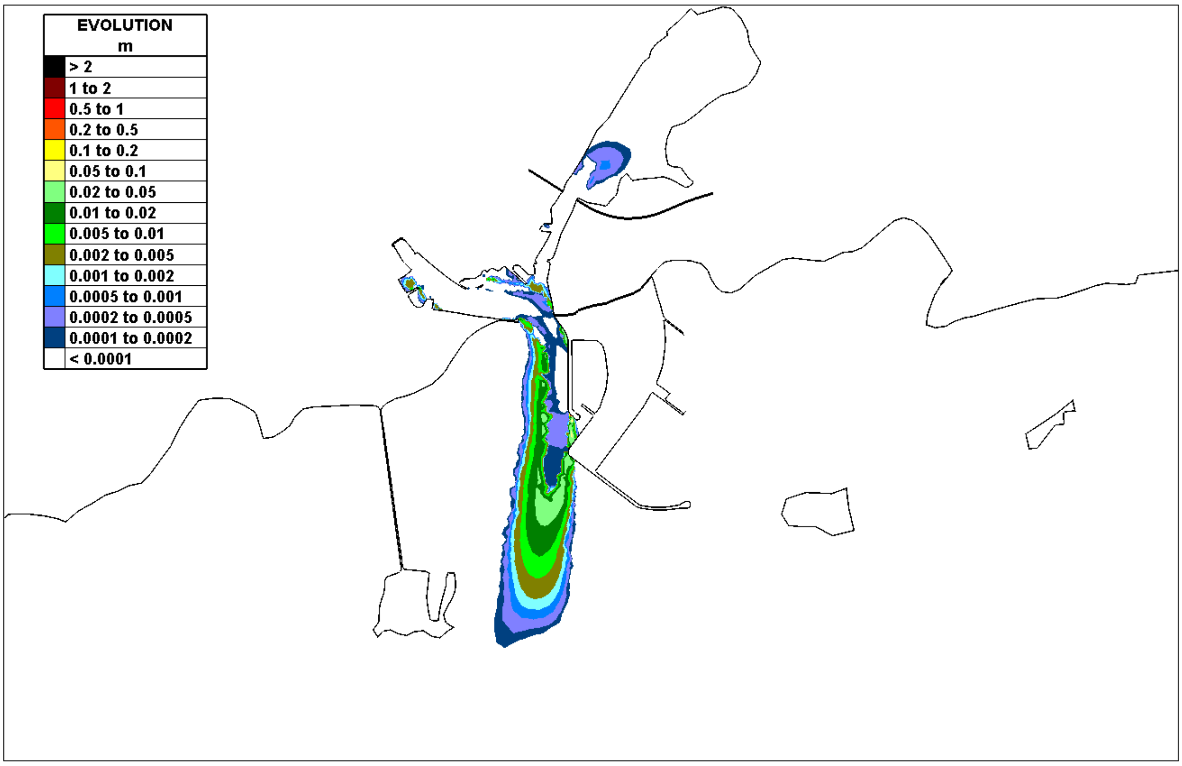


Figure 4.1.15 Deposition of a Corrib fine sand under winter flows (272cumec) at the end of 15 days Simulation - Proposed Case

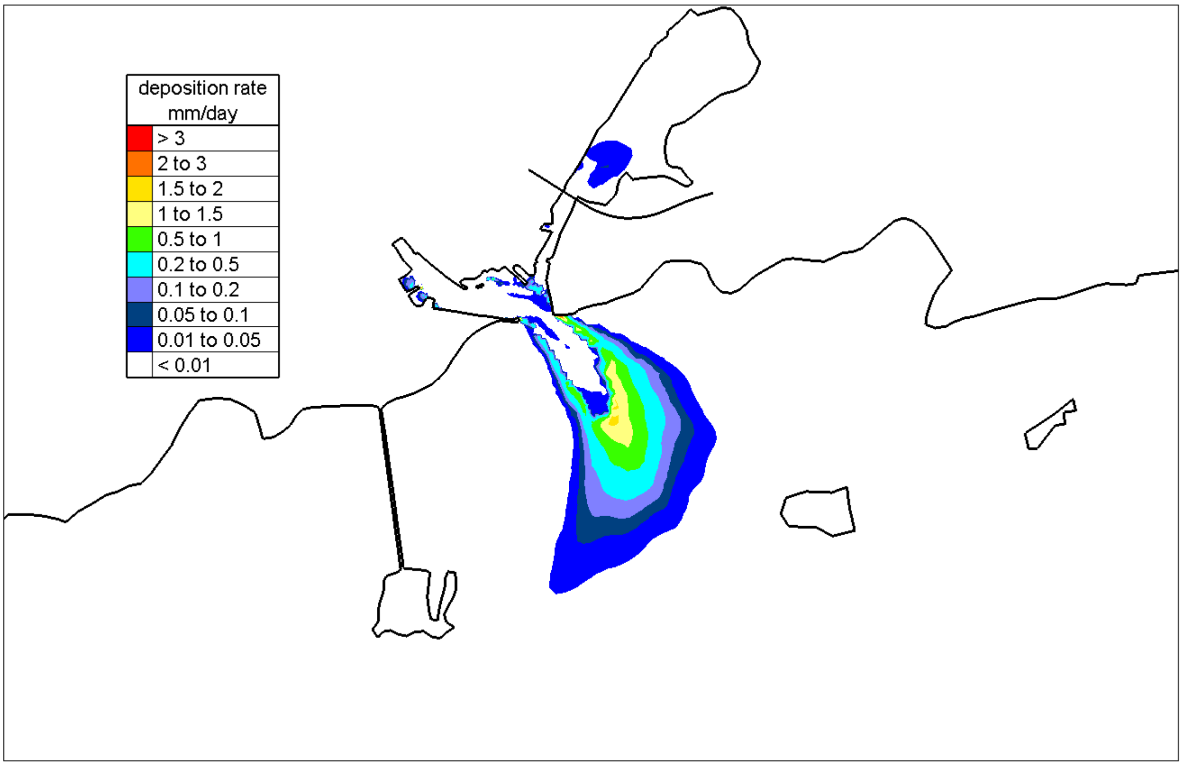


Figure 4.1.16 Computed depositional rates of a River Corrib fine sand under Winter flood flows (1-%ile 272cumec) - Existing Case.

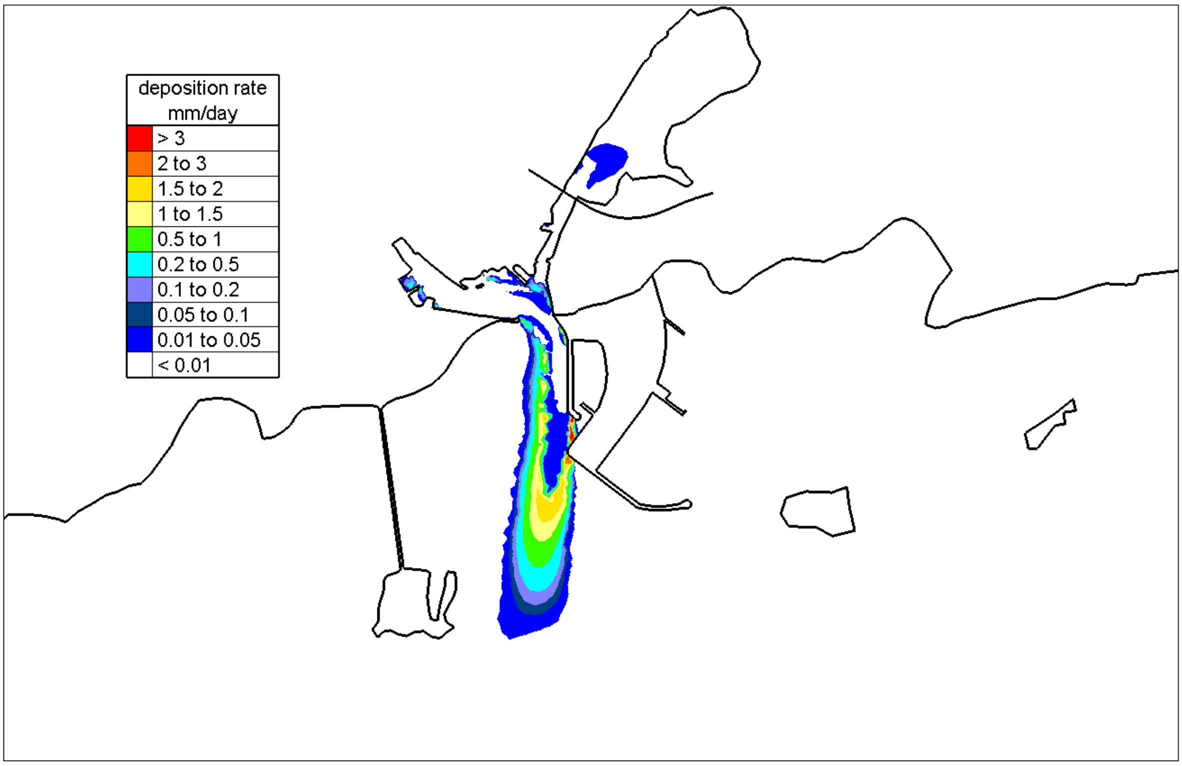


Figure 4.1.17 Computed depositional rates of a River Corrib fine sand under Winter flood flows (1-%ile 272cumec) - Proposed Case

4.1.5 Storm Wave Morphology in the vicinity of the Development

SISYPHE simulations were carried out examining the potential effect of storm wave conditions on the morphology of Inner Galway Bay. In order to provide meaningful information on wave dominated morphology an assumption had to be made in the modelling that the sediment was a sand having a typically d_{50} of 0.12mm. Simulations were run for a continuous two-day design storm wave event and the evolution determined between the initial and final bed levels. The storm winds specified are from the south and southwest using 30m/s wind speeds and combined with an Atlantic swell using the same strength winds offshore. The hydrodynamics accompanying the wave storm simulation are spring tides and median river flows. A zero sediment flux (inflow condition) was applied at the Corrib inflow boundary.

The evolution results for a south storm event are presented in Figures 4.1.18 and 4.1.19 and for a southwest storm event in Figures 4.1.20 and 4.1.21 under existing and proposed cases respectively.

The simulation results show considerable erosion along the exposed shoreline area to the west of the Mutton Island causeway with deposition of this eroded material occurring locally offshore under both south and southwesterly storms. Erosion is also predicted immediately to the west and south of Mutton Island. The simulation indicates that some migration of this sediment around Mutton Island towards the northeast of the causeway is likely.

In the vicinity of the Harbour Area for both proposed and existing cases the simulation shows that little erosional or depositional activity is taking place in the vicinity of the New Harbour development and the existing and proposed channels, particularly in comparison to the exposed shoreline to the west of Mutton Island and also to the east of the development in the vicinity of Hare and Rabbit islands.

The plots for the existing case show some erosion and deposition predicted along the shoreline area to the east of the Corrib entrance. This is substantially reduced under the proposed harbour case which affords a degree of shelter to this shoreline from the Wave climate and thus the erosional wave forces. This includes protection to the vulnerable shoreline cliff section immediately to the west of Ballyloughaun Beach (refer to Plate 4.1).

Significant erosion of Hare and Rabbit Island shoreline areas are predicted in both cases (no noticeable difference between proposed and existing cases) with deposition indicated in the lee of these islands.

Importantly for the new proposed approach channel to the Commercial Port the sediment transport storm wave simulations do not indicate any significant erosional or depositional features along the channel with only minor deposition occurring near the breakwater entrance to the port indicating a reasonably stable environment for the dredge channel. For the proposed and existing cases some local deposition under wave action is shown in the navigation channels to the docks near the Corrib entrance. The rate of deposition shown is not significant.

These simulations were unable to capture the longer term littoral drift mechanism but do indicate that erosional forces on exposed shoreline deposit the material just offshore of the zone of erosion where further storms (from south to west) can progressively move sediment eastward around Mutton Island. The dredging history and channel bed surveys indicate that sediment building up in the channel is primarily fine sand given the location of the deposit within the channel and consequently its source has to be from littoral drift as opposed to siltation from the Corrib. The surveys also indicate that the depositional rate is relatively low at c. 9,000 tonnes per annum and that the main drift occurs between -1 and -4m OD Malin.

Drift along the bed in the deeper waters cannot be ruled out but is likely to be considerably less given the tidal flows, wave characteristics and depth of water. It is important to note that the design of Mutton Island outfall had intended to site the diffuser manifold slightly further offshore (southwards) but bed conditions showed a deep silt which constrained the design to locating closer to the island.

Plate 4-1 Typical view of eroded Boulder Clay shoreline banks to the southeast of Ballyloughaun Beach adjacent to the Harbour Development. These erodible shorelines are likely to be the principal Source of Silts, sands gravel and cobbles released during Storms that forms the seabed sediments in the Vicinity

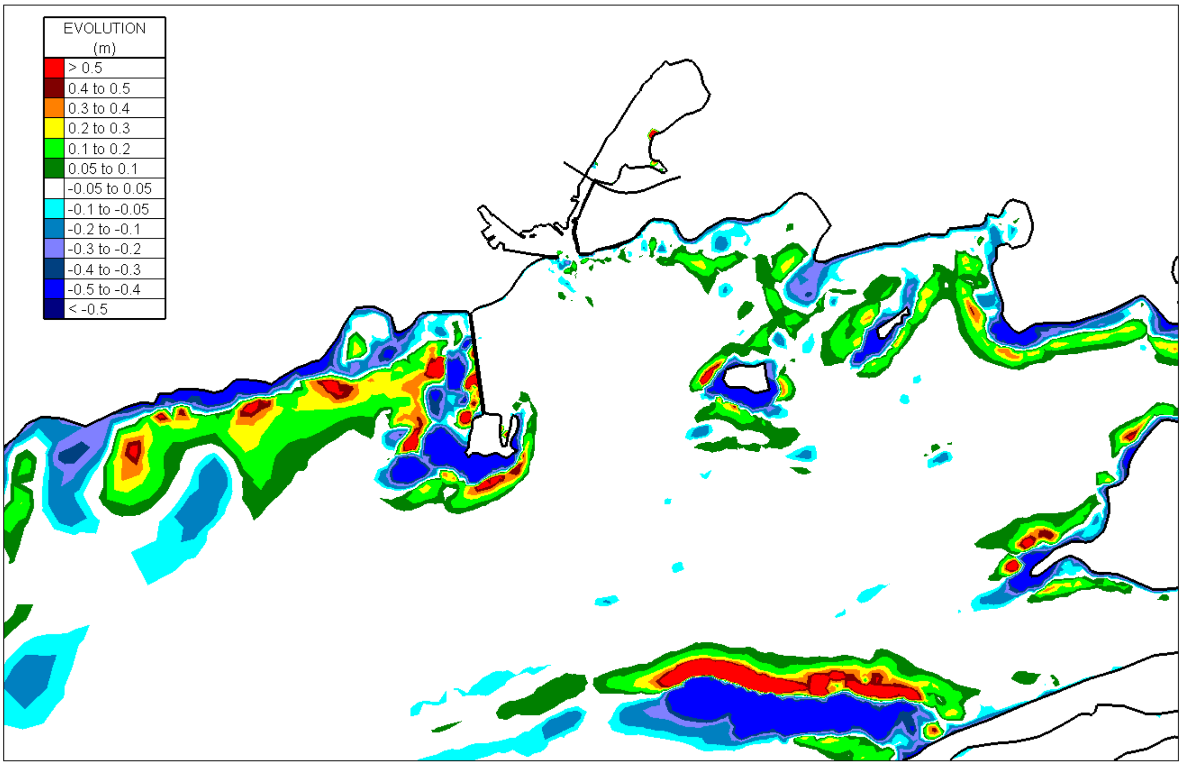


Figure 4.1.18South Storm Waves Simulation modelling a fine sand - Existing Case

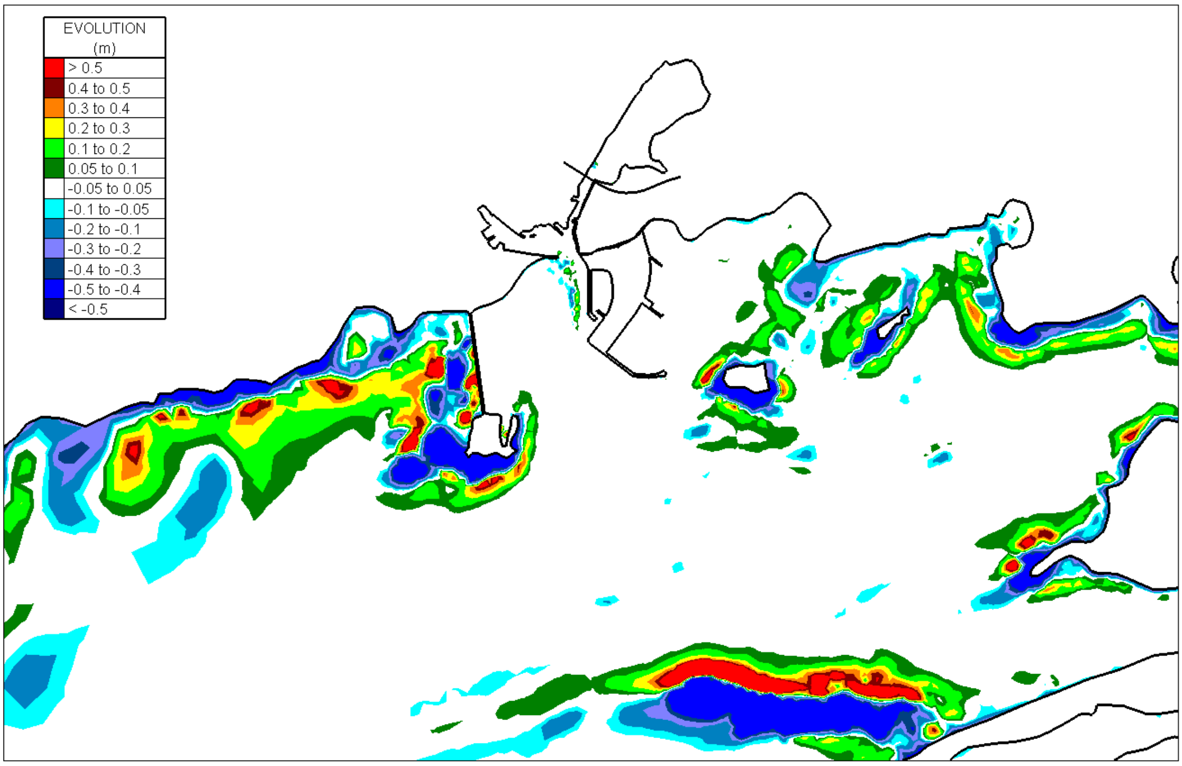


Figure 4.1.19 South Storm Waves Simulation modelling a fine sand - Proposed Case

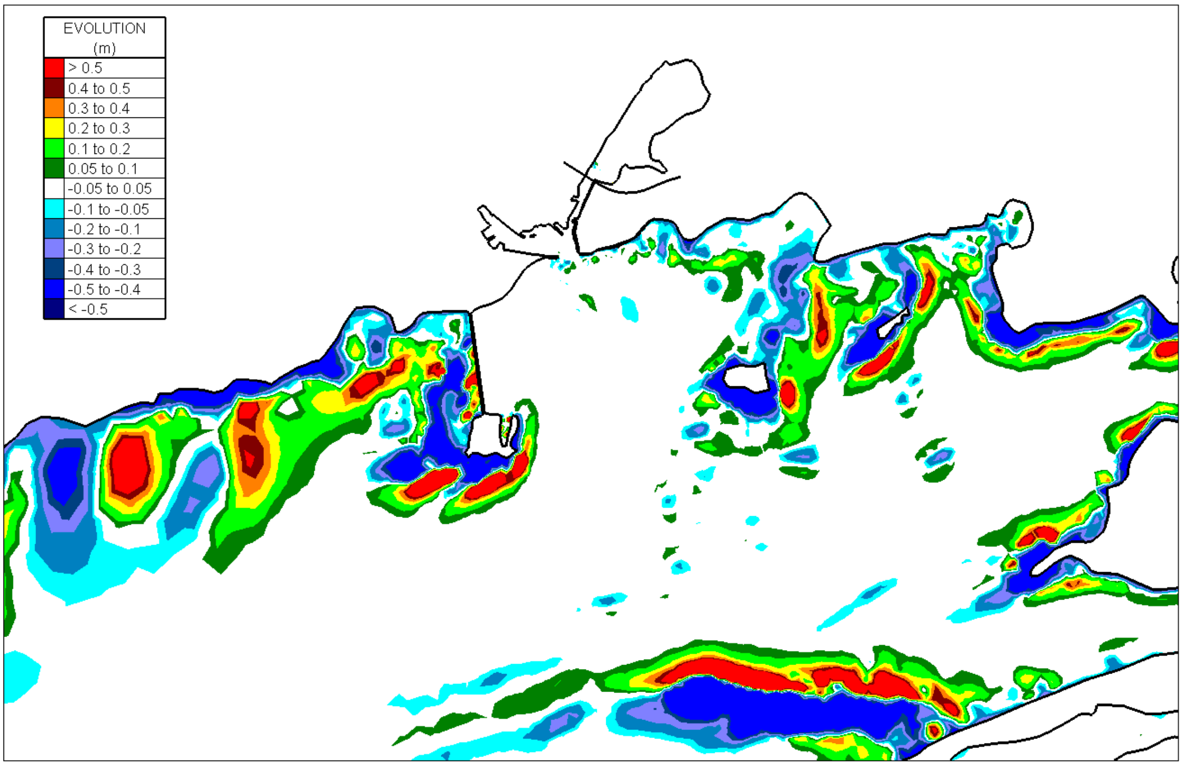


Figure 4.1.20 Southwest Storm Waves Simulation modelling a fine sand - Existing Case

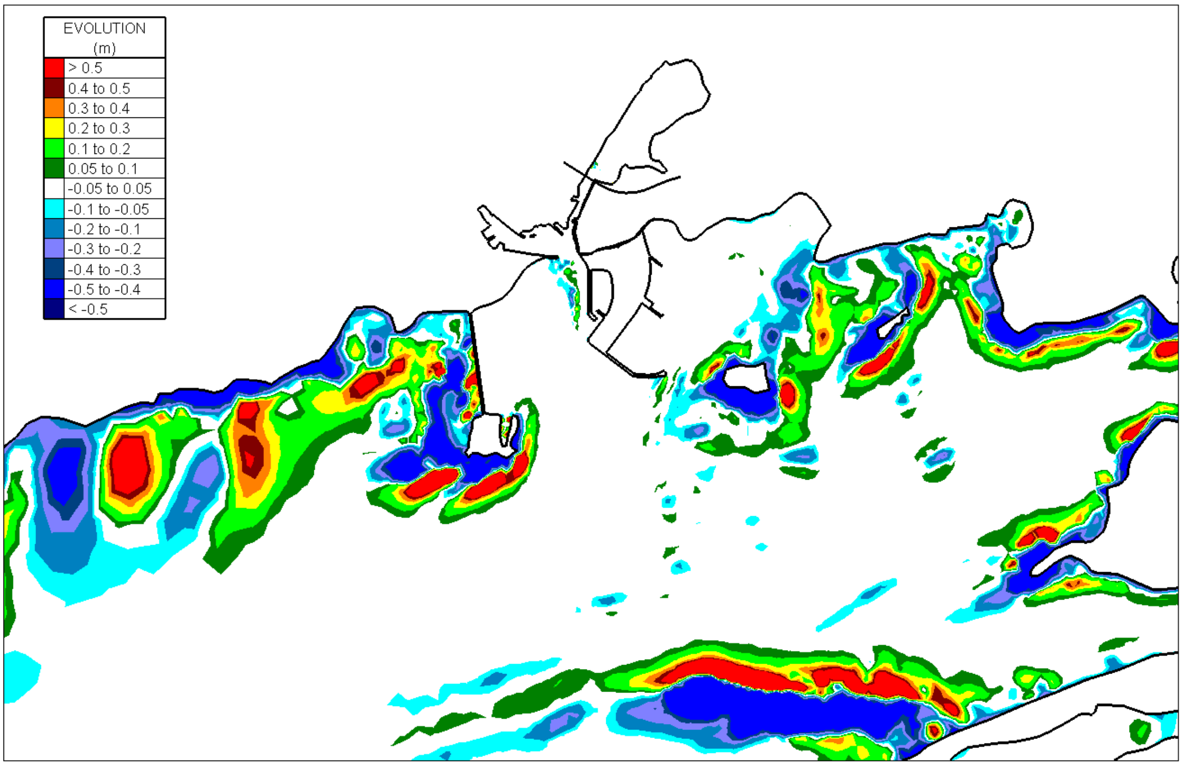


Figure 4.1.21 Southwest Storm Waves Simulation modelling a fine sand - Existing Case

4.1.6 Capital Dredge Depositional Features

In the EIS 11 dredging locations (refer to Figures 8.4.41 and 8.4.50 of the EIS) over the dredge area were simulated for a 4day continuous release of dredge sediment refer to EIS (Figures 8.4.42 to 8.4.49 and 8.4.51 to 8.4.57). Combining the results of these 11 dredge locations and their respective plume characteristics over the tidal cycle a mean dredge suspended sediment concentration was evaluated and is presented in Figure 4.1.22. This figure shows concentration bands (depth and tidal mean averaged extracted from Telemac3D suspended solids simulations) of < 1mg/l, 1 to 2mg/l and >2mg/l. It is important to note that figure 4.1.22 represents the unmitigated case in which dredging occurs throughout the tidal cycle. The proposed mitigation for the new navigation channel to the docks to minimise sediment entering Lough Atalia is dredging work only taking place on the ebbing tide and thereby avoiding direct inflow from the dredge works on the incoming flooding tide.

The simulations presented in the EIS Figures 8.4.42 to 8.4.49 show that the coarse silt/ fine sand fraction deposits rapidly and that the plume is local to the dredge works with elevated sediment concentrations occurring close to the dredge works area and reducing rapidly with distance from the dredging. The finer silt simulations show good dispersal of sediment.

To convert suspended sediment concentration to depositional rates, assuming an ability to settle based on the critical shear velocity, the settling velocity is used to produce a rate of sediment in kg per m^2. For example an average suspended sediment concentration of 1mg/l over a 12month period will potentially deposit on the sea floor 3.152kg per m^2 of silt using a settlement rate of 0.0001m/s for fine silt. It should be noted that the dredge program will not result in a continuous dredge concentration lasting for 12months and such durations will be considerable less based on the dredging program (refer to dredging sequence summarised below).

Converting this mass loading of 3.152kg per m^2 to sediment depth gives 1.98mm (2mm) of sediment depth per m^2 (based on using sediment grain density of 2,650kg/m^3 and an average porosity of 40%). The shear stress analysis presented in the EIS under Figures 8.4.16 to 8.4.39 indicate that deposition of the finer silt will take place within the receiving waters and plume area shown in Figure 4.1.22 below. Only when the Corrib is in flood will erosion of the deposited material within the channel occur resuspending the sediment and dispersing it widely within the Bay at low concentrations.

The suspended sediment concentration contour plot in Figure 4.1.22 can be interpreted in terms of deposition rate as follows (based on a grossly conservative 12month continuous dredging period throughout the dredge works area:

blue < 2mm siltation depth,
green 2 to 4mm siltation depth,
yellow > 4mm siltation depth

Summary of Dredging sequence

The proposed dredge sequence is as follows:

A) New channel to old port months 10 to 11, Oct/Nov year 1, suction/ pumped to lagoons 1 and 2 mitigated by dredging only on turning or ebbing tide see EIS (script 8.4.2.8.4. and 4.4.2.9.5)

B) Soft dredge over turning circle etc, months 20 to 23 Aug / Nov Year 2, suction/ pumped to lagoons mitigated by marina wall (element 6)

C) Dredge of stiffer materials at B, months 32 to 34 Aug / Oct Year 3, backhoe / barge to initial quay mitigated by lagoon 6 (element 8)

D) i) Dredge marina access and berths, month 56 Aug year 5, suction / pumped to lagoon 7, mitigated as per dredge work A)
ii) Dredge fishing pier, month 56 aug year 5, " mitigated by quays ,breakwater and land formation (elements 10,11, and 12)

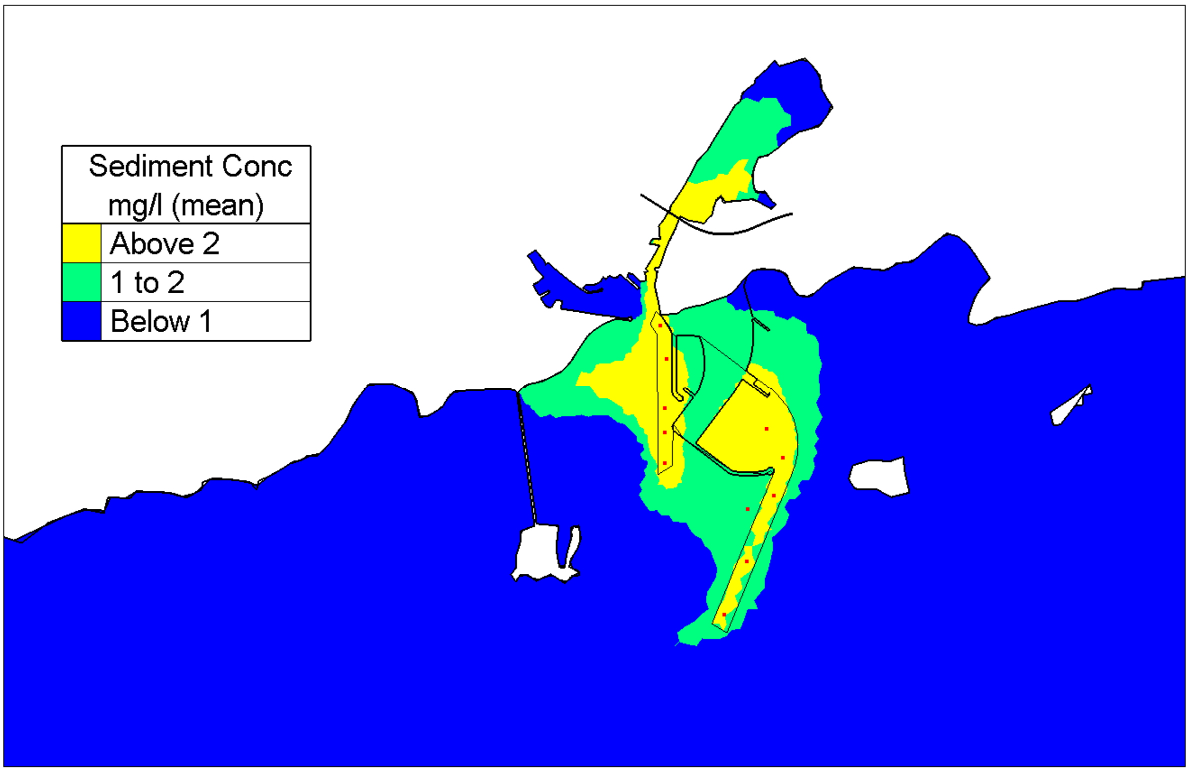


Figure 4.1.22 Capital Dredge Sediment concentrations extrapolation from sediment transport results from EIS Figures 8.4.42 to 8.4.49 and 8.4.51 to 8.4.57 representing the unmitigated case

The above concentrations and deposition rates assume that the dredge sediment is completely a silt, when in fact approximately 50% of the dredge material is a fine sand that was shown in the EIS modelling to settle out locally within the dredge works area and thus the deposition rate presented in Figure 4.1.22 below for the blue, green and yellow areas is likely to be half the above figures. Due to the dredging of the new channel to the old Port being restricted to ebbing flows only, the deposition will be significantly lower in Lough Atalia.

The area of impact shown in Figure 4.1.22 is relatively local to the Development and the impact magnitude in terms of suspended solids concentrations and depositional rates is small. The proposed mitigation measures and the sequencing and duration of dredge operations outlined in the EIS will minimise impact to the water column and to the sea floor from deposition.

4.1.7 Conclusions

The Maintenance dredging requirement of the existing navigation channel is reasonably low requiring maintenance every 12years at approximately 9000tonnes per annum. The source of the dredge is primarily a fine sand from littoral drift as opposed to the Corrib silts. The Corrib silts if unable to settle out upstream of the Galway Barrage will not settle out easily within the navigational channel or the immediate harbour area. The littoral drift heading eastward is not very significant and currently the existing channel traps this drift with the main sediment infill occurring at -1 to -4 m OD Malin.

Under the proposed case the new navigation channel to the docks will trap this littoral sediment similar to the existing channel but the deposit after winter river flows is likely to occur further southwards in the channel near the Marina entrance.

One cannot rule out deeper littoral drift being captured by the new channel to the commercial Port however it is expected that such drift similar to the docks navigation channel will not be significant. The Commercial Port Area itself is sheltered from the littoral material and settlement rates will be low and will be from suspended silts. Conservatively it is expected that the Maintenance requirement for the Harbour Development should be of a similar period (12years) and less than twice the existing dredge requirement.

The depositional impact of the Capital dredge activities from presence of silt plumes is a minor impact and depositional rates outside of the dredge works area will be low.

4.2 POTENTIAL FOR TRANSPORT OF SAND FROM RIVER CORRIB

Query:

Furthermore and related to the above estimates are required for the total annual transport of fine sand from the River Corrib (section 8.4.2.7) to assist in the understanding the near harbour morphology.

Response:

4.2.1 Introduction

The sediment load from the Corrib River is small due to the very large lake system located upstream of Galway City which provides considerable retention time to settle out all but the fine sediment fractions. Previous dredging of the canals and moorings upstream of the Salmon Weir barrage encountered a fine silt.

4.2.2 Hydrology

The Corrib River is a short outflow channel from Lough Corrib which is gated at the Galway Barrage and under the management of the OPW Arterial Drainage Section. The OPW are responsible for maintaining minimum and maximum summer and winter lake levels for navigation requirements and flood relief.

The Corrib Catchment is some 3111km^2 in area to its sea outfall. A large portion of this catchment is karst limestone which produces a relatively damped response to rainfall events. The Lake Area of Lough Corrib is 176km^2 in area making it Irelands second largest Lake second to Lough Neagh in Northern Ireland. Immediately upstream of Lough Corrib is Lough Mask which has an area of some 83 km^2. These lakes are reasonably deep with Lough Corrib on average 12m deep (lake Volume of c. 2.11km^3) and Lough Mask 15m deep (lake Volume of c. 1.3km^3). These lakes are reasonably deep and provide a long retention time within the Lake volume for settlement of sediments, with only fines discharging from the Lake.

The mean annual rainfall over the Corrib Catchment is 1331mm and the evapotranspiration is 452mm resulting in 879mm effective rainfall representing an average Catchment flow rate of 63cumec. A flow duration curve for the River Corrib at Wolftone Bridge gauging station located in the estuary is presented below. This presents a mild sloped curve indicating gradual change of flow from flood to low flow with the range varying from 9 to 272cumec and a median flow of 82cumec.

At the median Flow of 82cumec the hydraulic retention time in Lough Corrib is of the order of 298days which is substantial for settlement of all but very fine silts. At winter flood flows of say 500cumec entering the lake the hydraulic retention time is of the order of 49days (which is still substantial). Silt deposited near the Lake outlet or along the river channel can be stirred up during flood conditions but EPA sampling would indicate that even under winter flows suspended sediment is relatively small.

Figure 4.2.1 Corrib Catchment Map showing Lough Corrib and Lough Mask

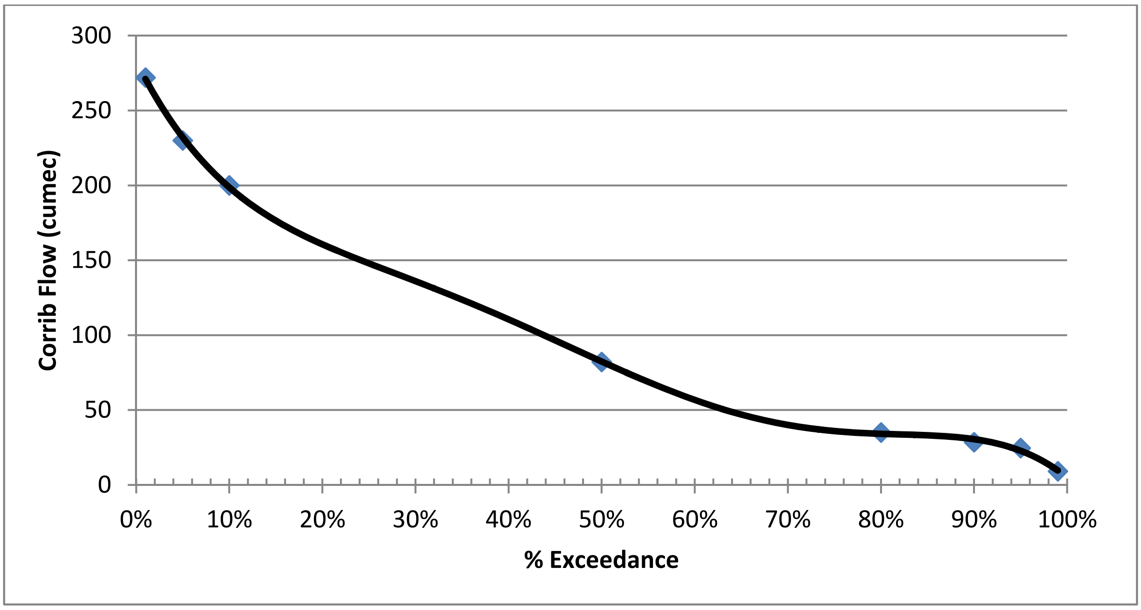


Figure 4.2.2 Flow Duration Curve for River Corrib at Galway City

The Corrib channel upstream of the Salmon weir Barrage is backwatered by the gate control and consequently flow velocities are generally very low and even during flood conditions the velocities are not significant. The downstream channel from the Barrage to the Claddagh Basin is a short, steep, rock cut channel with little potential for providing any significant contribution to the sediment load to the Bay.

4.2.3 Monitoring Data

A review of EPA Suspended solids monitoring from 2010 to Dec 2013 reveals a consistent trend of very low suspended solids concentrations throughout the year and generally at 4 mg/l or below and consistent throughout the year and between sample locations. Some elevated spikes of 10 and 62mg/l occur but these are very occasional and are often not consistent with results for the other sample locations taken on the same date.

Testing

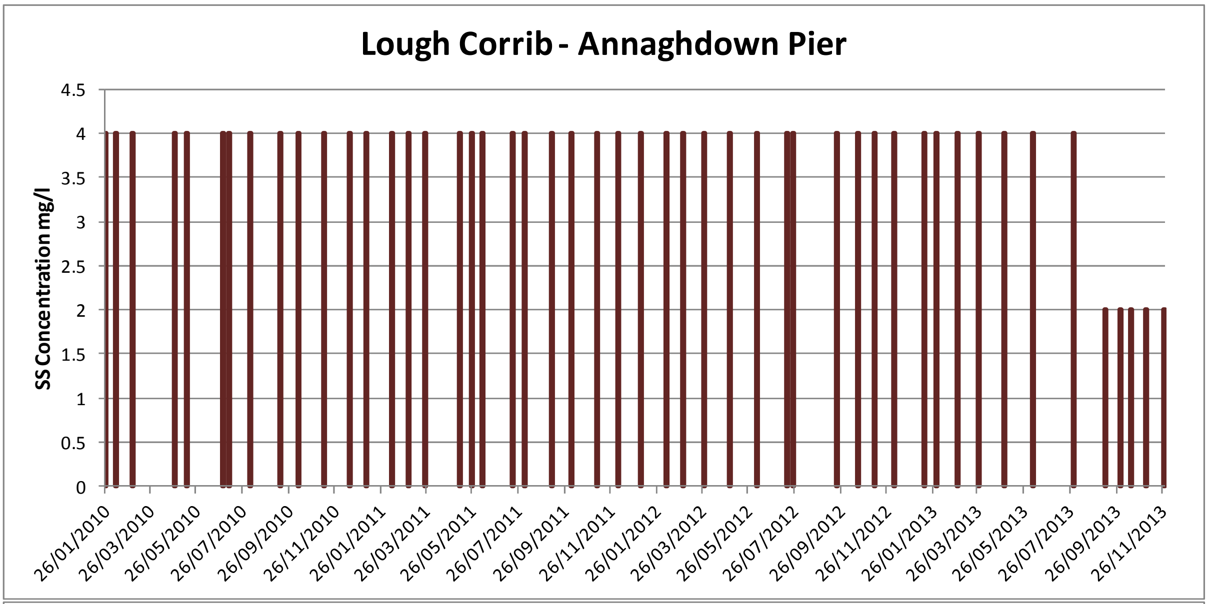
In reply to this further information a sediment trap was deployed by Aquafact on the river bed upstream of the Salmon Weirs for the month of September 2014. On retrieval no sediment was present within the trap. September was a very month with almost historical low flows.

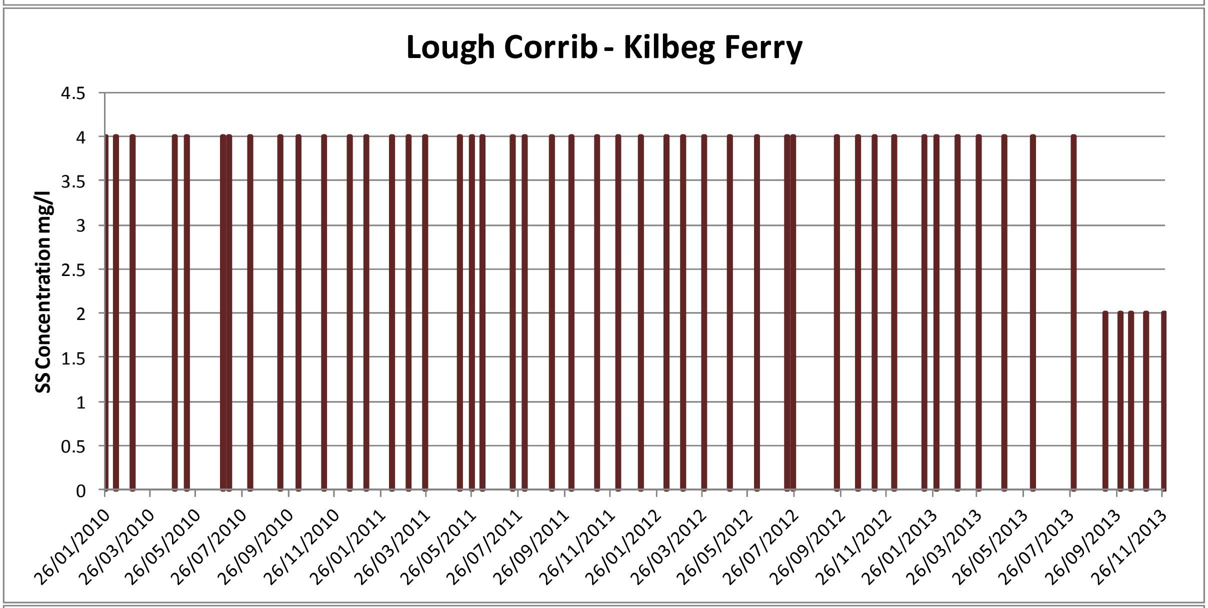
4.2.4 Sediment Load from the Corrib

The EPA data consistently reports suspended solids concentration of 4mg/l. It is suspected that the 4 mg/l figure recorded in the EPA data is the Limit of Quantitation for the testing. Improved testing towards the end of 2013 suggest typical suspended solid concentrations of 2mg/l. Therefore the annual sediment load from the River Corrib is likely to be between 5000 and 10,000 tonnes of sediment (82cumec at suspended solids concentration of 2 to 4mg/l). The EPA monitoring data does not indicate a high frequency of spikes associated with winter flood conditions.

Given the substantial settlement time available in Lough Corrib, the river silt that eventually discharges to the harbour waters will be a fine silt of which a large portion is unlikely to settle out in the immediate receiving waters of the Bay. As a best estimate at least 50% of the 5000 to 10,000T per Annum will not settle out in the harbour waters (i.e. Corrib entrance to inside of Mutton and Hare Islands).

It is considered that the primary source of the sediment settling in the existing navigation channels is generated by Wave action on the soft Boulder Clay shoreline areas to the east and by littoral drift originating from the west.





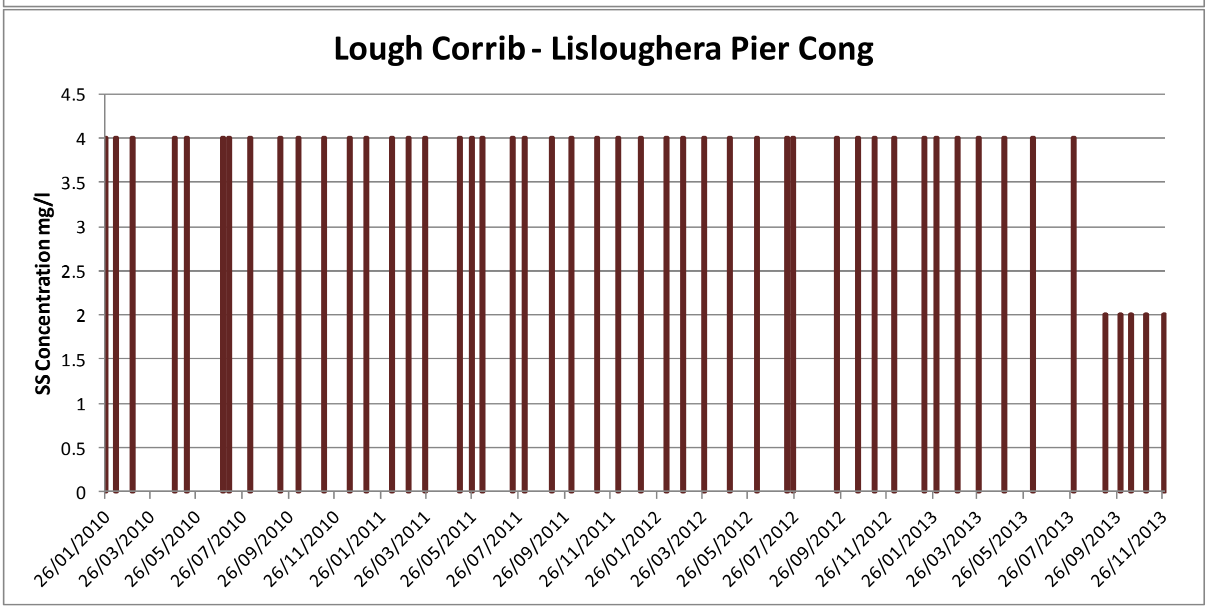
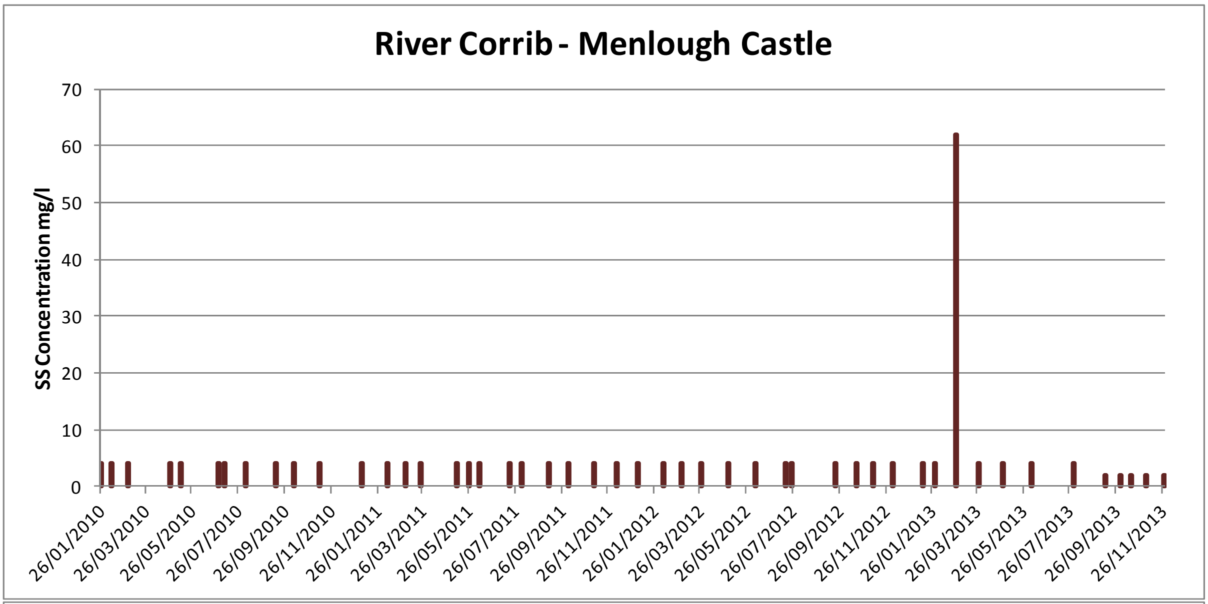
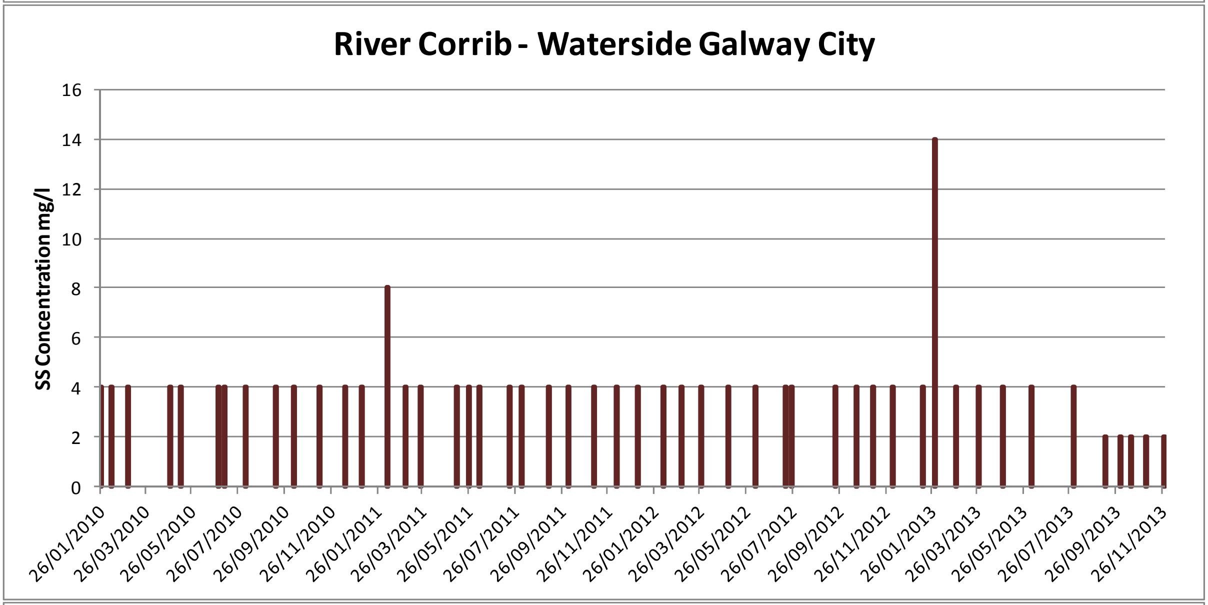


Figure 4.2.3 EPA Lough Corrib Suspended Sampling Results 2010-2013 (note In most cases the samples are below the Limit of Quantitation ranging from 4-8 mg/l)





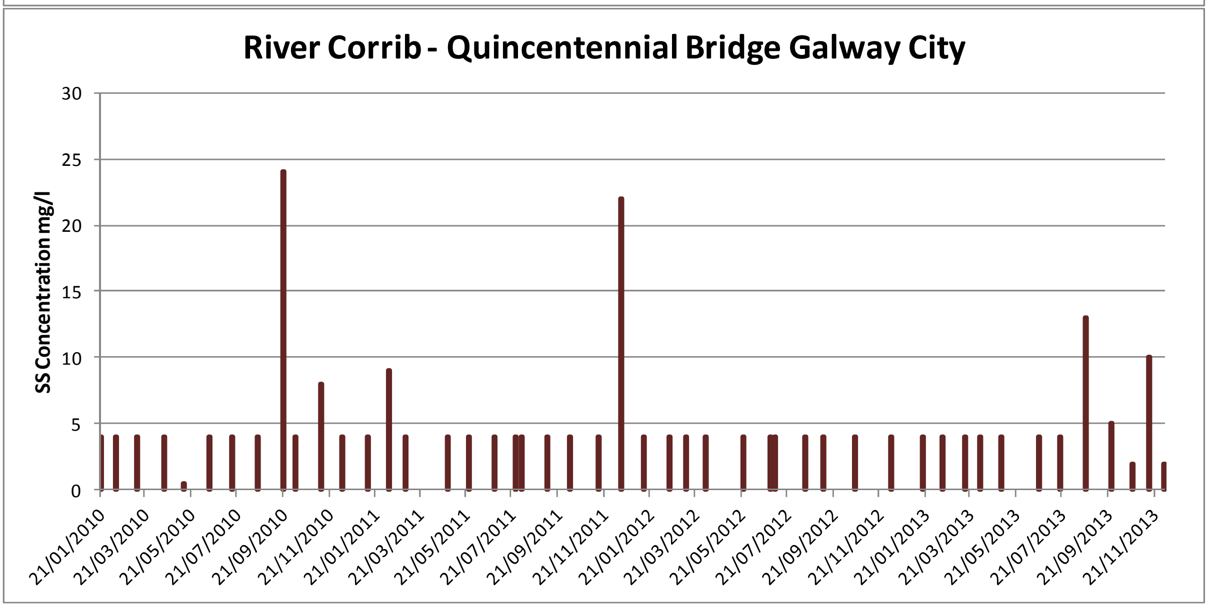


Figure 4.2.4 EPA River Corrib Suspended Sampling Results 2010-2013 (note In most cases the samples are below the Limit of Quantitation ranging from 4-8 mg/l)

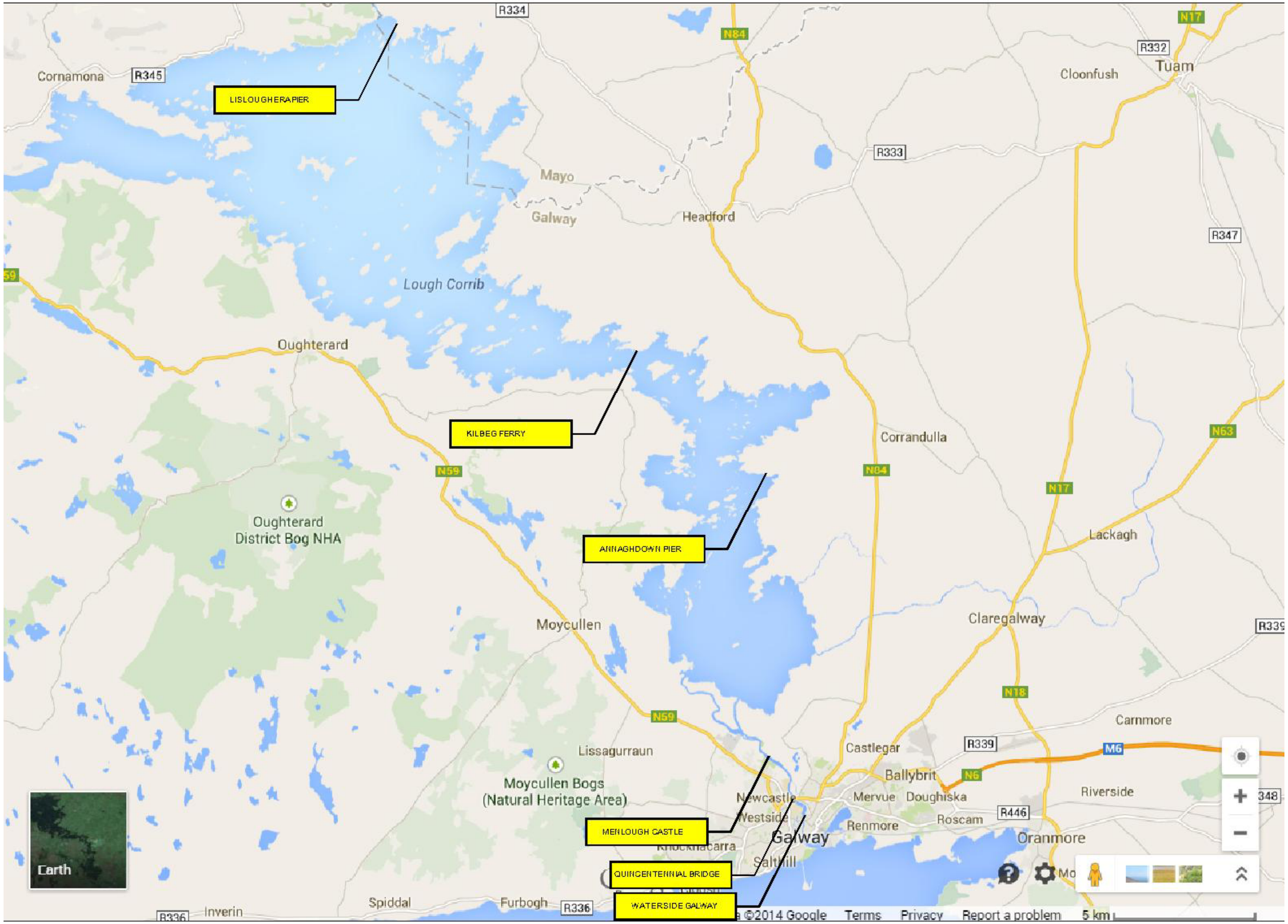


Figure 4.2.5 Location of EPA Sample Points

4.3 WIND WAVES:

4.3.1 Modelling of Wind Waves

Query:

The wind waves appear to be quite small in the harbor area according to the model results presented in 8.4.6, mainly due to the protective impact from the Mutton-Island causeway. The near field wave climate in this area is modeled using the ARTEMIS numerical model. For waves coming from SSW and S, wave heights up to 1.6m can be attained, Figure 8.4.135. It seems that the near field wave climate is calculated without including impact of current, unlike the spectral wave model TOMAWAC applied further away. If this is the case, the waves can actually be even higher than predicted in the EIS at a large outflow from Corrib River combined with the tidal flow due to current refraction. Please provide further justification for the large change in the flow pattern in this area being of no importance for the wave climate.

Response:

In the EIS the Wave climate modelling of the proposed Harbour area was carried out using ARTEMIS Wave Agitation model which solves Berkhoff's equation or Mild Slope Equation through finite element formulation. The Mild Slope Equation has been extended to integrate dissipation processes. With a consistent set of boundary conditions, ARTEMIS is able to model the following processes:

- Bottom refraction
- Diffraction by obstacles
- Radiation or free outflow conditions
- Depth induced wave breaking
- Bottom friction
- Full or partial reflections against walls, breakwaters, dikes, ...

Similar to other such Industry standard Boussinesq type Wave models ARTEMIS cannot include the effects of refraction by currents or include the effect of localised wind growth.

It is acknowledged that a wave field travelling against opposing currents will have a tendency to steepen due to a Doppler shift resulting in a shorter intrinsic wave period (shorter wave length) and increased wave height (Hedges et al. 1985, and Lia et al. 1989). Rsearch has shown that in a strong opposing current the wave steepness and wave height increase significantly. These changes can take place rapidly where the waves are blocked by the current and are often accompanied with current induced whitecapping and reflections.

Consequently wave heights are likely to be higher than predicted by the ARTEMIS Model where opposing currents are significant which in the case of Galway Harbour is specifically along the new approach channel to Galway Docks for the proposed case and along the existing old channel to the Docks for the existing Case (without development).

4.3.2 Methodology

In order to quantify the effect of refraction effects by currents on wave heights the SWAN model is used to examine wind waves with and without an Atlantic swell . The SWAN model is a spectral model that is solved in an iterative manner using an implicit finite difference solution scheme. The current version of the SWAN model allows regular and irregular meshes to be input. The SWAN model (1993 to 2014) is developed by Delft University of Technology, the Netherlands.

SWAN accounts for the following physics:

- Wave propagation in time and space, shoaling, refraction due to current and depth, frequency shifting due to currents and non-stationary depth.
- Wave generation by wind.
- Three- and four-wave interactions.
- Whitecapping, bottom friction and depth-induced breaking.
- Dissipation due to aquatic vegetation, turbulent flow and viscous fluid mud.
- Wave-induced set-up.
- Propagation from laboratory up to global scales.
- Transmission through and reflection (specular and diffuse) against obstacles.
- Diffraction.

The SWAN model was choosen over the Tomawac Spectral Wave model used in the EIS as it handles better diffraction and in particular local wind wave generation in the absence of an existing wave field.

The drawbacks with the SWAN model are that its implicit numerical scheme makes its solution diffusive and it does not handle well the process of full or partial reflection off structures / breakwaters. However it is considered a sufficiently adept and robust wave model to simulate the local wave climate and the effect on the wave field of changes in the current velocity pattern surrounding the Galway Harbour Development.

In respect to the Galway Harbour Study strong outward opposing currents are generated by the flood flows in the River Corrib under both the existing undeveloped case and for the proposed case. In terms of flooding and flood risk the critical period is towards or slightly after highwater. The current velocity from the hydrodynamic model for spring tide, tidal surge conditions and 100year design flood flows under existing and proposed Harbour cases was input to the SWAN model (refer to Figure 4.3.1 and 4.3.2 showing the velocities for the Proposed and Existing cases after highwater Spring tides.

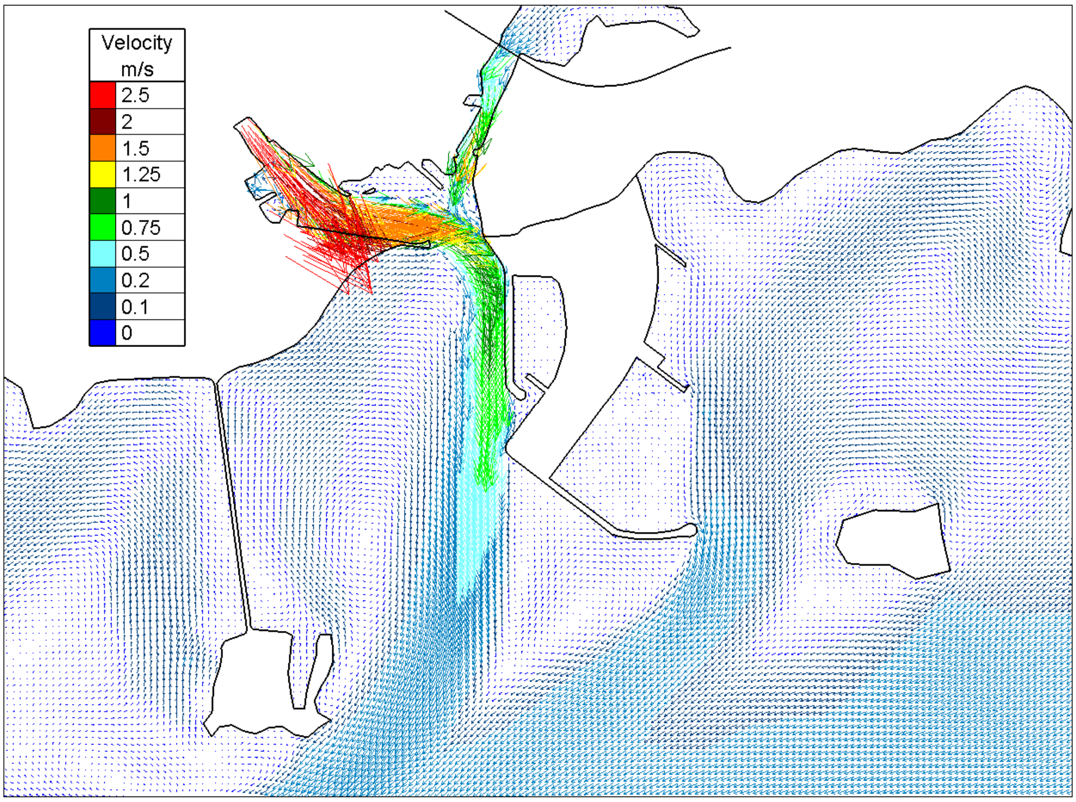


Figure 4.3.1 Snapshot of opposing flow and tidal velocities for Corrib 100year flood flow and spring tides with the Harbour Development

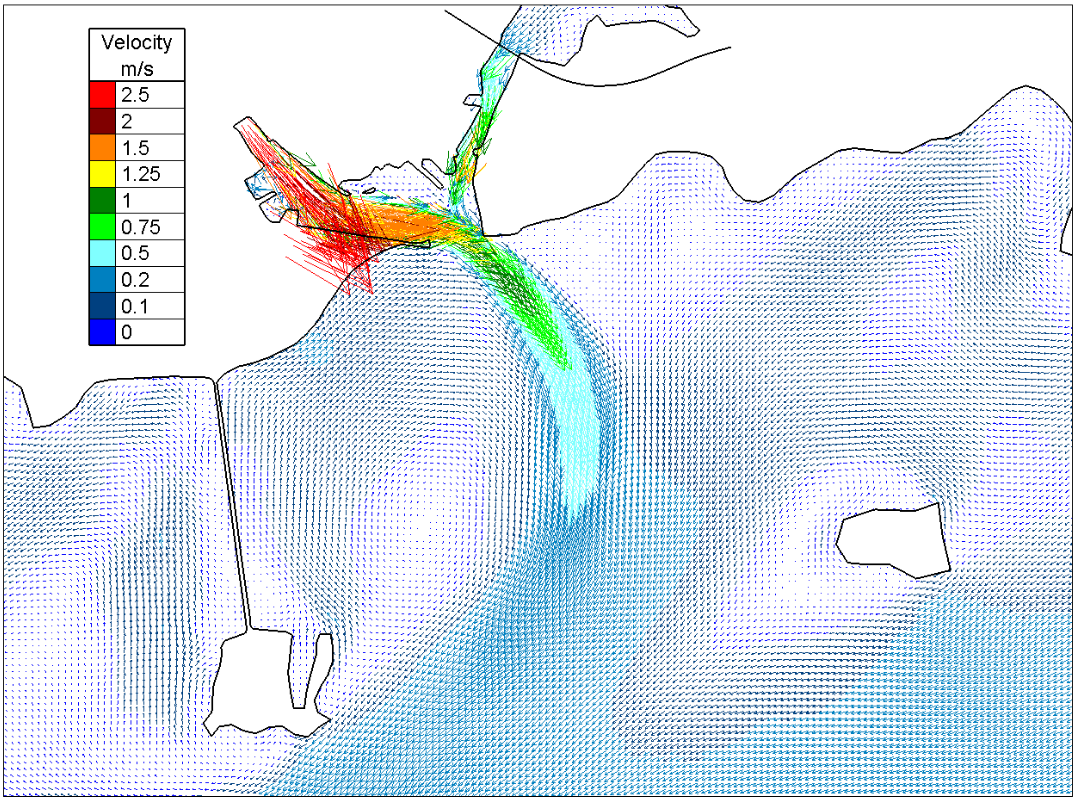
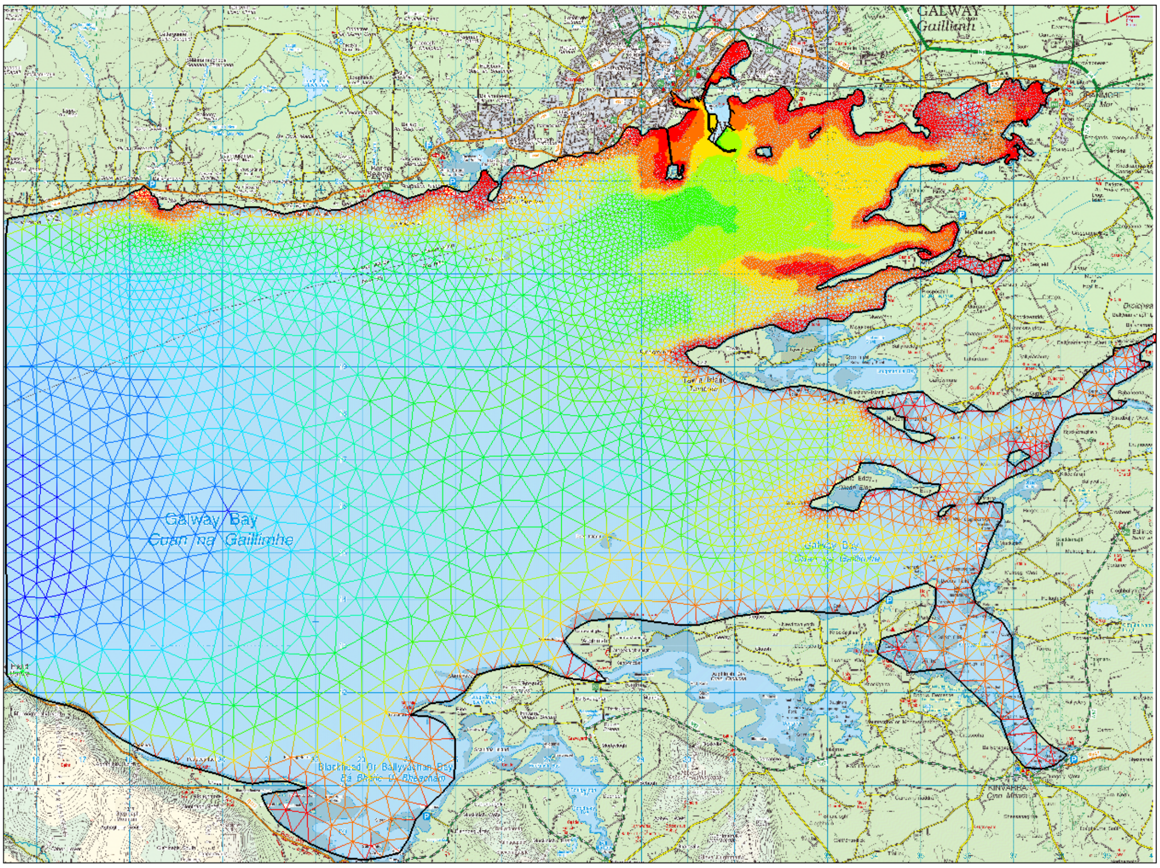


Figure 4.3.2 Snapshot of opposing flow and tidal velocities for Corrib 100year flood flow and spring tides without the Harbour Development (existing Case)

The irregular finite element mesh of bathymetry and boundary geometry used in the Telemac3d and 2d hydrodynamic models was input to the Swan model so as to maintain the same node locations and allow for direct input of the current velocity and water depths file from the Telemac simulations. This refined mesh provides high resolution detail in the dredge channels, the harbour area and the Claddagh Basin Area for modelling the wave field, refer to Figure 4.3.3.



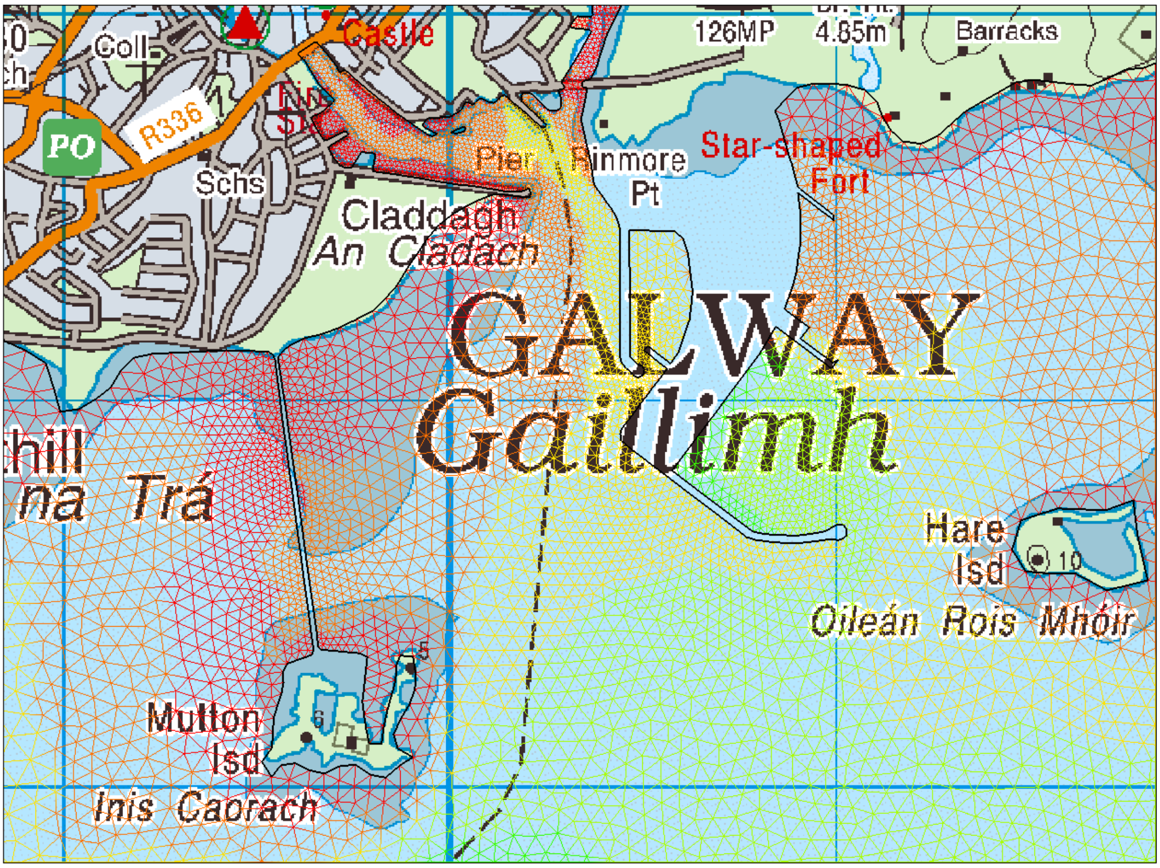


Figure 4.3.3 Swan Wave Model Domain and refined mesh in vicinity of Harbour Development (similar to hydrodynamic model mesh)

4.3.3 Effect of Tidal Currents on Wave Field

The swan model was run to demonstrate the effect that the predicted tidal currents close to highwater had on wave heights for the SSW and South Local wind direction combined with an Atlantic storm swell. Proposed and existing simulations were run both with and without tidal currents included. The predicted Significant Wave Heights are presented in Figures 4.3.4 to 4.3.6 for the Proposed Case under SSW winds, Figures 4.3.7 to 4.3.9 under South Winds. For the existing Case the predicted Significant Wave Heights are presented in Figures 4.3.10 to 4.3.12 for the for SSW winds and 4.3.13 to 4.3.15 for southerly winds.

4.3.4 Discussion

The simulations show that localised increases in wave height occur due to the presence of an opposing current for both the existing and proposed cases. For the existing case under SSW and Southerly wind waves (3.13 to 3.15) the effect is a local increase of 0.1 to 0.2m in significant wave height along the Navigation channel to Corrib entrance and 0.1m in the wider area . On a southeasterly storm wind (3.16 to 3.18) the predicted change in wave height is 0.15m at the Corrib Entrance and 0.2 to 0.3 in the approach channel for the Existing Case. On A SSW there is little predicted effect by the currents on the wave heights with increase within the range of 0.05 to 0.2m. (4.3.10 to 4.3.12)

Under the proposed case a similar pattern to the existing case of wave height increase due to currents is predicted for the wider area of the Bay having an increase in wave heights of the order of 0.1m. A significant local increase in wave heights are predicted along the proposed navigation channel to the Docks adjacent to the Marina having maximum increases of 0.5 to 0.6m due to refraction by high River Corrib currents. However along Nimmo's Pier and for a small section of Southpark shoreline to the West of the pier moderate increases of 0.05 to 0.1m are predicted. Such increase are also predicted at the entrance to the Corrib east of Nimmo's Pier.

In conclusion the effect of currents on wave climate along the vulnerable shoreline of Corrib entrance to the Claddagh basin, Nimmo's Pier and the Southpark coastline and other vulnerable area is shown through the above analysis not to be a significant factor with predicted increases in wave height of 0.1m and lower for the proposed case. The comparison of 4.3.6 with 4.3.12 and 4.3.9 with 4.3.15 show the same increase in heights for tidal velocity upstream of the Corrib entrance, proposed and existing. No increases arise along the South Park shore in this regard.

4.3.18 shows the greater waves upstream of the Corrib entrance in the existing case are caused by S.E. storm winds from which it will now be sheltered.

The impact of current on wind waves is best seen on the new Plots 4.3.6 S.S.W. and 4.3.9 S. This is in parallel to the marina breakwater and the height of same has been checked as adequate.

The impact on the Western side of the head of Nimmos Pier was previously reported in EIS 8.4.141. The further combined studies included in this R.F.I. show it at Plot 4.4.42. This shows the impact at that location to be no worse with the impact of current included.

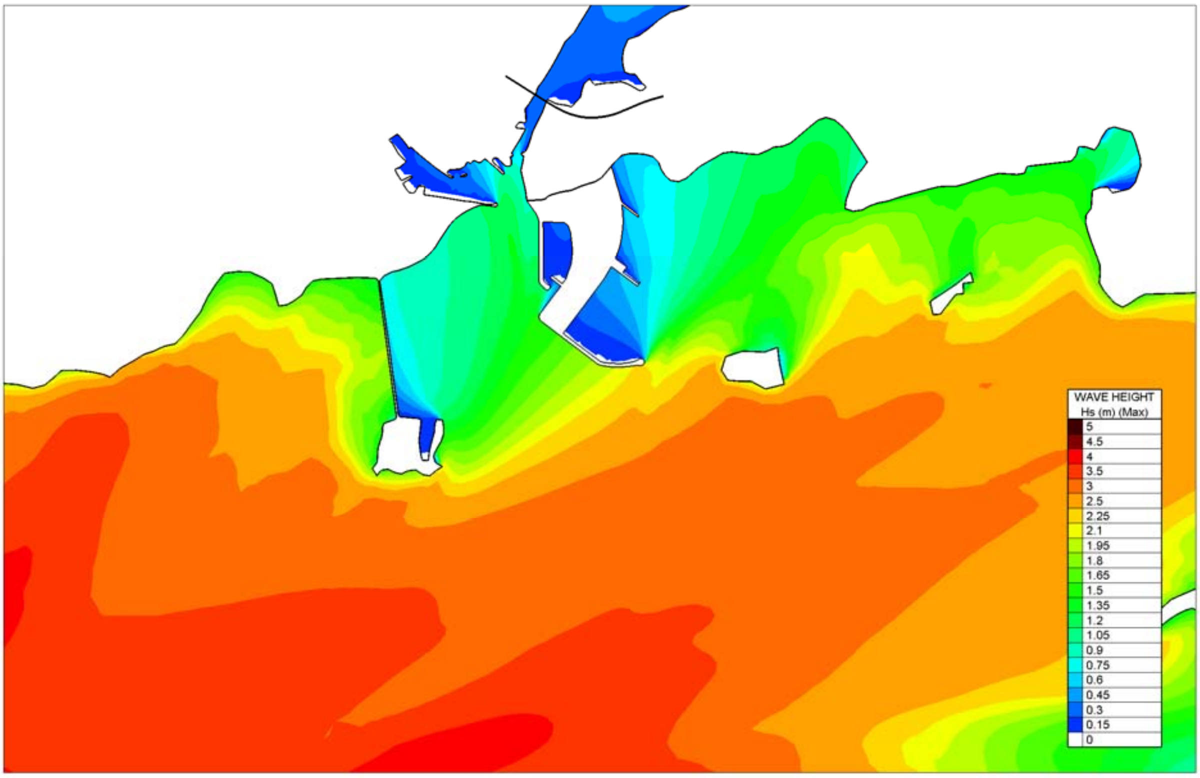


Figure 4.3.4 Predicted Wave Climate for SSW storm Wind without including tidal velocities - Proposed

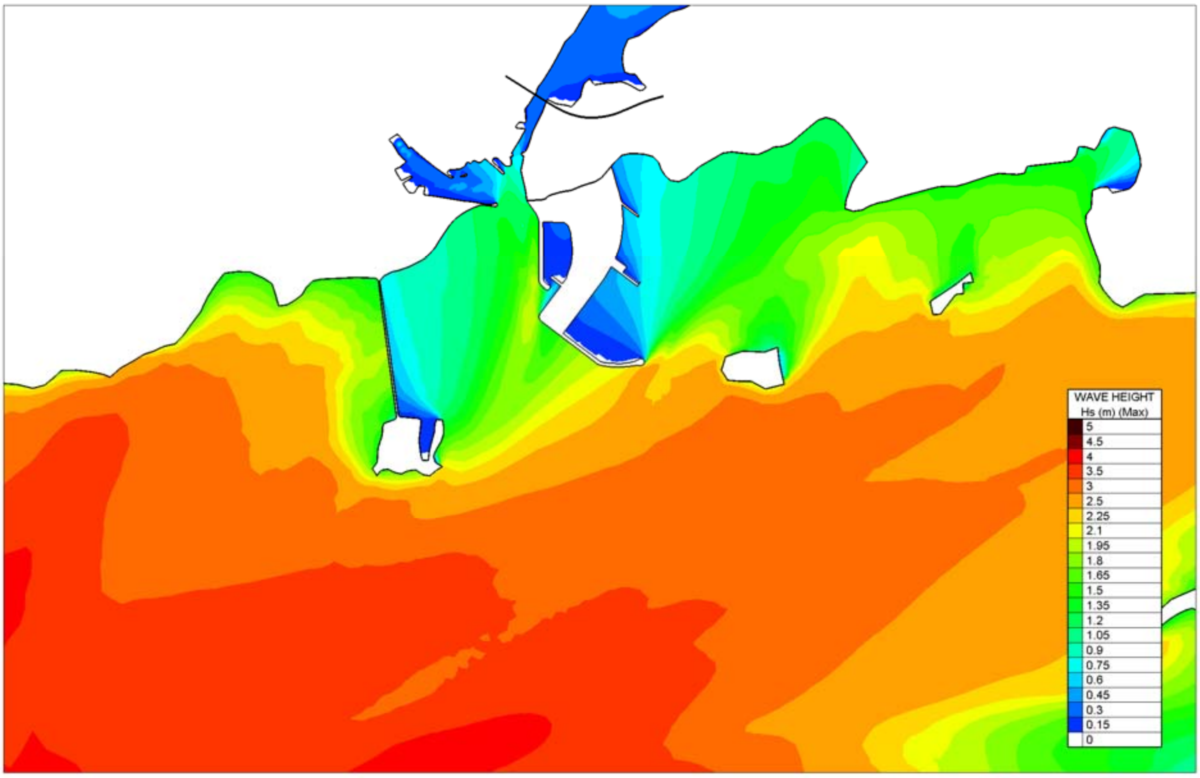


Figure 4.3.5 Predicted Wave Climate for SSW storm Wind with tidal velocities included - Proposed

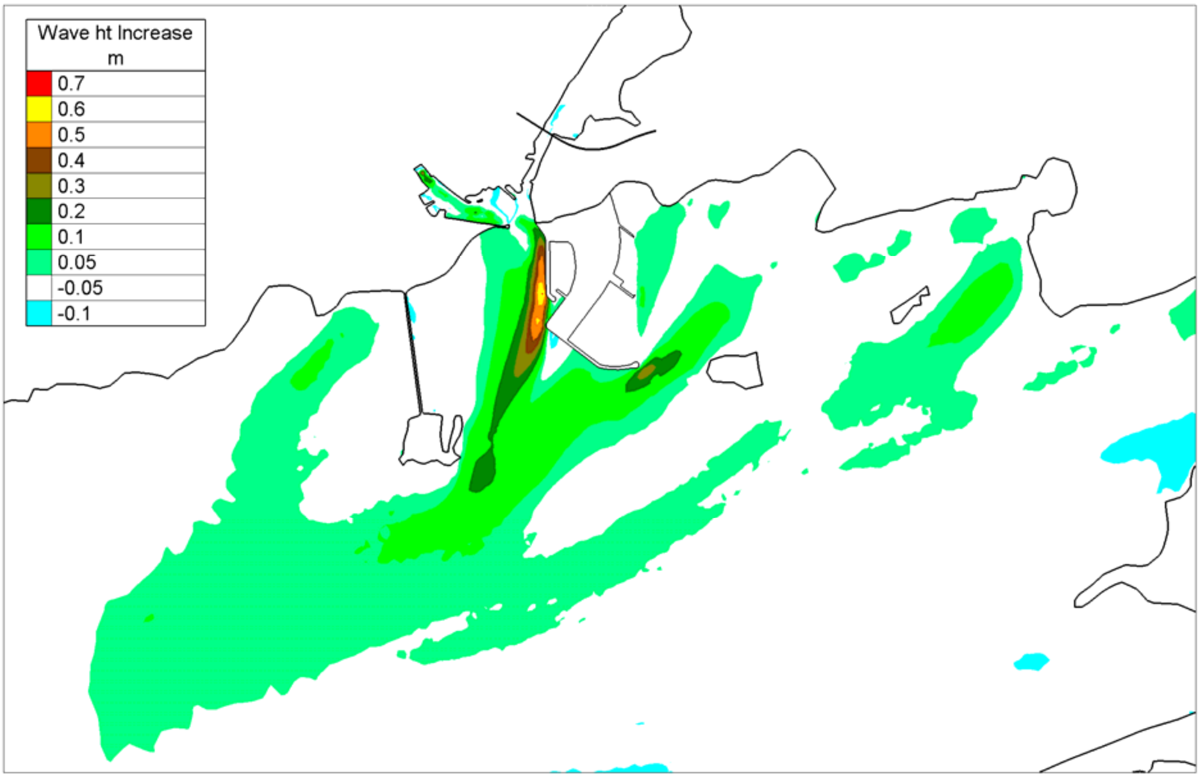


Figure 4.3.6 Difference Plot showing the effect of Tidal velocities on Wave height for SSW Storm wind conditions - Proposed

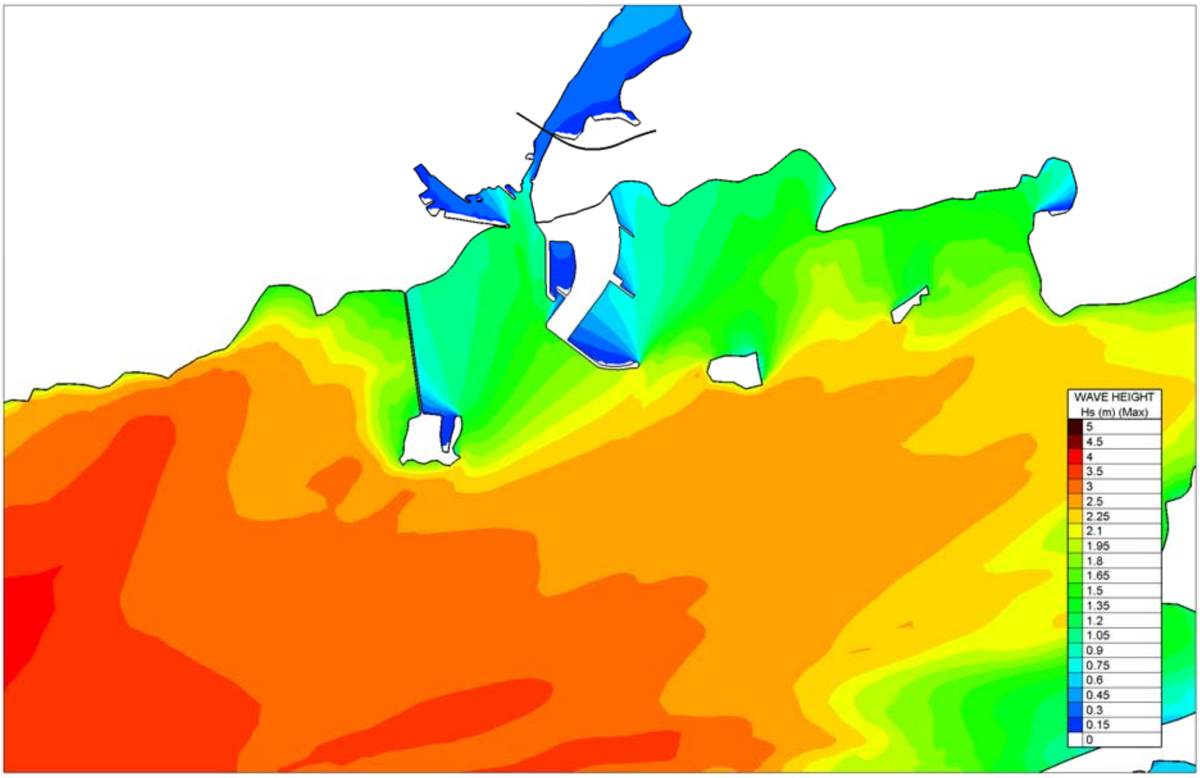


Figure 4.3.7 Predicted Wave Climate for South storm winds without including tidal velocities - Proposed

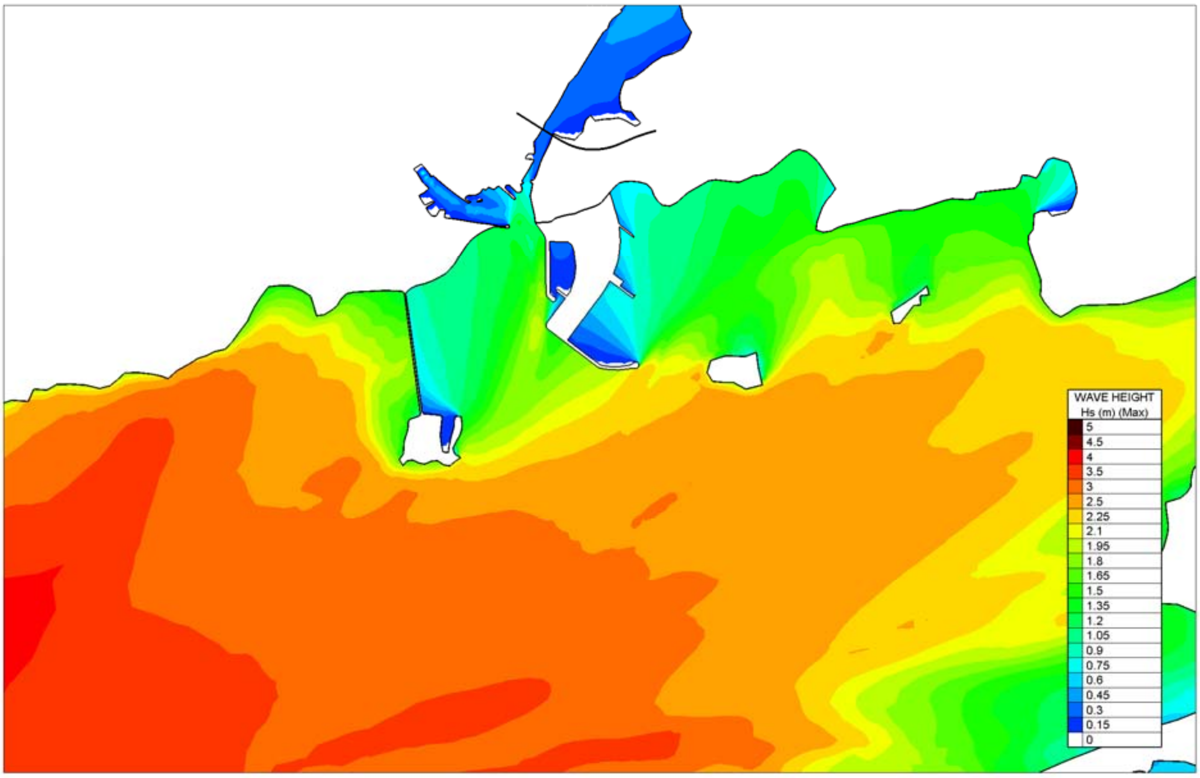


Figure 4.3.8 Predicted Wave Climate for South storm winds with tidal velocities included - Proposed

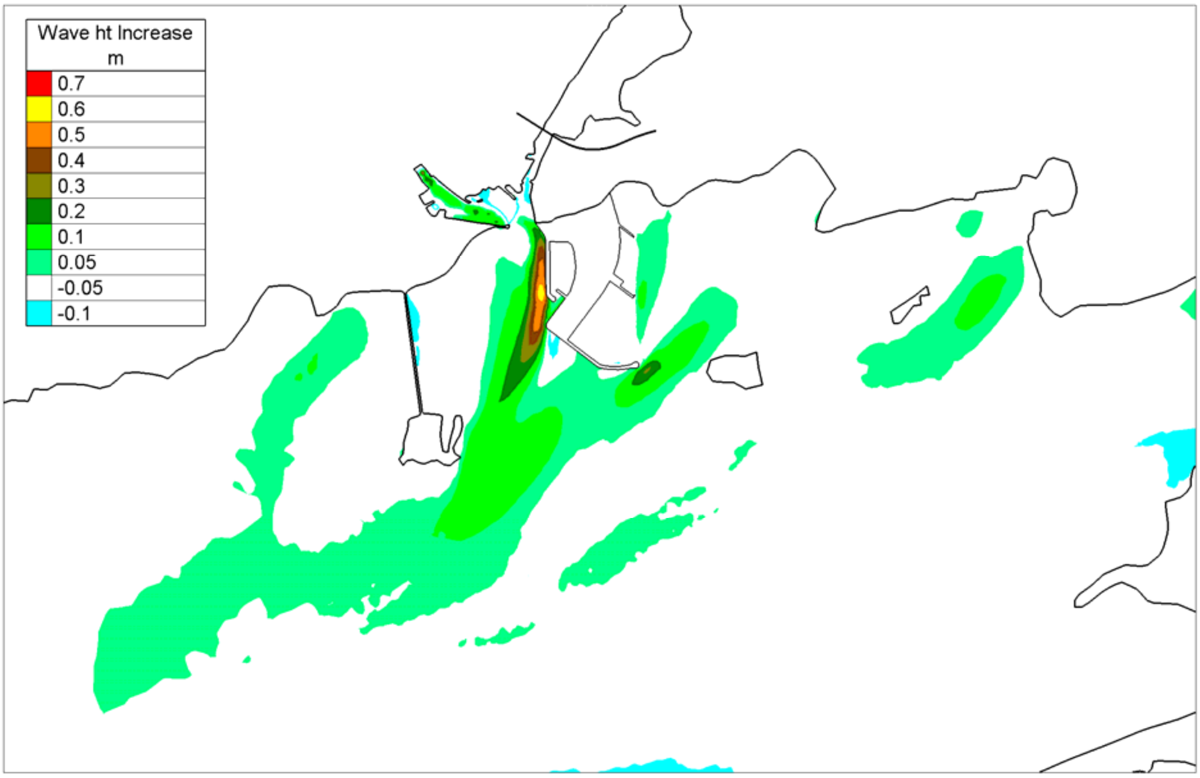


Figure 4.3.9 Difference Plot showing the effect of Tidal velocities on Wave height for South Storm wind conditions - Proposed

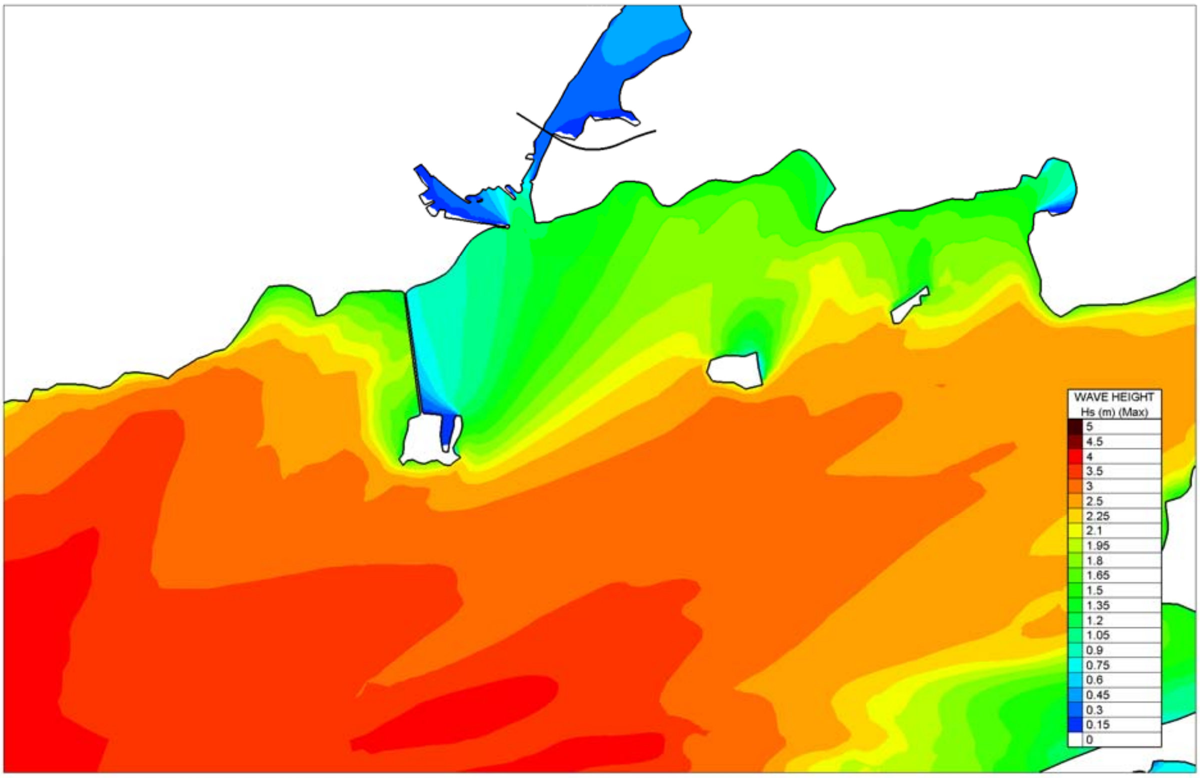


Figure 4.3.10 Predicted Wave Climate for SSW storm Wind without including tidal velocities – Existing

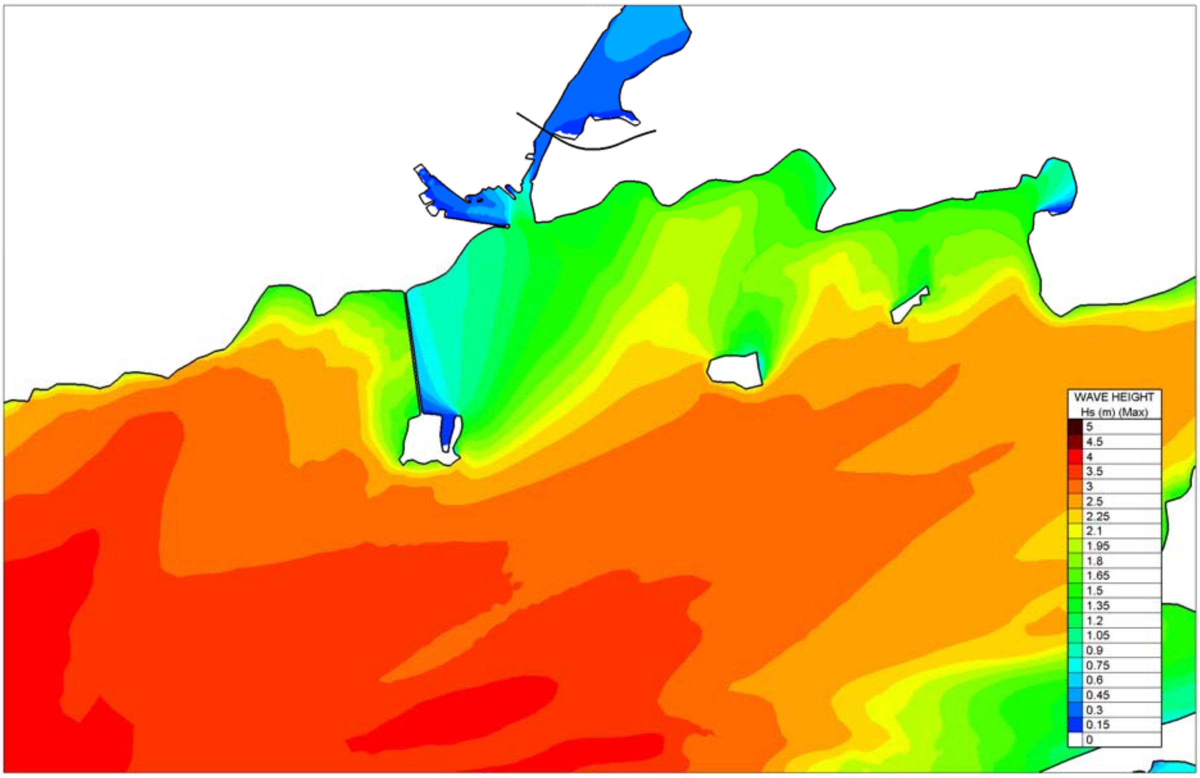


Figure 4.3.11 Predicted Wave Climate for SSW storm Wind with tidal velocities included - Existing

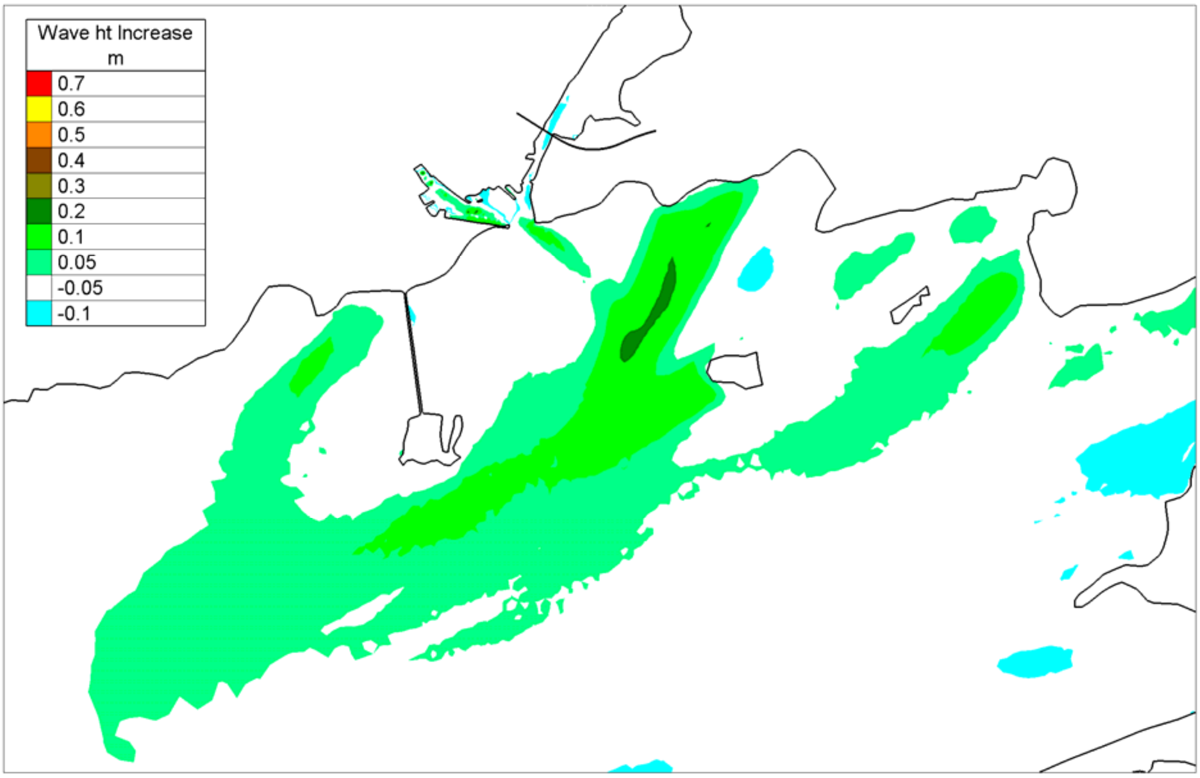


Figure 4.3.12 Difference Plot showing the effect of Tidal velocities on Wave height for SSW Storm wind conditions - Existing

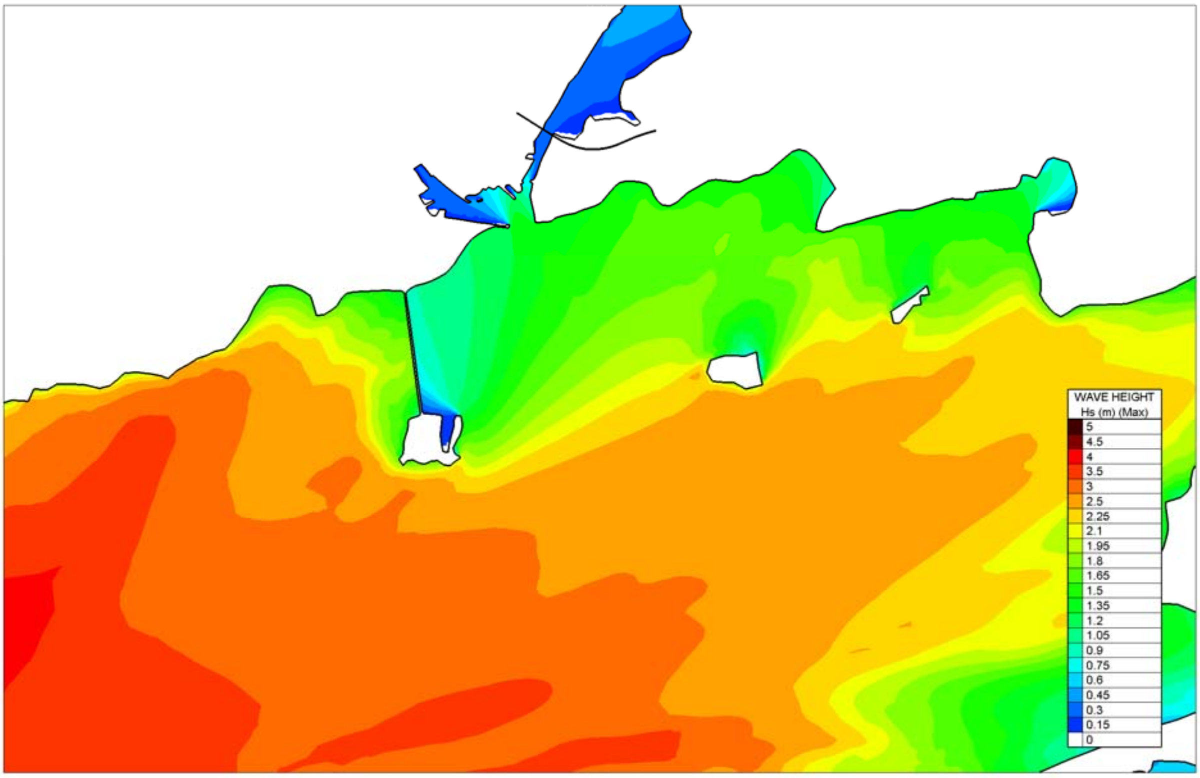


Figure 4.3.13 Predicted Wave Climate for South storm winds without including tidal velocities - Existing

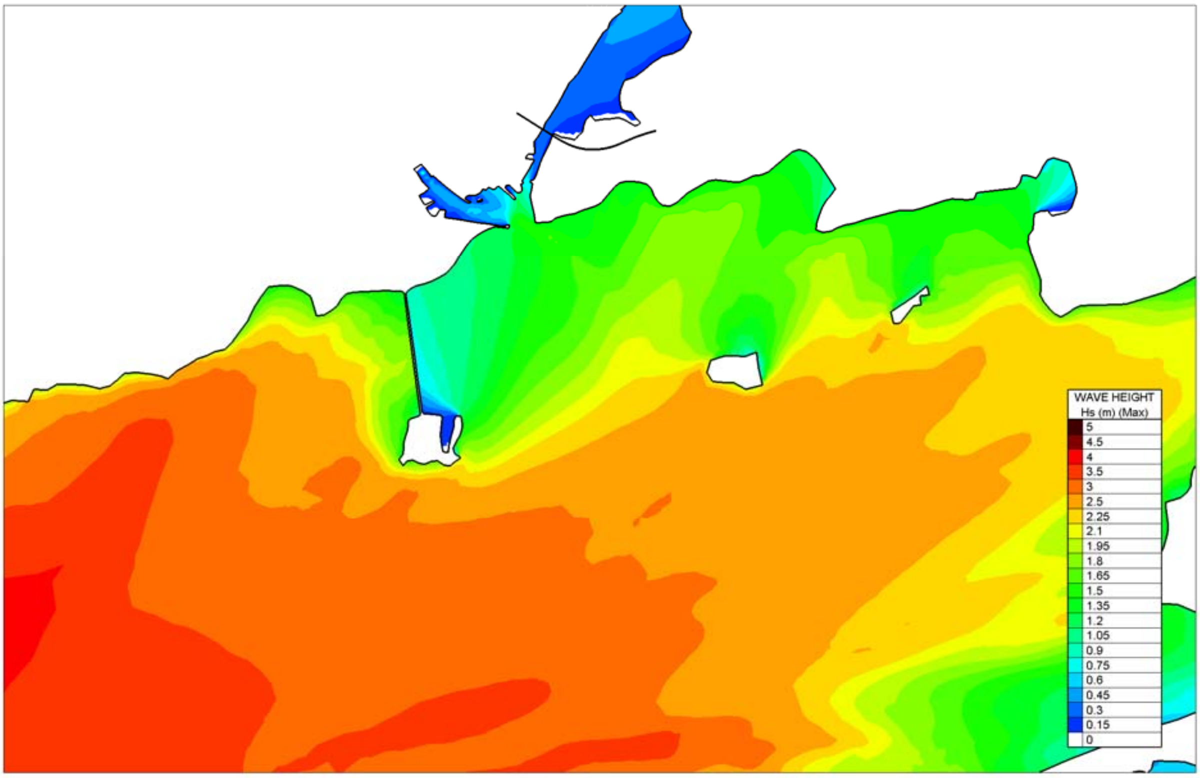


Figure 4.3.14 Predicted Wave Climate for South storm winds with tidal velocities included - Existing

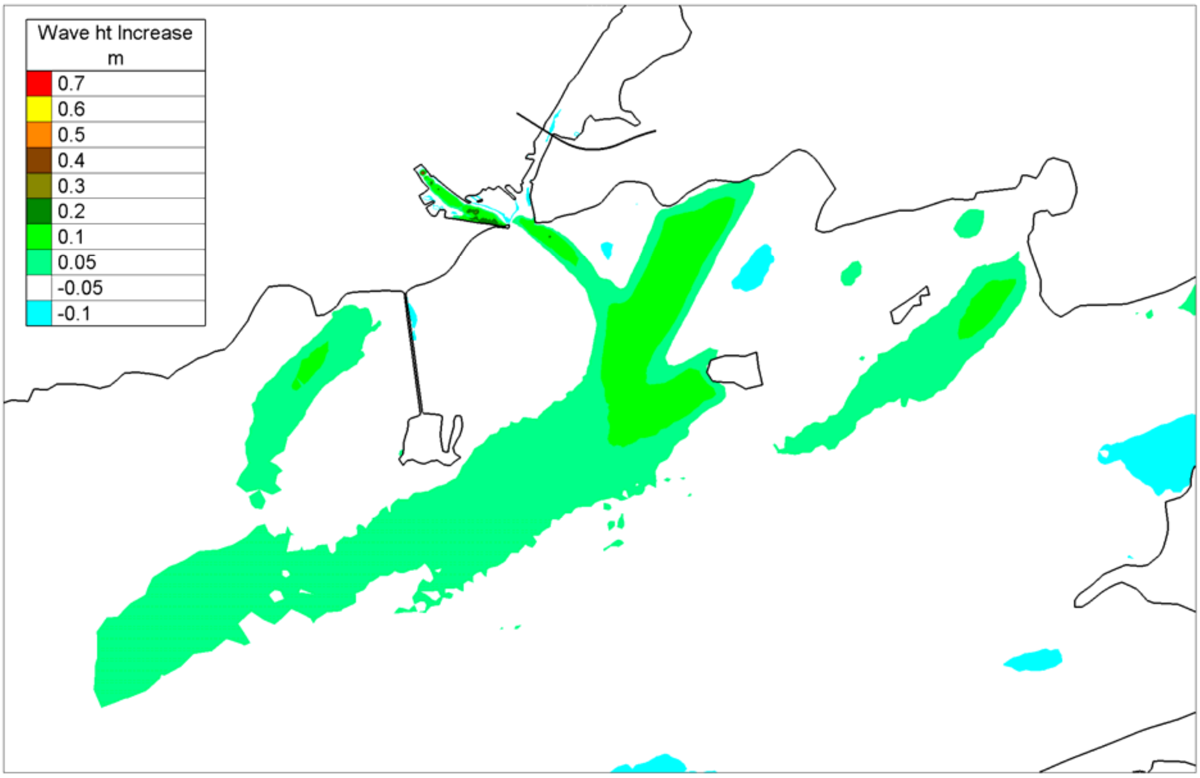


Figure 4.3.15 Difference Plot showing the effect of Tidal velocities on Wave height for South Storm wind conditions - Existing

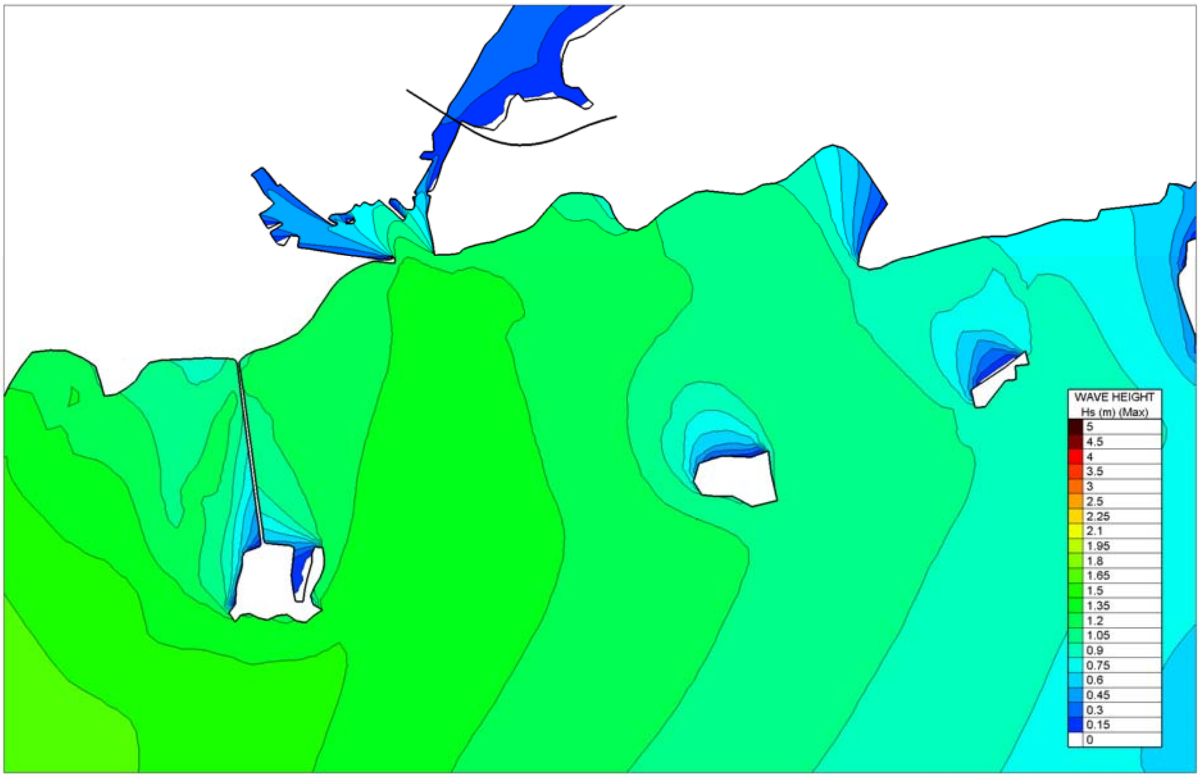


Figure 4.3.16 Predicted Wave Climate for local SE storm wind waves without tidal velocities included - Existing

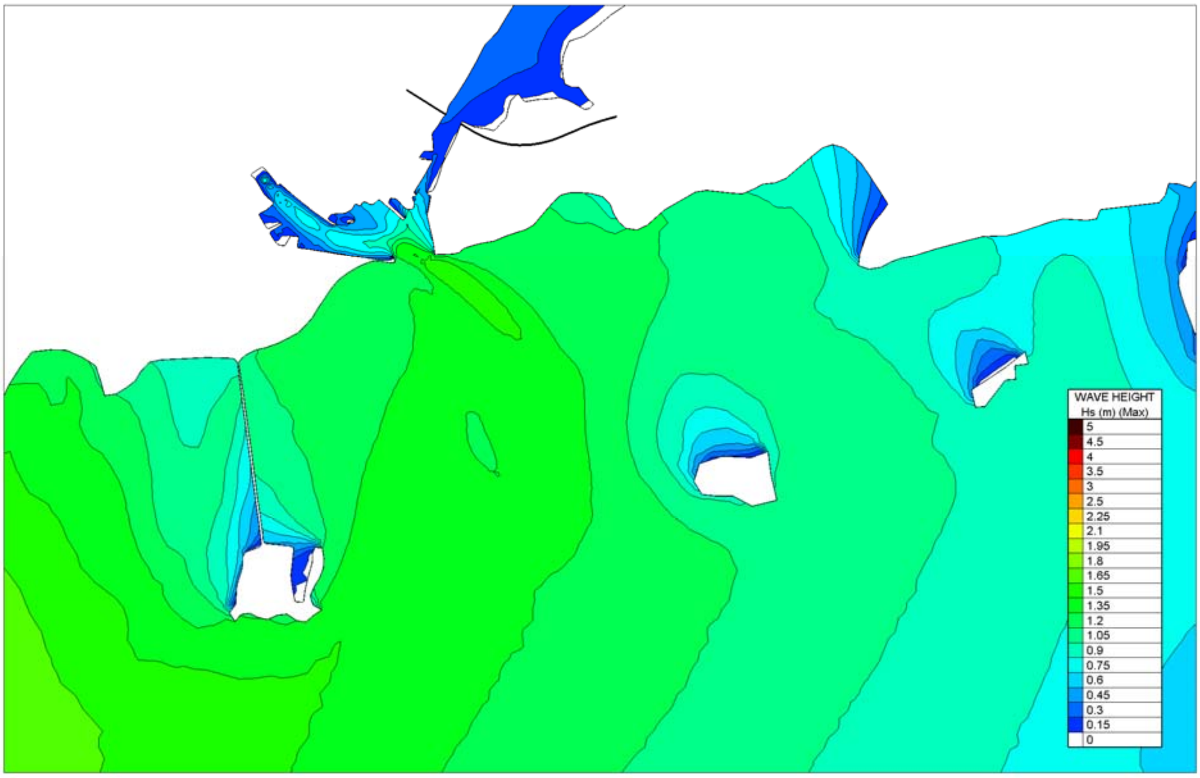


Figure 4.3.17 Predicted Wave Climate for local SE storm wind waves with tidal velocities included - Existing

Figure 4.3.18 Difference Plot showing the effect of Tidal velocities on Wave height for SE Storm Wind Waves - Existing

4.4 RELATIONSHIP BETWEEN WIND WAVES AND CURRENT EFFECTS

Query:

Please clarify whether within the area that experiences high wind waves, willÿ the wave heights be exacerbated if the current-effects are included?

Response:

4.4.1 Introduction

To incorporate the effect of Tidal Currents for the proposed and existing cases a full range of Wave climate simulations were carried out modelling both Atlantic Swell and Local wind Waves using the SWAN Spectral Model described in Section 3. These simulation were carried out with the tidal currents from the hydrodynamic model included for the proposed and existing cases.

4.4.2 Wave Climate Simulations

The following Wave Simulations Runs were carried out for proposed and existing Cases:

- West Storm Wind Waves and Atlantic Storm Swell (Figure 4.4.1, 4.4.2 & 4.4.25)
- WSW Storm Wind Waves and Atlantic Storm Swell (Figure 4.4.3, 4.4.4 & 4.4.26)
- SW Storm Wind Waves and Atlantic Storm Swell (Figure 4.4.5, 4.4.6 & 4.4.27)
- SSW Storm Wind Waves and Atlantic Storm Swell (Figure 4.4.7, 4.4.8 & 4.4.28)
- South Storm Wind Waves and Atlantic Storm Swell (Figure 4.4.9, 4.4.10 & 4.4.29)

- WSW Local generated Storm Wind Waves (Figure 4.4.11, 4.4.12 & 4.4.30)
- SW Local generated Storm Wind Waves (Figure 4.4.13, 4.4.114 & 4.4.31)
- SSW Local generated Storm Wind Waves (Figure 4.4.15, 4.4.16 & 4.4.32)
- South Local generated Storm Wind Waves (Figure 4.4.17, 4.4.18 & 4.4.33)
- SSE Local generated Storm Wind Waves (Figure 4.4.19, 4.4.20 & 4.4.34)
- SE Local generated Storm Wind Waves (Figure 4.4.21, 4.4.22 & 4.4.35)
- ESE Local generated Storm Wind Waves (Figure 4.4.23 4.4.24 & 4.4.36)

In these simulations the storm winds and local storm winds were taken as 30m/s.

The significant wave heights are presented in Figure 4.4.1 to 4.4.24 and wave height difference plot between proposed and existing cases are presented in Figures 4.4.25 to 4.4.36.

The results from the above simulations are compiled to produce a Plot of Maximum Wave Heights within the Bay for all on-shore directions (local wind waves and Atlantic storm swell) which is requested by An Bord Pleanála under Item 9 of the Further Information Request, refer to Figures 4.4.37 to 4.4.40.

4.4.3 Discussion

A full series of the SWAN Spectral Wave model simulation runs were carried out to complement the ARTEMIS Simulation results reported in the EIS. The SWAN modelling included for refraction by currents and generally showed compatible results with the Artemis Model. Along the Southpark shoreline it showed wave heights only slightly higher than the Artemis Model (0.1 to 0.3m) which may be as a result of the ARTEMIS model being unable to include local wind generation within its domain (i.e. between the incident wave boundary and the shoreline). These SWAN results in combination with the ARTEMIS wave results can be used to assess the potential impact of the development on the surrounding wave climate.

In terms of Impact by the proposed development on the wave climate both sets of model results (Artemis and Swan) generally agree.

For both Atlantic and local wind generated waves from the West to South sector an increased wave climate occurs to the west of the Harbour development with increased wave heights predicted in the vicinity of Nimmo's Pier and the easterly section of Southpark shoreline with increases ranging between 0.05 and 0.2m, see 4.4.42.

4.4.42 shows a reduction in maximum wave heights at the Corrib entrance predicted by both the Artemis and Swan models in the proposed case.

4.4.41 shows a reaction in maximum wave heights in the Corrib / Claddagh Basin and on the South park shore other than the small area near to the head of Nimmos Pier.

A reduction in wave climate is predicted to the East of the Development between Ballyloughaun to the north and Hare Island to the south and the Harbour development.

For the South to East Wind fetch directions the proposed development has generally a sheltering effect and particularly on its western side which shelters against an ESE and SE wave directions which for the existing case can propagate up the Claddagh Basin.

In terms of maximum wave heights along the shoreline area of Southpark and the Corrib entrance the Swan Model indicates an overall reduction in the maximum wave heights as a result of the development (due to the sheltering of southeasterly wind waves).

The Renmore shoreline from east of Ballyloughaun Beach to the proposed Harbour is afforded significant shelter from Waves as a result of the development.

The only area of significant wave height change due to the refraction by currents is in the proposed navigation channel near the Marina entrance with predicted increases in wave heights of 0.5 to 0.6m as a result of strong flood Corrib Flow velocities). This is not critical as the Marina Breakwater is suitably sized in terms of Crest level.

The effect from tidal velocities elsewhere in the Bay on wave heights is not significant with predicted maximum increases of 0.1 to 0.2 m/s when opposing the wave direction (i.e. ebbing Flow).

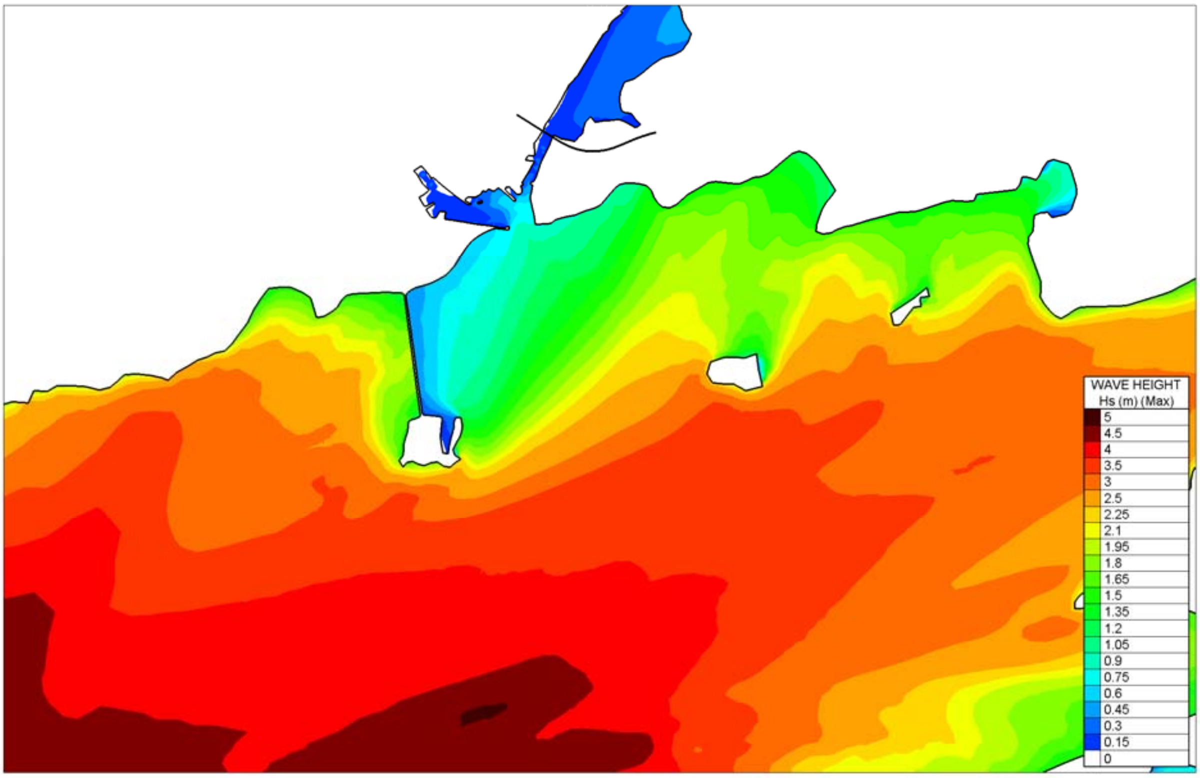


Figure 4.4.1 Computed Significant Wave heights for Atlantic Storm and West Storm Winds - Existing

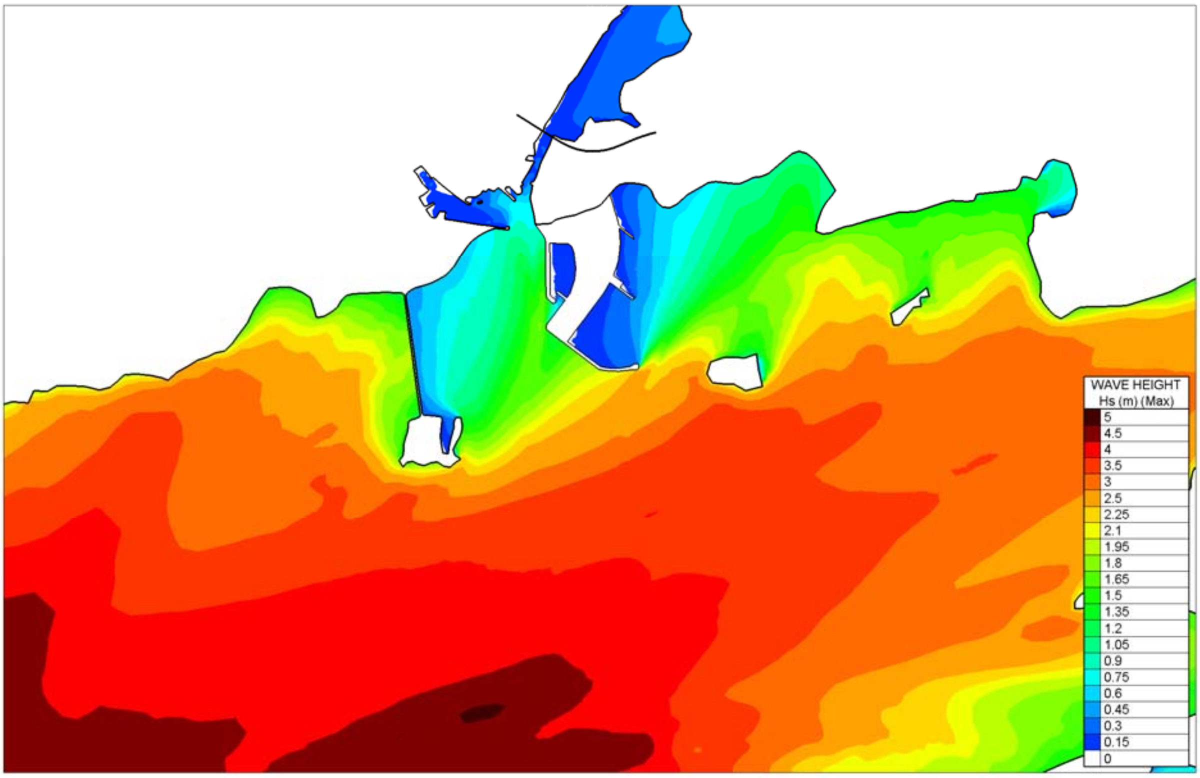


Figure 4.4.2 Computed Significant Wave heights for Atlantic Storm and West Storm Winds - Proposed

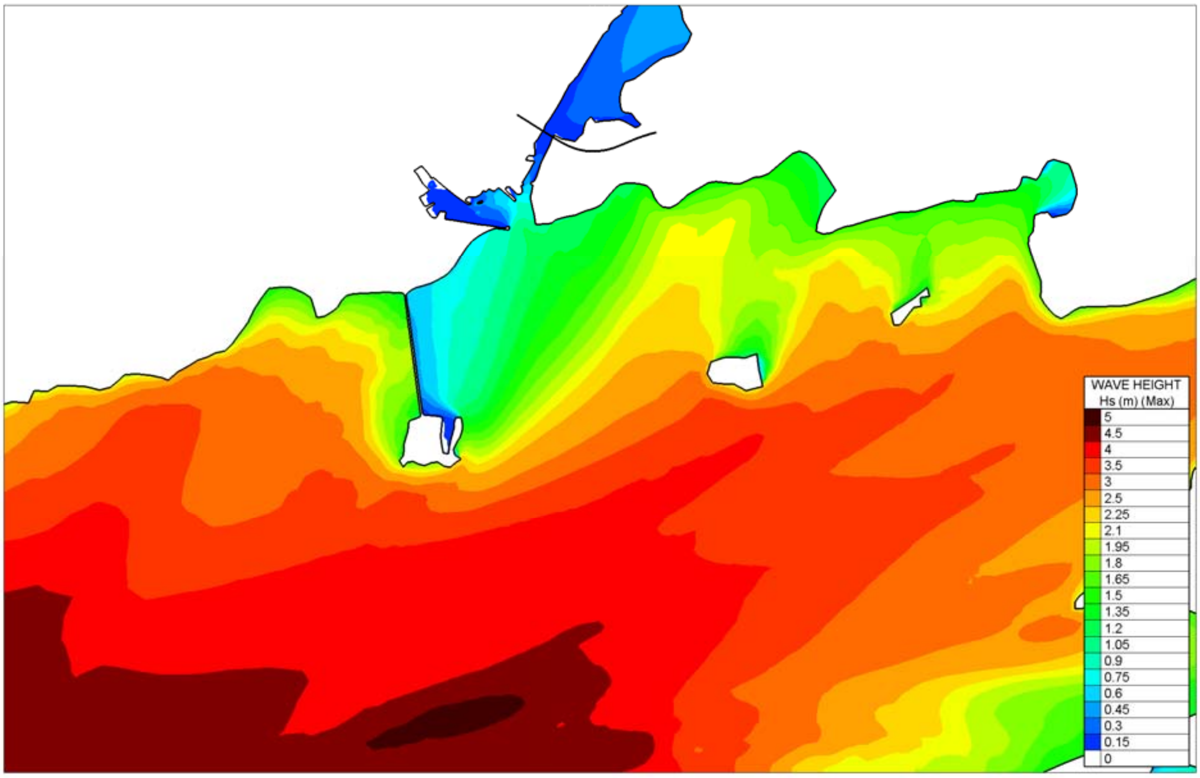


Figure 4.4.3 Computed Significant Wave heights for Atlantic Storm and WSW

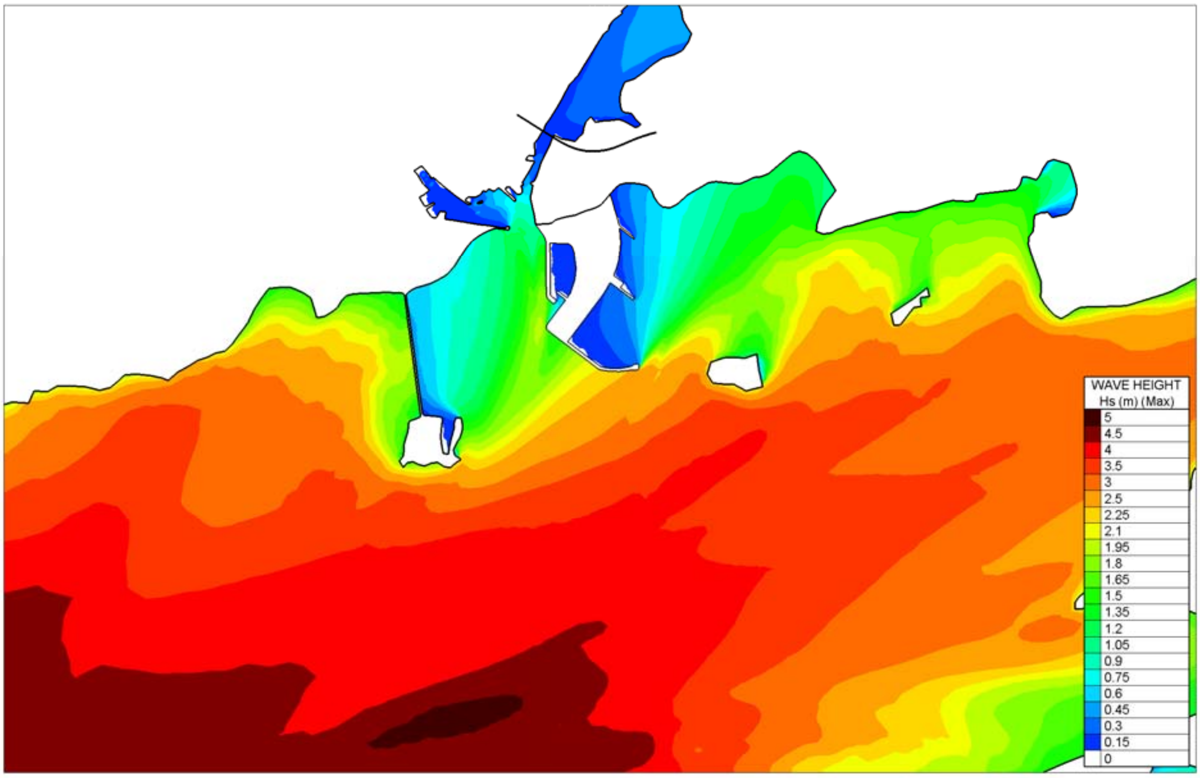


Figure 4.4.4 Computed Significant Wave heights for Atlantic Storm and WSW

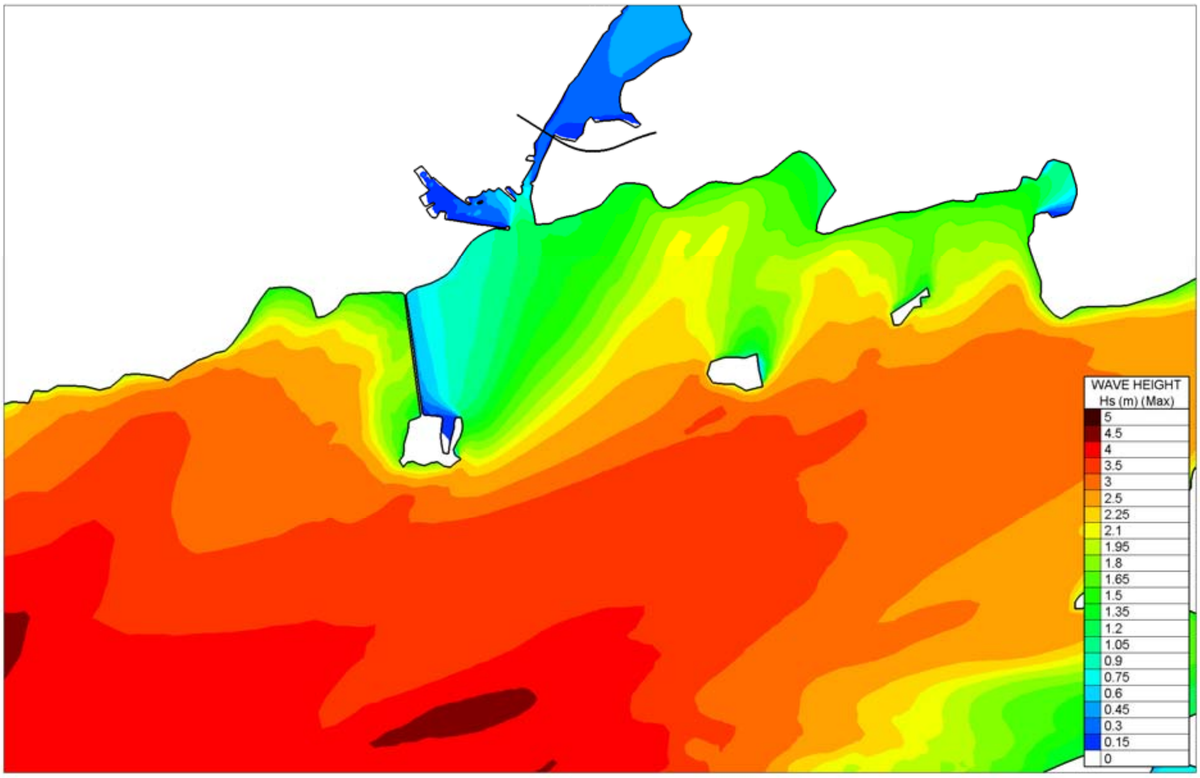


Figure 4.4.5 Computed Significant Wave heights for Atlantic Storm and SW

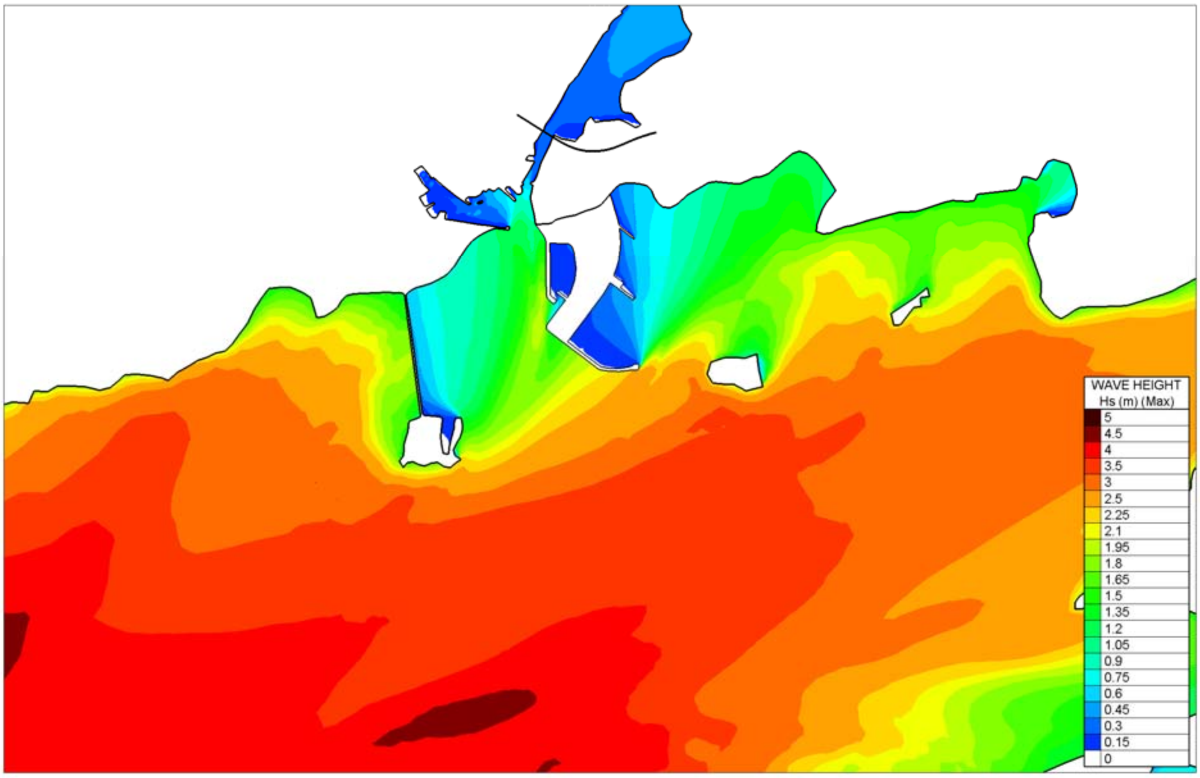


Figure 4.4.6 Computed Significant Wave heights for Atlantic Storm and SW

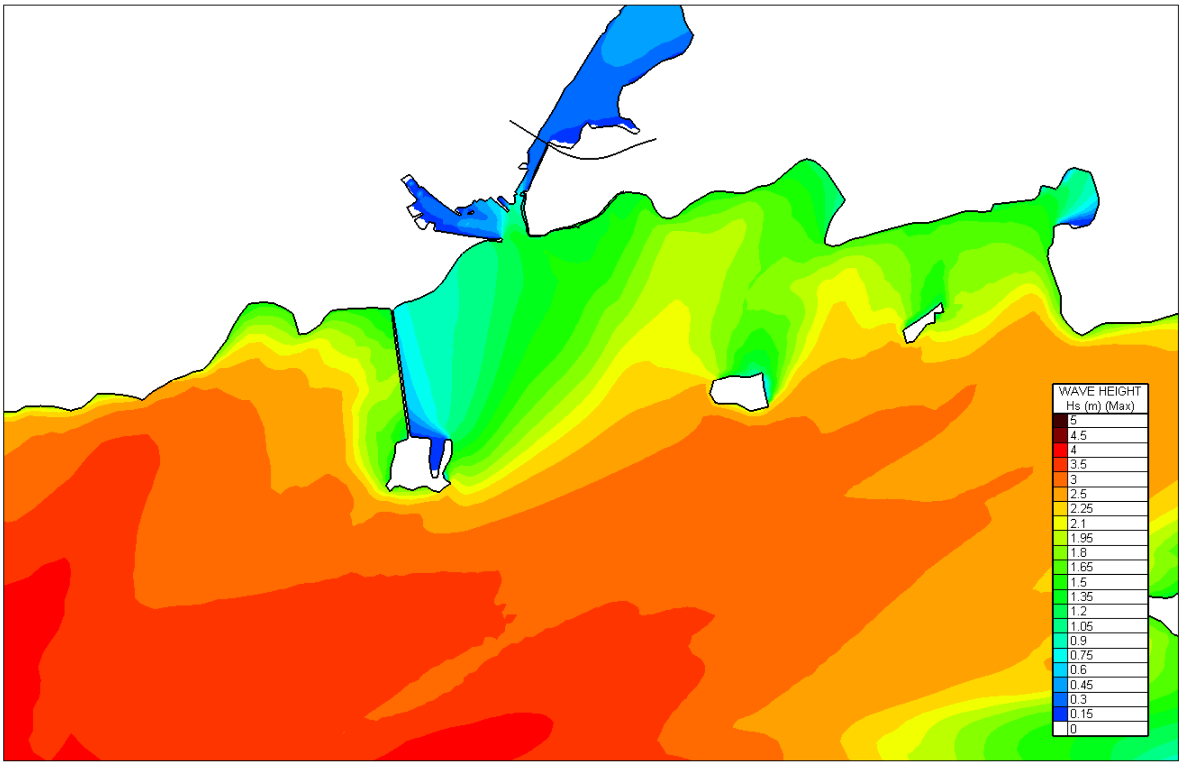


Figure 4.4.7 Computed Significant Wave heights for Atlantic Storm and SSW Storm Winds - Existing

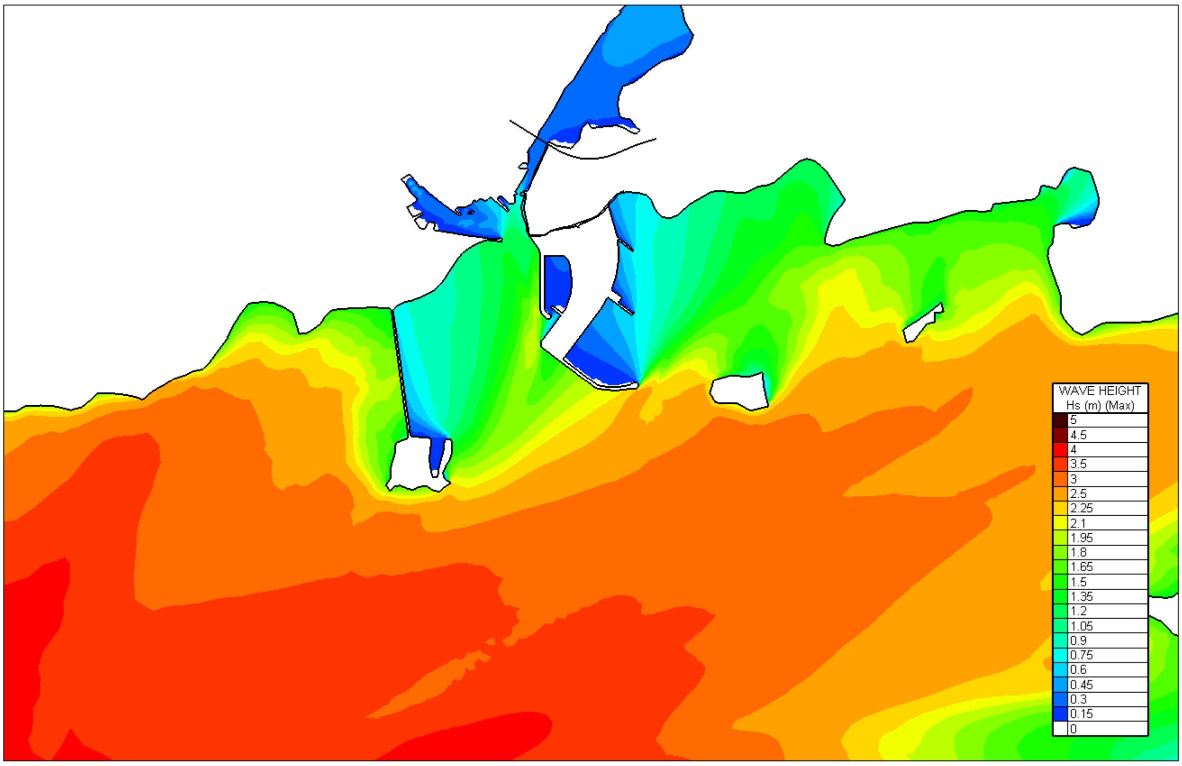


Figure 4.4.8 Computed Significant Wave heights for Atlantic Storm and SSW Storm Winds - Proposed

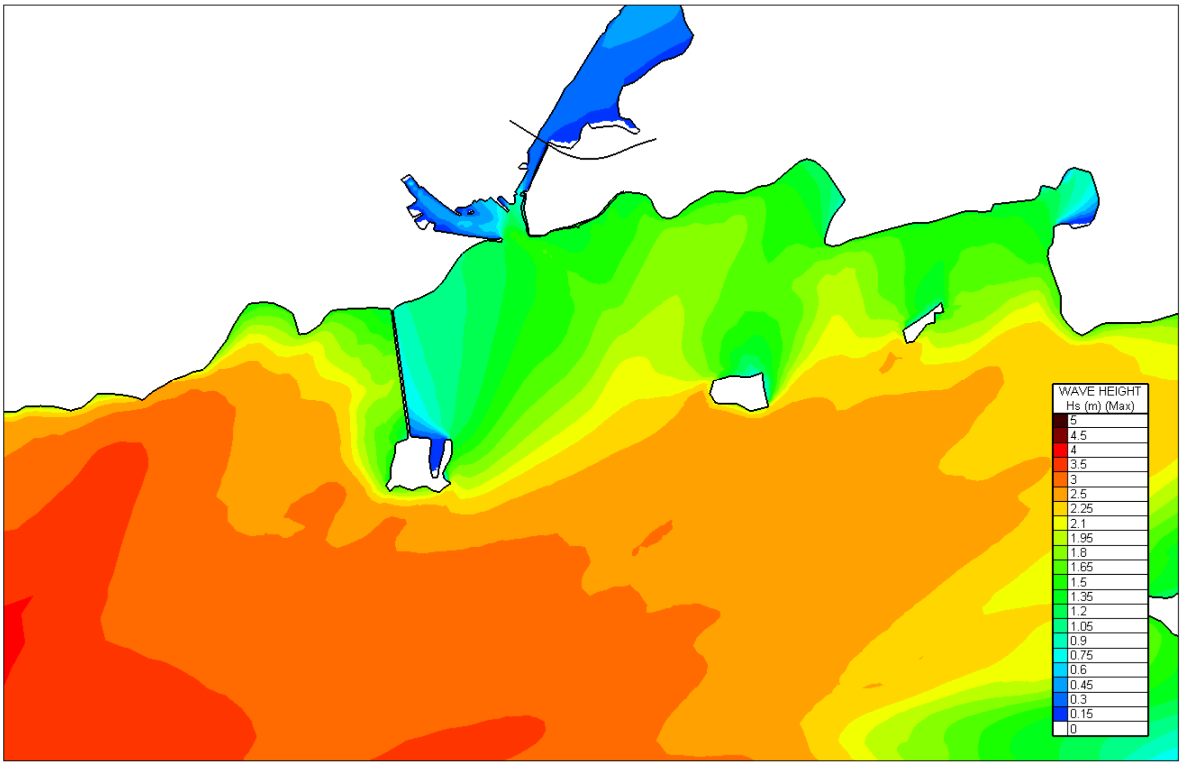


Figure 4.4.9 Computed Significant Wave heights for Atlantic Storm and South Storm Winds - Existing

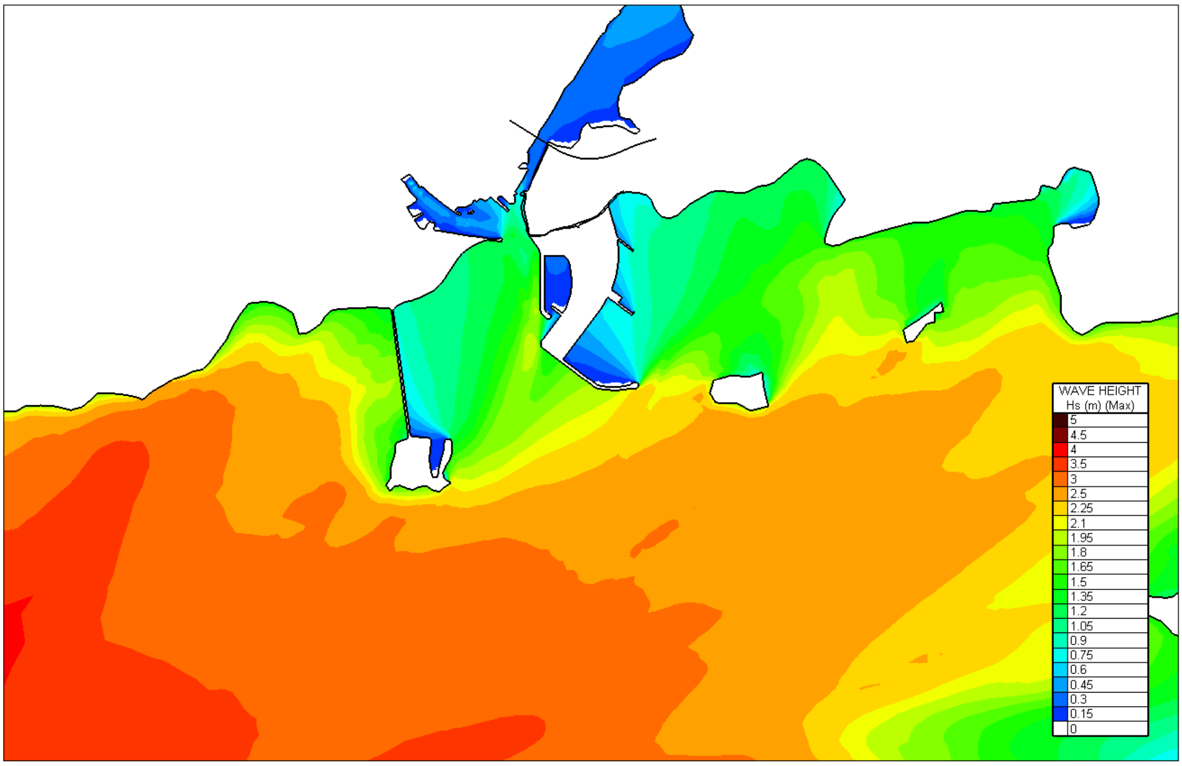


Figure 4.4.10 Computed Significant Wave heights for Atlantic Storm and South Storm Winds - Proposed

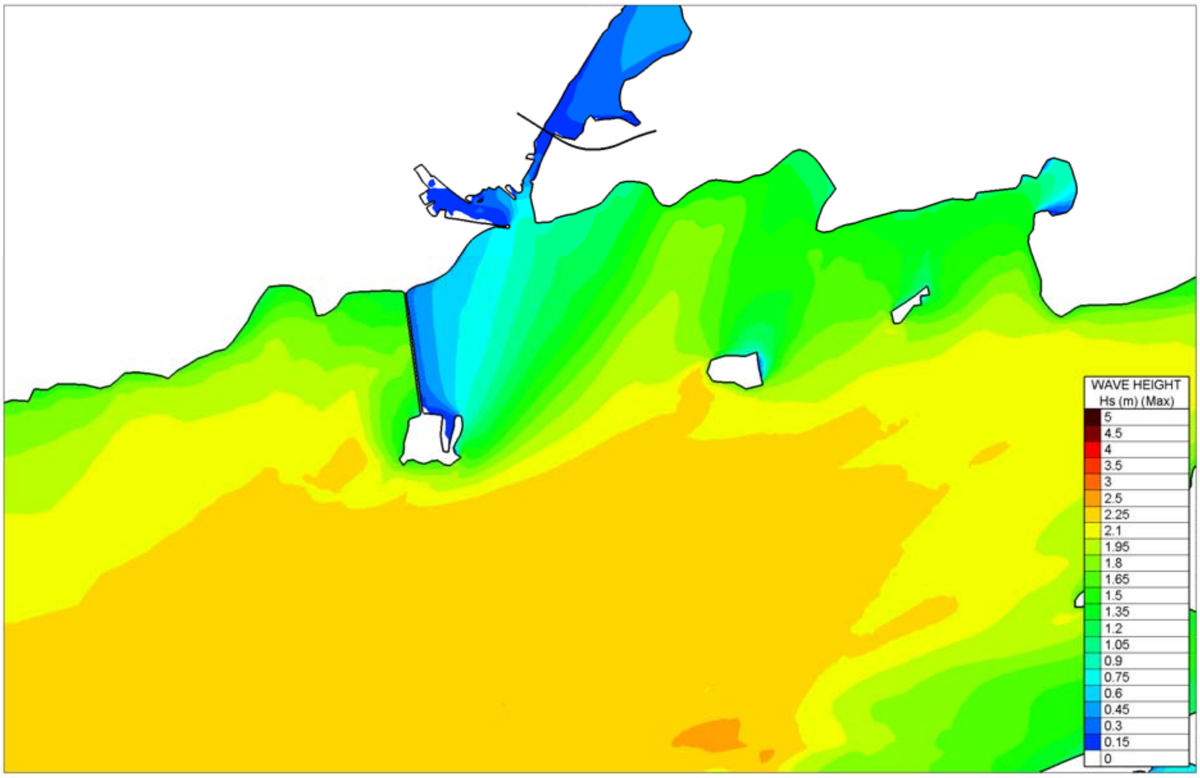


Figure 4.4.11 Computed Significant Wave heights for Local WSW Storm Winds - Existing

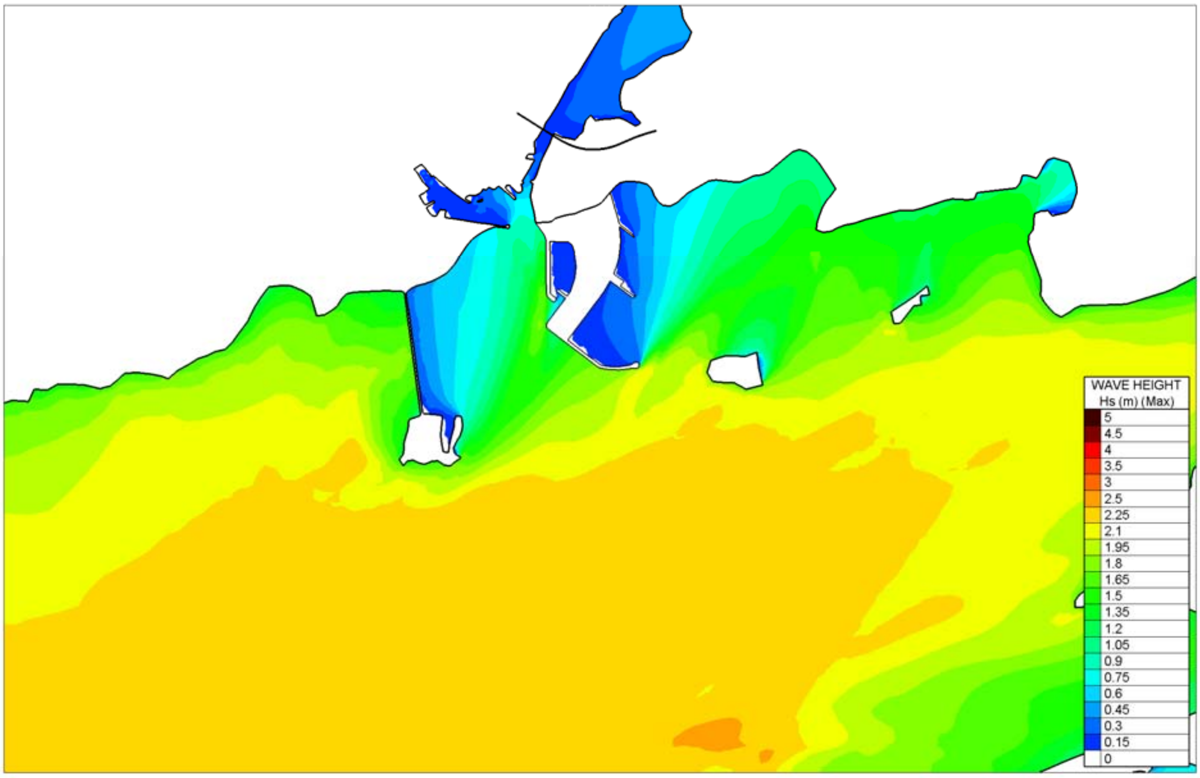


Figure 4.4.12 Computed Significant Wave heights for Local WSW Storm Winds - Proposed

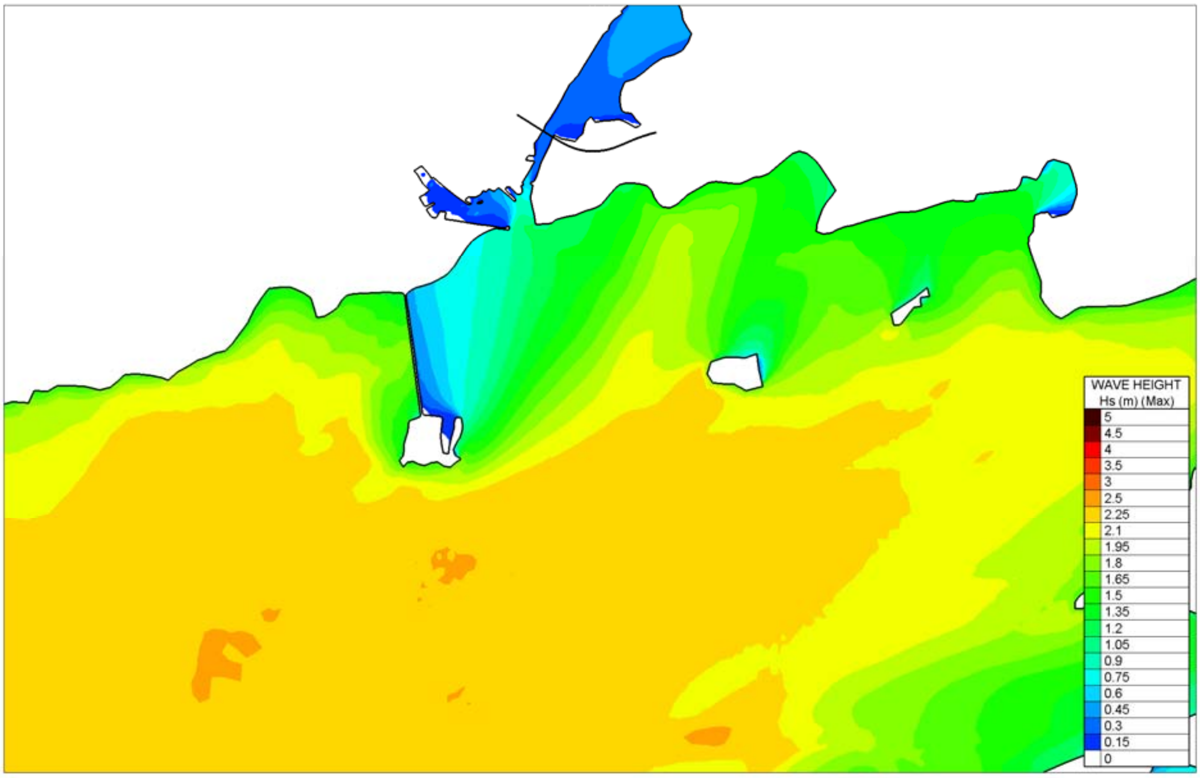


Figure 4.4.13 Computed Significant Wave heights for Local SW Storm Winds - Existing

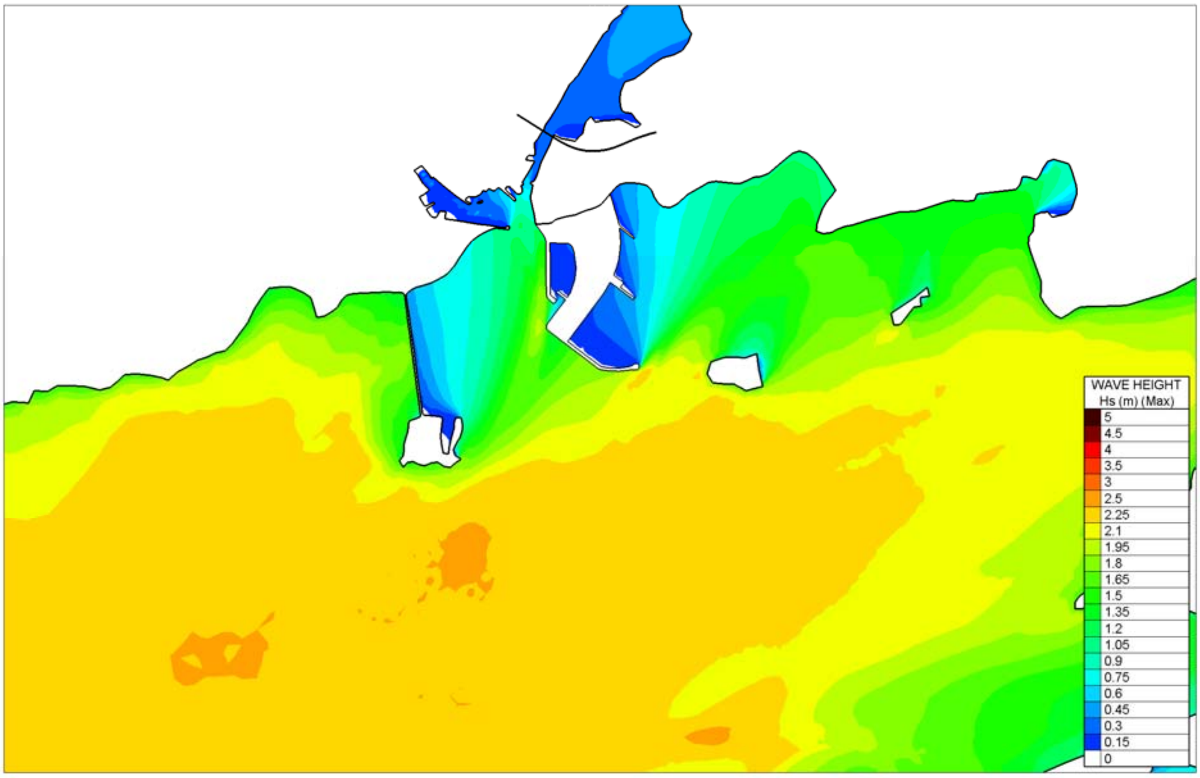


Figure 4.4.14 Computed Significant Wave heights for Local SW Storm Winds - Proposed

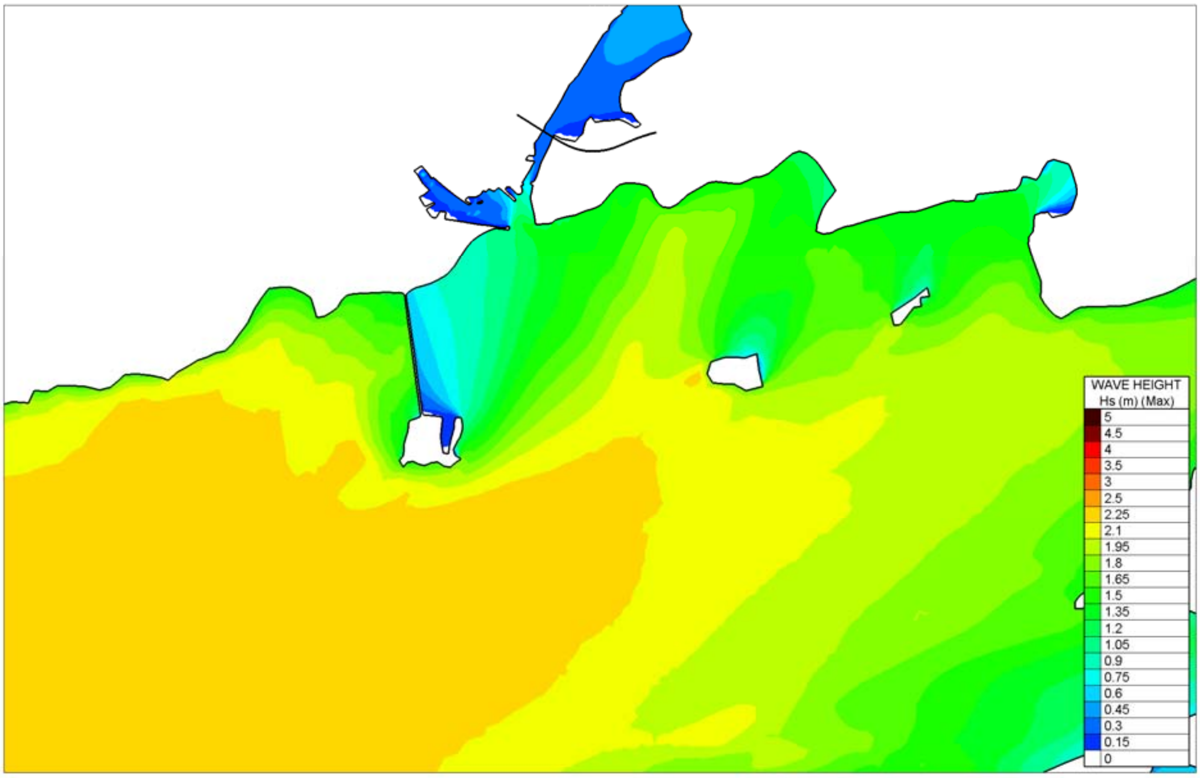


Figure 4.4.15 Computed Significant Wave heights for Local SSW Storm Winds - Existing

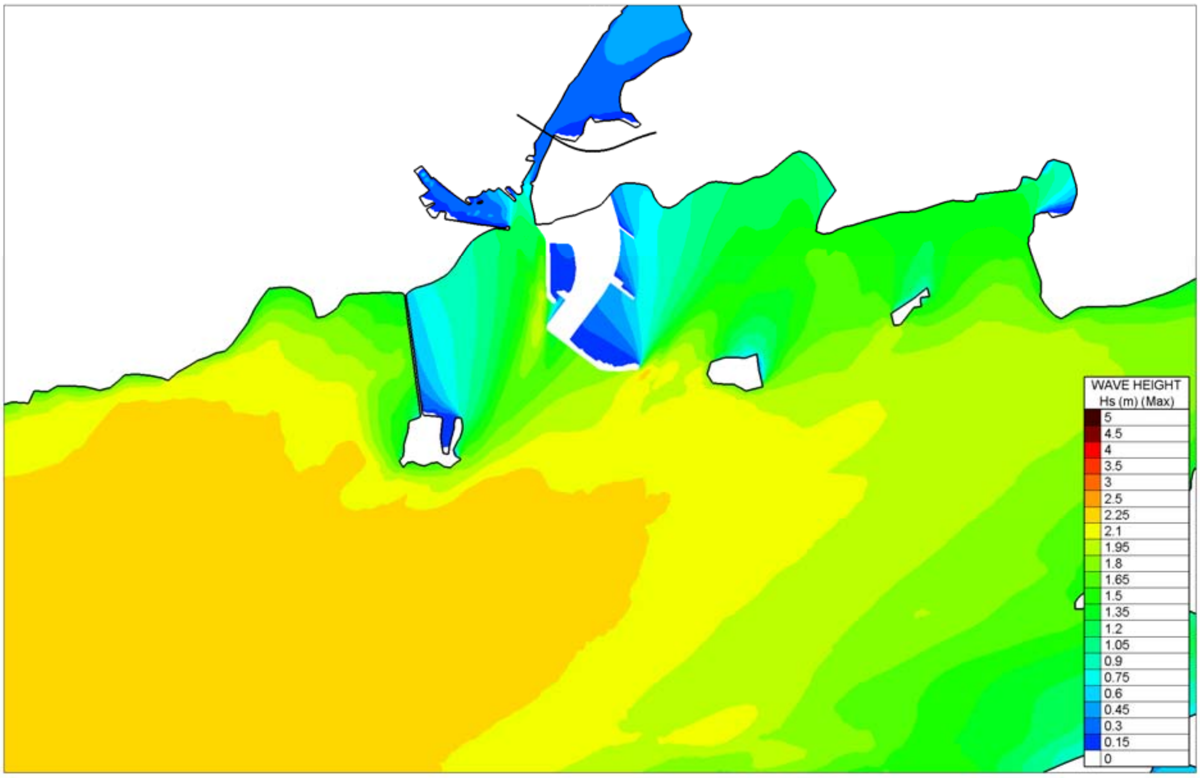


Figure 4.4.16 Computed Significant Wave heights for Local SSW Storm Winds - Proposed

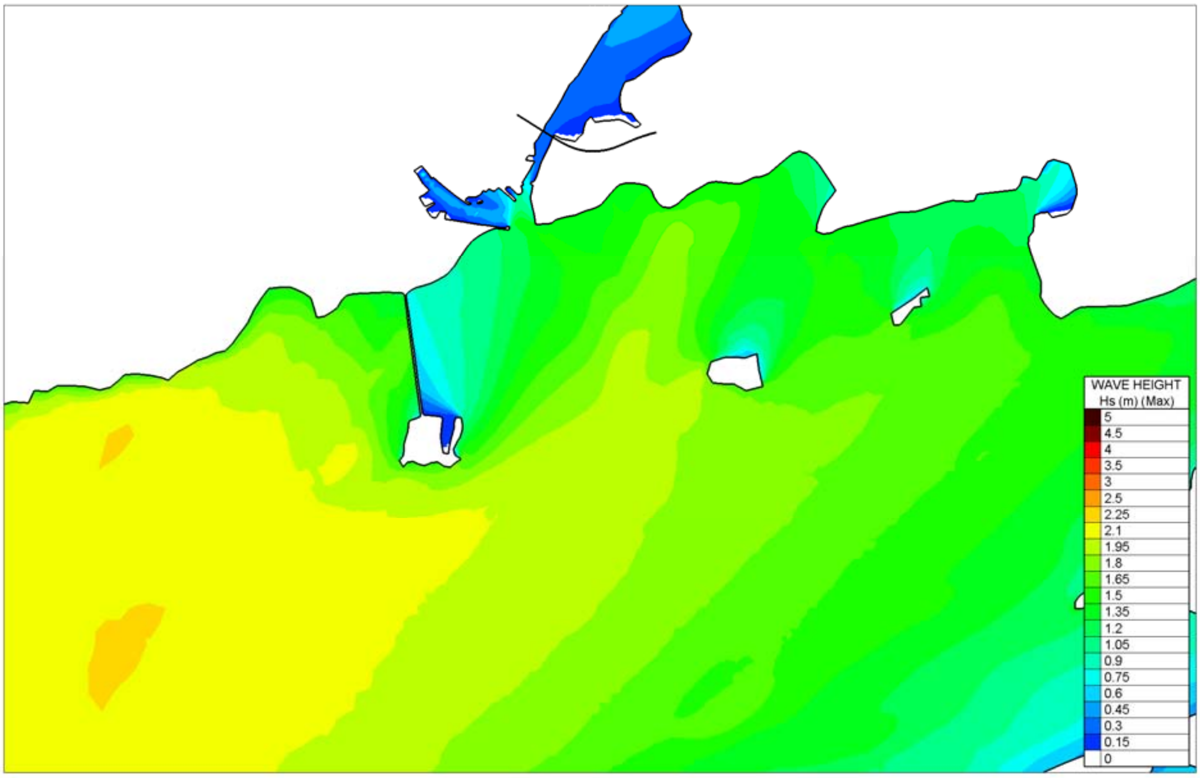


Figure 4.4.17 Computed Significant Wave heights for Local South Storm Winds - Existing

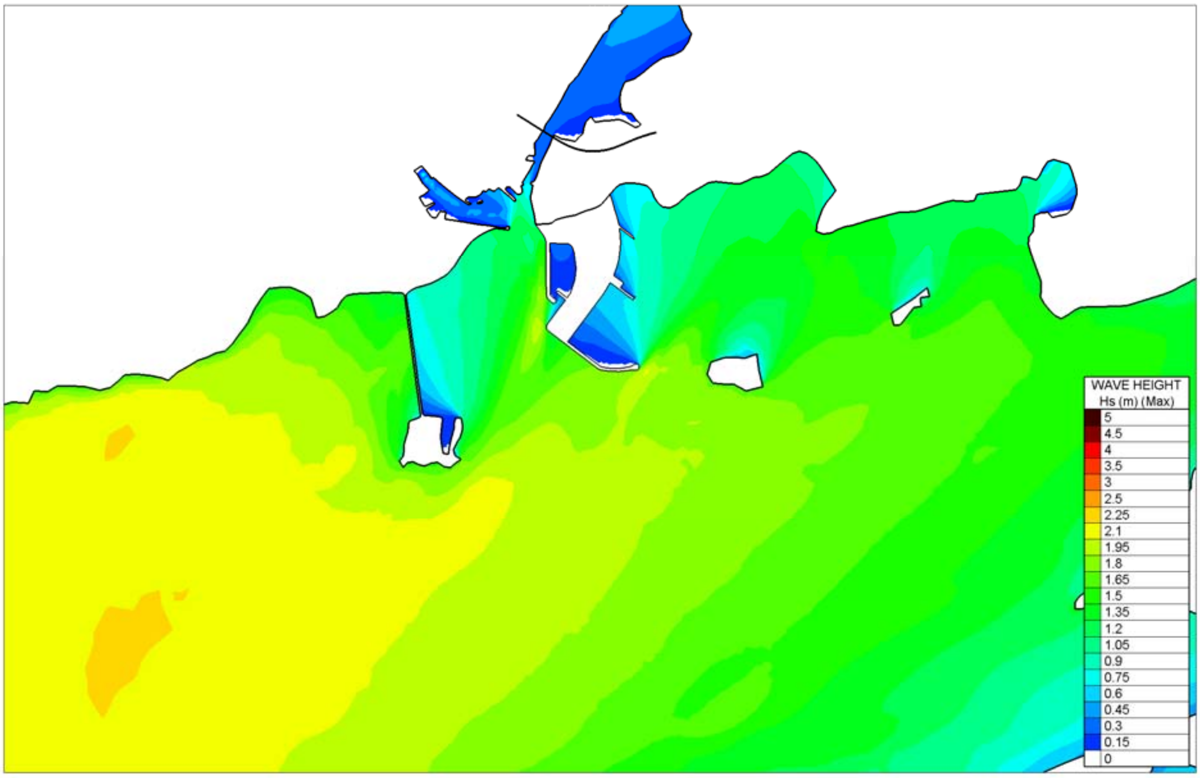


Figure 4.4.18 Computed Significant Wave heights for Local South Storm Winds - Proposed

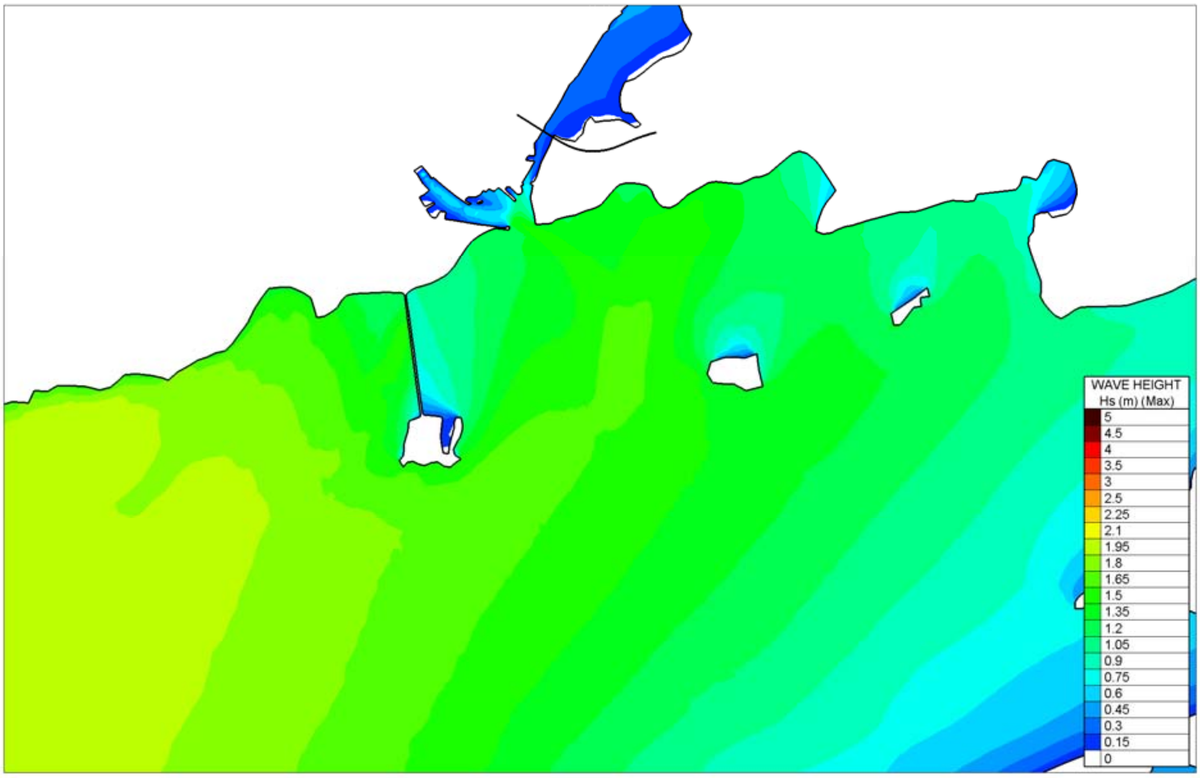


Figure 4.4.19 Computed Significant Wave heights for Local SSE Storm Winds - Existing

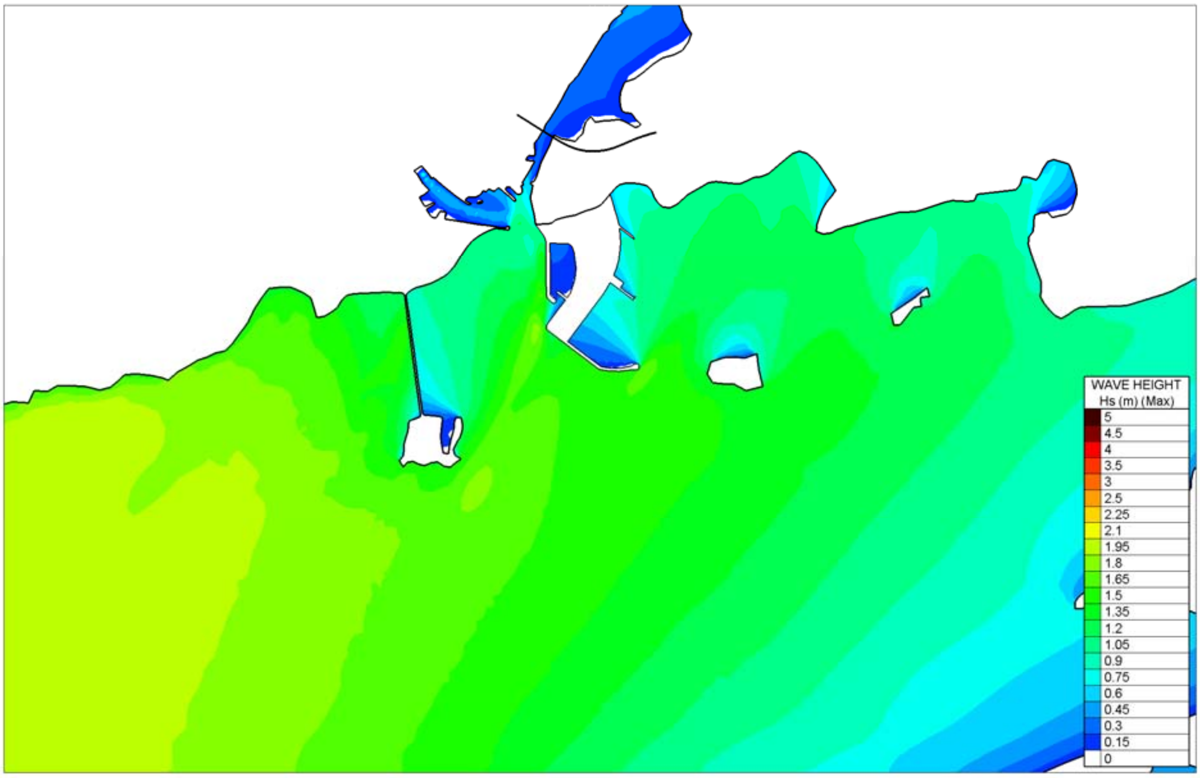


Figure 4.4.20 Computed Significant Wave heights for Local SSE Storm Winds - Proposed

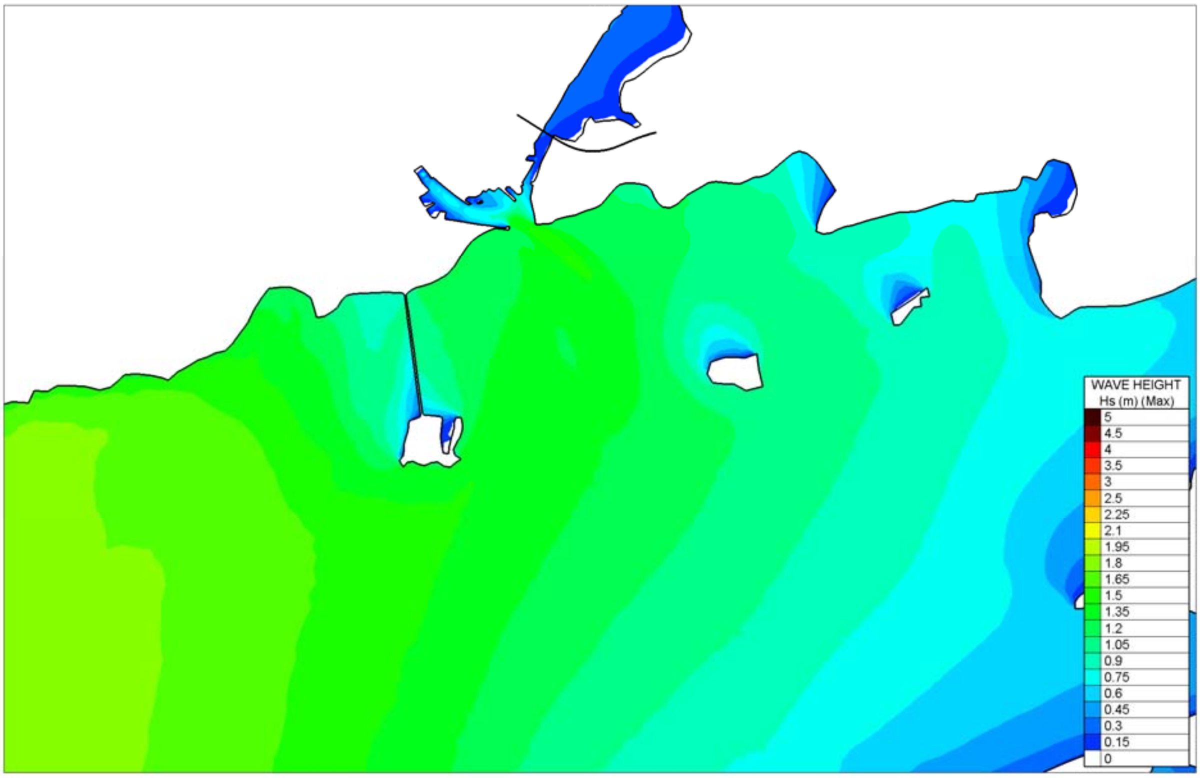


Figure 4.4.21 Computed Significant Wave heights for Local SE Storm Winds - Proposed

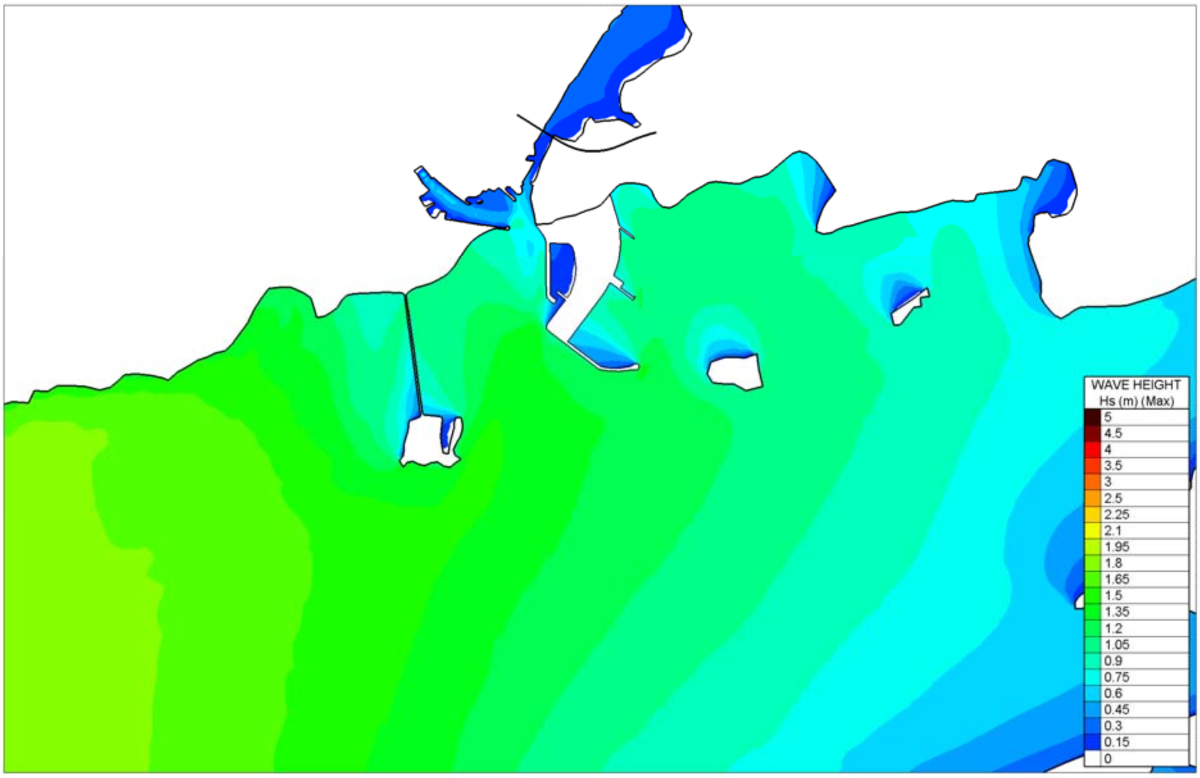


Figure 4.4.22 Computed Significant Wave heights for Local SE Storm Winds - Proposed

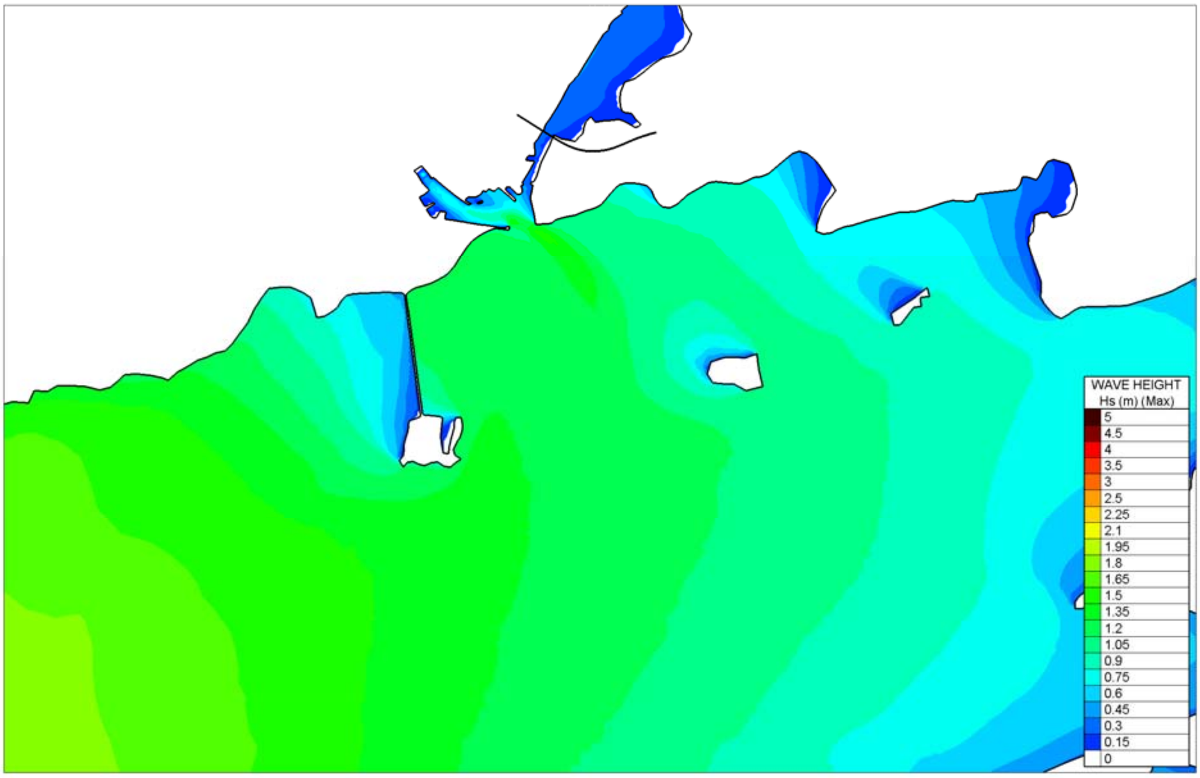


Figure 4.4.23 Computed Significant Wave heights for Local ESE Storm Winds - Existing

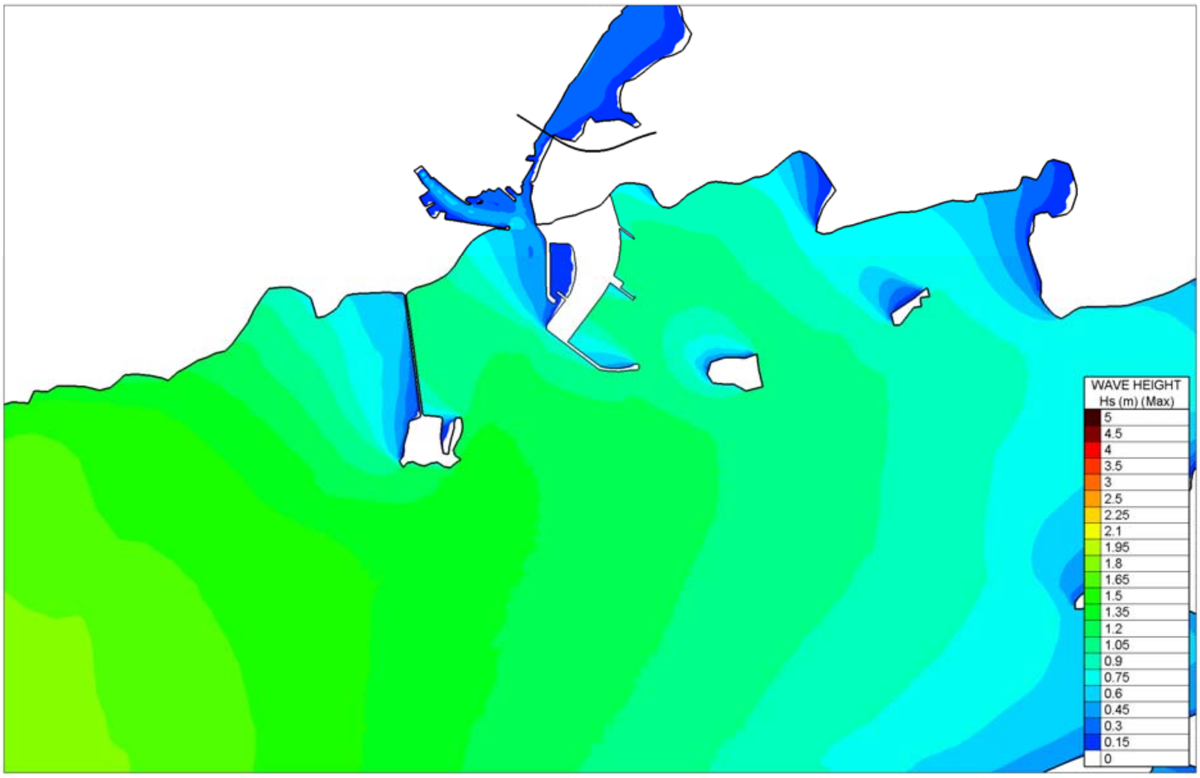


Figure 4.4.24 Computed Significant Wave heights for Local ESE Storm Winds - Proposed

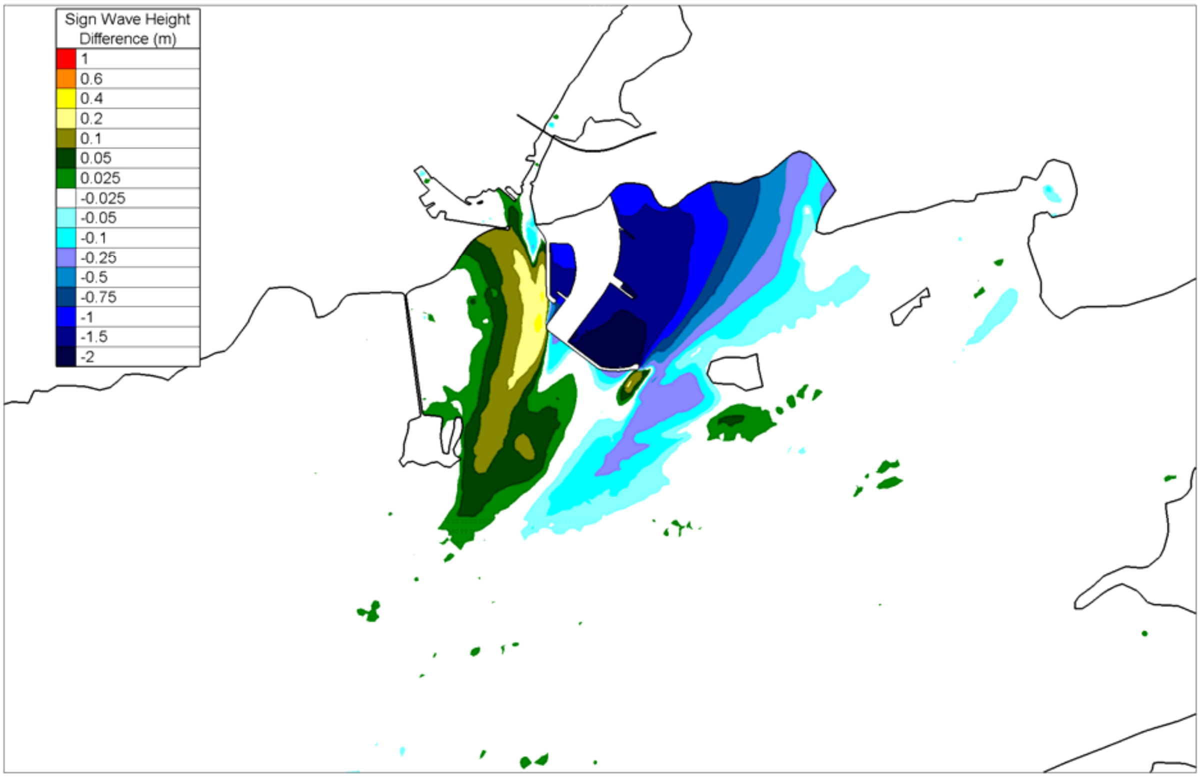


Figure 4.4.25 Difference Plot between Existing and Proposed Significant Wave heights for Atlantic Storm and West Storm Winds

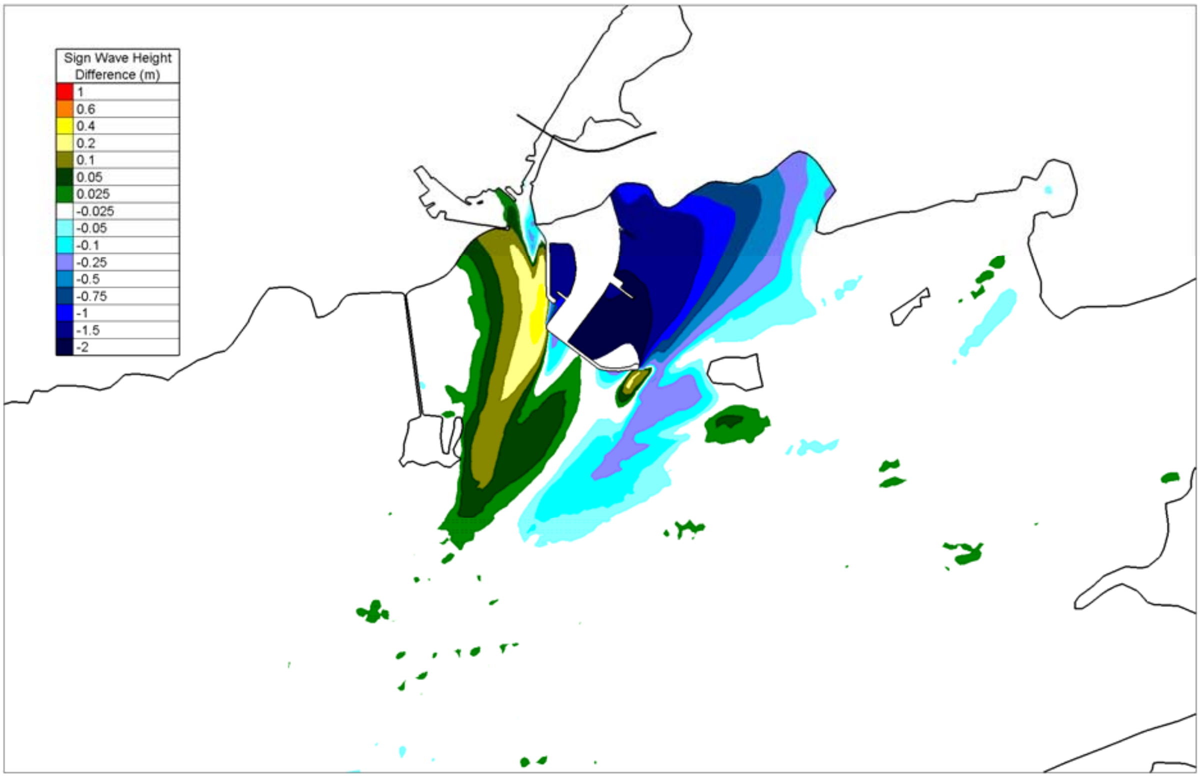


Figure 4.4.26 Difference Plot between Existing and Proposed Significant Wave heights for Atlantic Storm and WSW Storm Winds

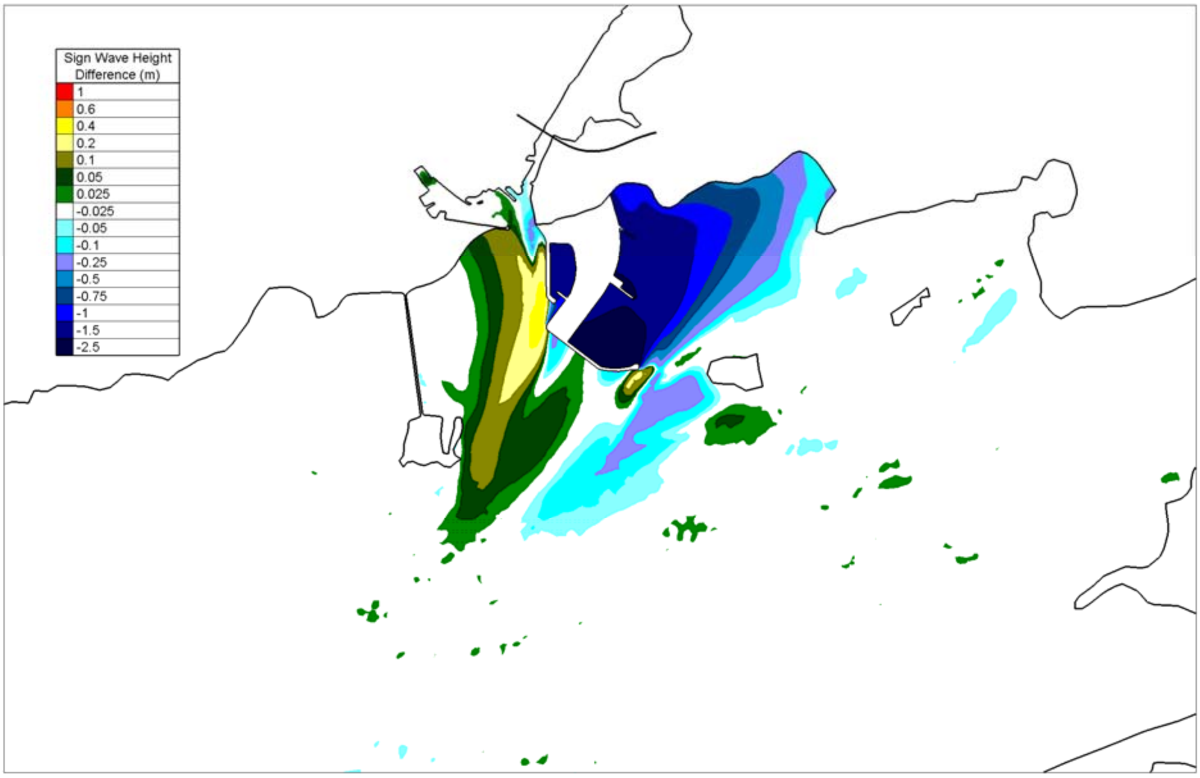


Figure 4.4.27 Difference Plot between Existing and Proposed Significant Wave heights for Atlantic Storm and SW Storm Winds

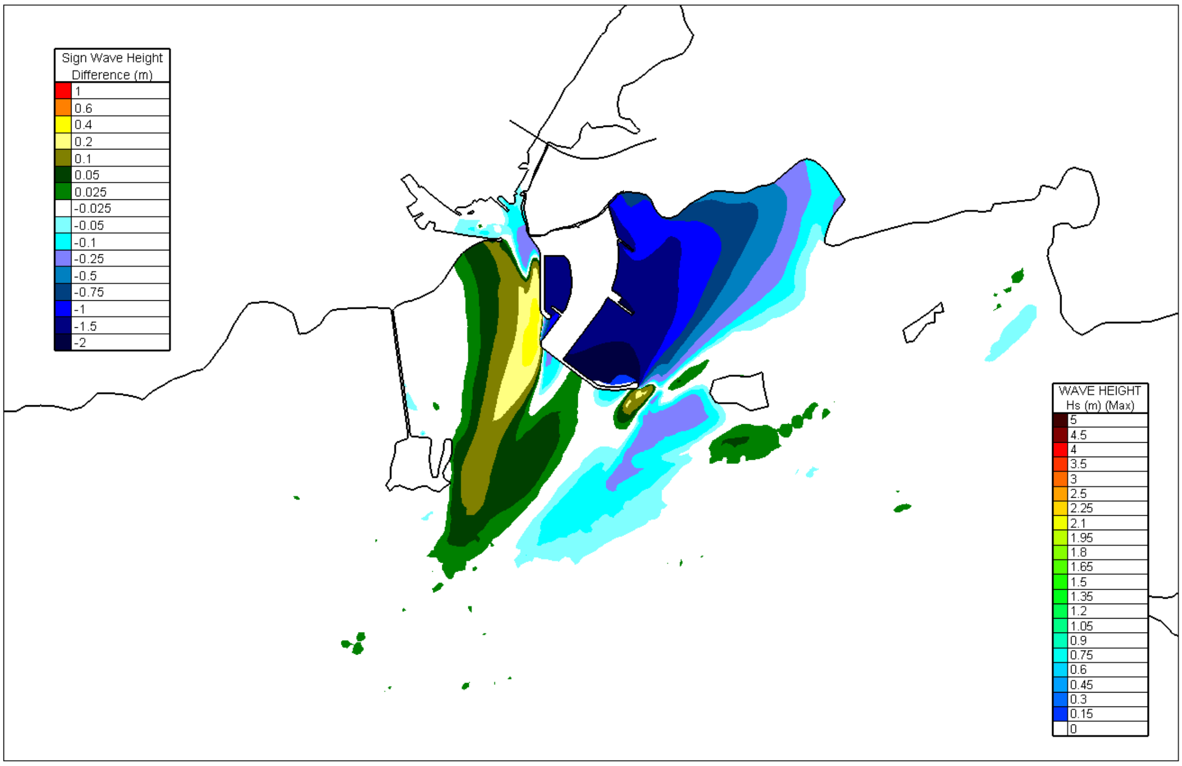


Figure 4.4.28 Difference Plot between Existing and Proposed Significant Wave heights for Atlantic Storm and SSW Storm Winds

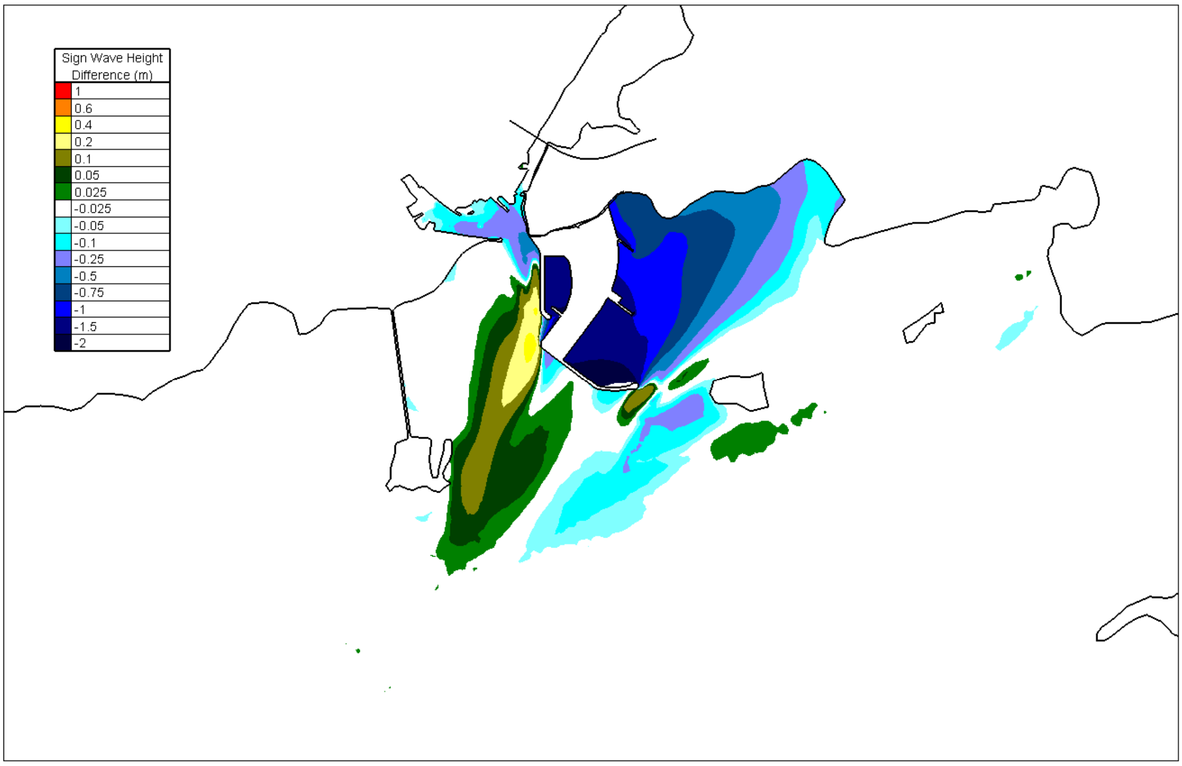


Figure 4.4.29 Difference Plot between Existing and Proposed Significant Wave heights for Atlantic Storm and South Storm Winds

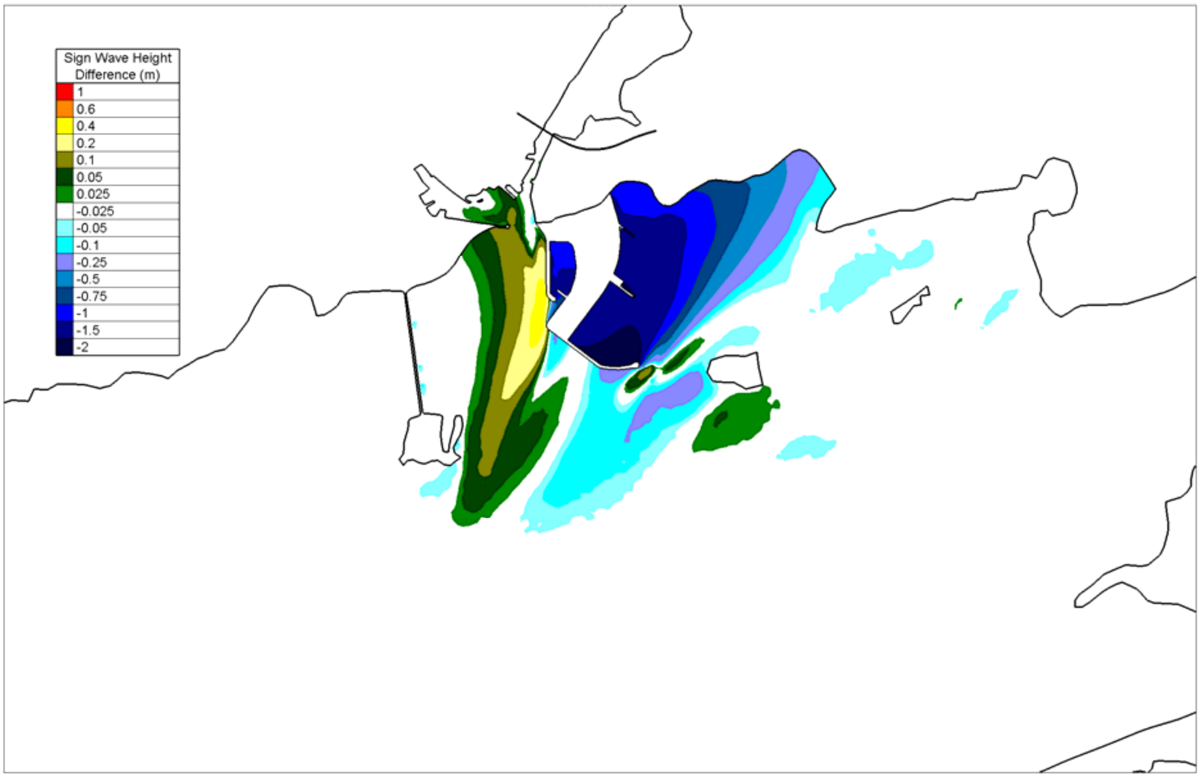


Figure 4.4.30 Difference Plot between Existing and Proposed Significant Wave heights for Local WSW Storm Winds

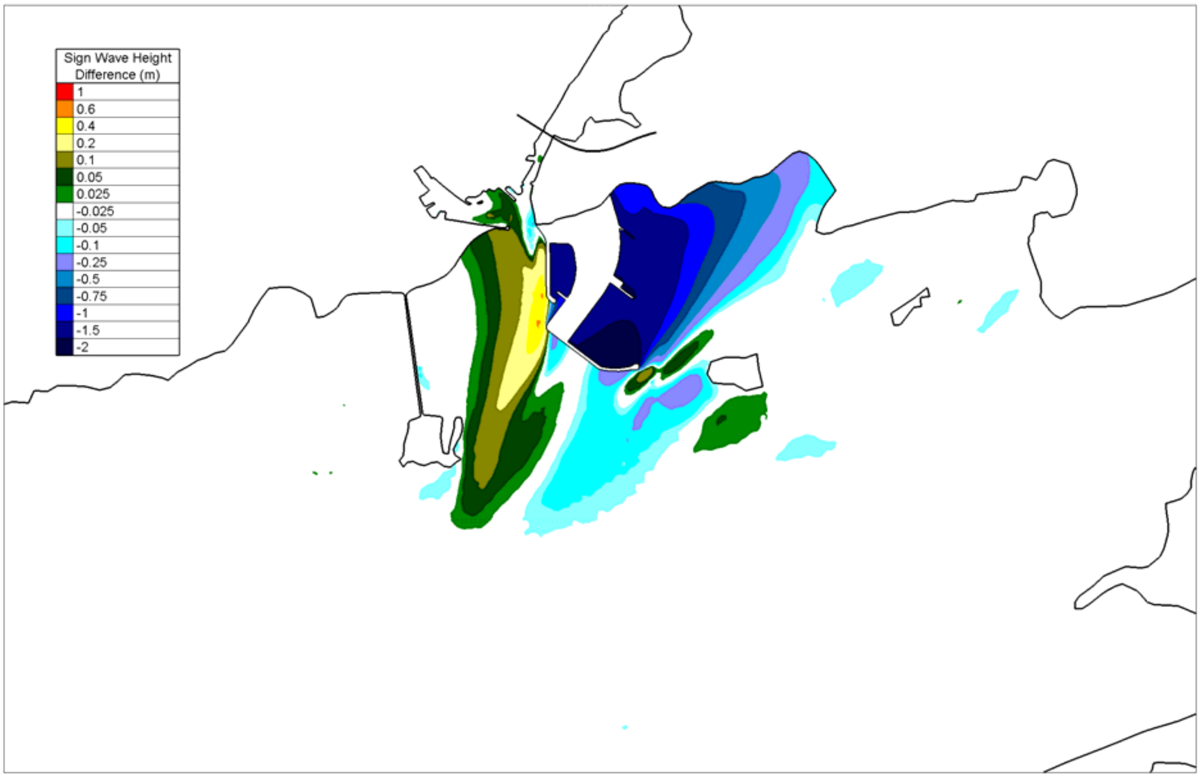


Figure 4.4.31 Difference Plot between Existing and Proposed Significant Wave heights for Local SW Storm Winds

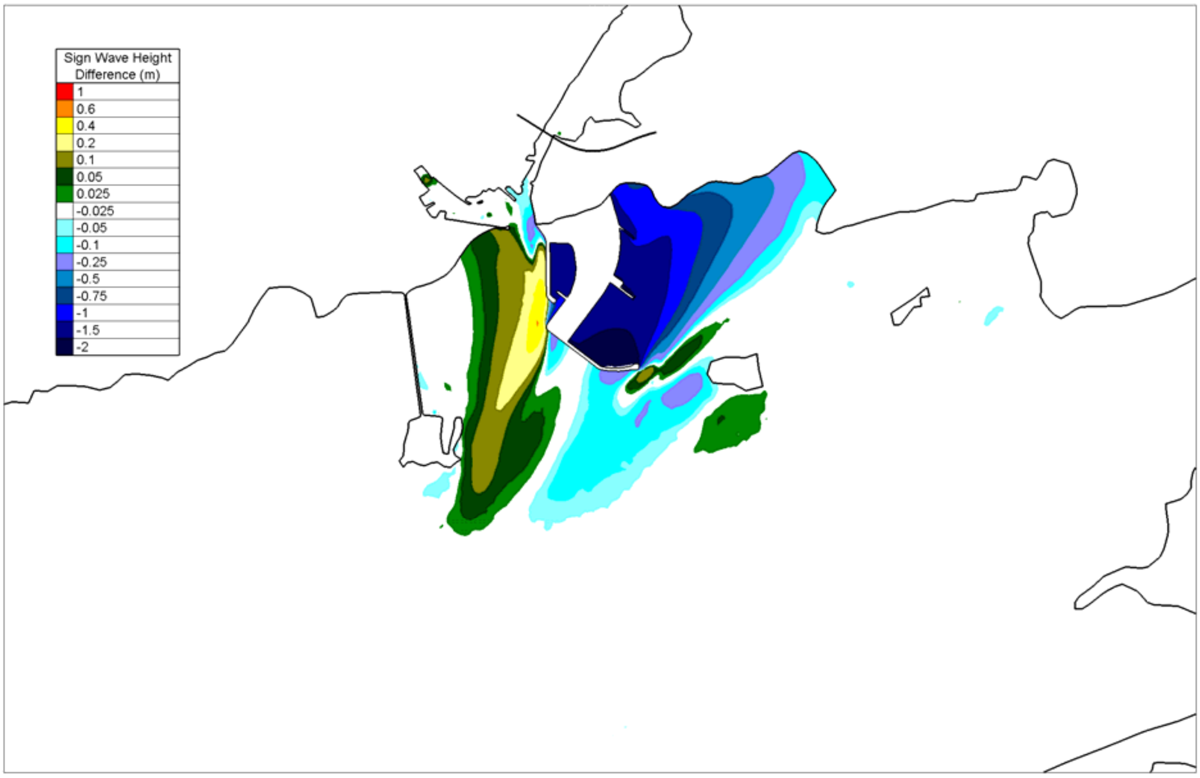


Figure 4.4.32 Difference Plot between Existing and Proposed Significant Wave heights for Local SSW Storm Winds

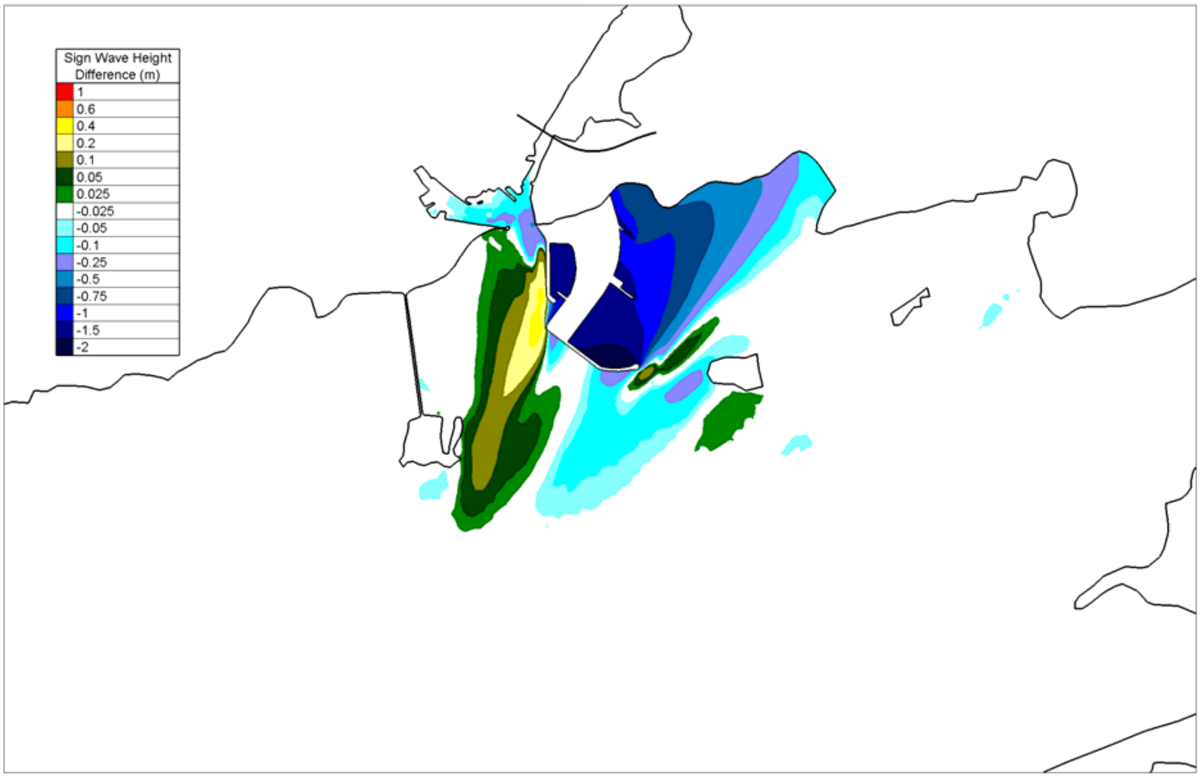


Figure 4.4.33 Difference Plot between Existing and Proposed Significant Wave heights for Local South Storm Winds

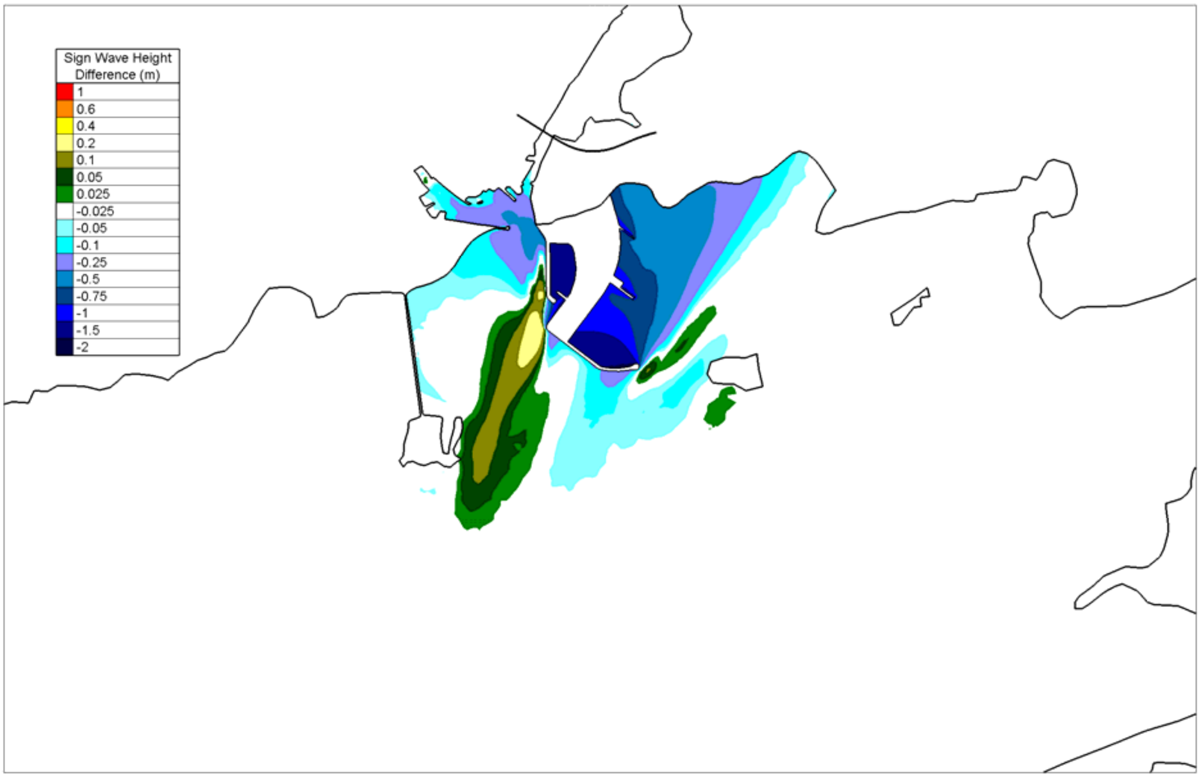


Figure 4.4.34 Difference Plot between Existing and Proposed Significant Wave heights for Local SSE Storm Winds

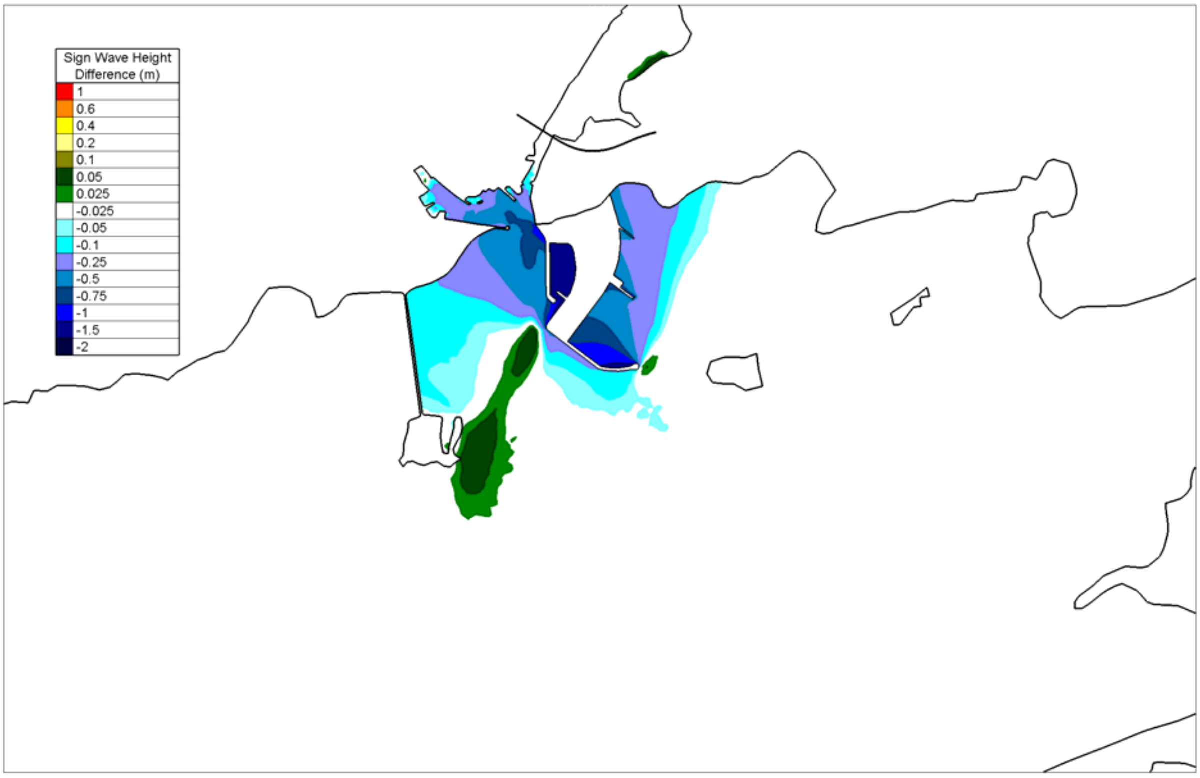


Figure 4.4.35 Difference Plot between Existing and Proposed Significant Wave heights for Local SSE Storm Winds

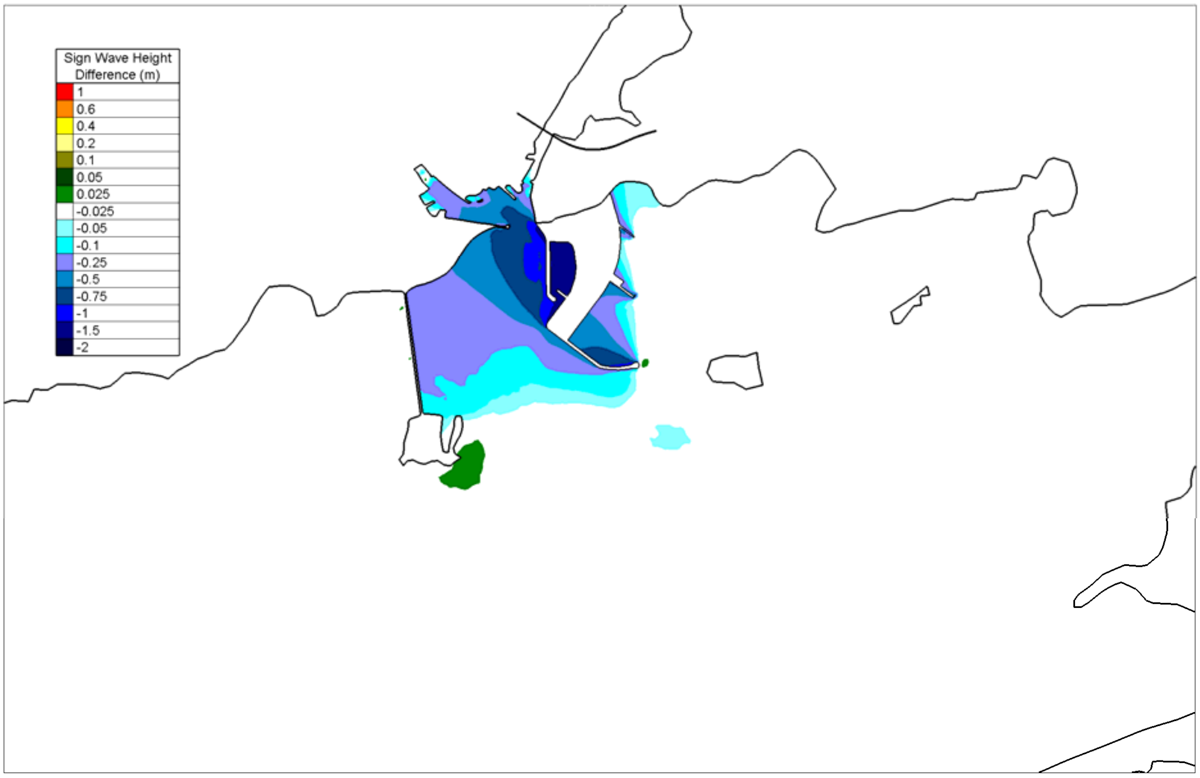


Figure 4.4.36 Difference Plot between Existing and Proposed Significant Wave heights for Local ESE Storm Winds

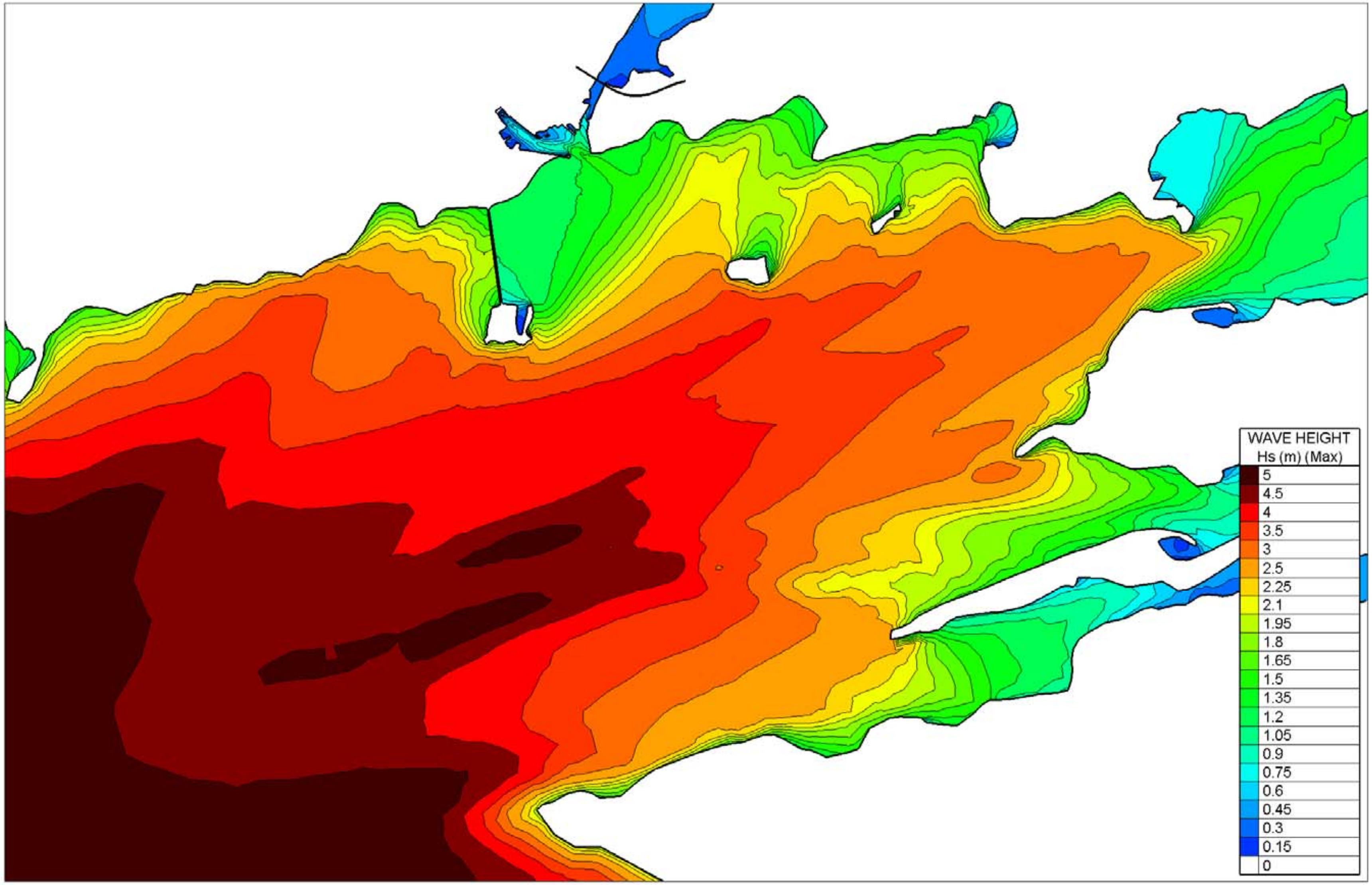


Figure 4.4.37 Computed Maximum Significant Wave Heights – Existing Case (all on shore directions W to ESE combined local and Atlantic storm swell wave climate runs)

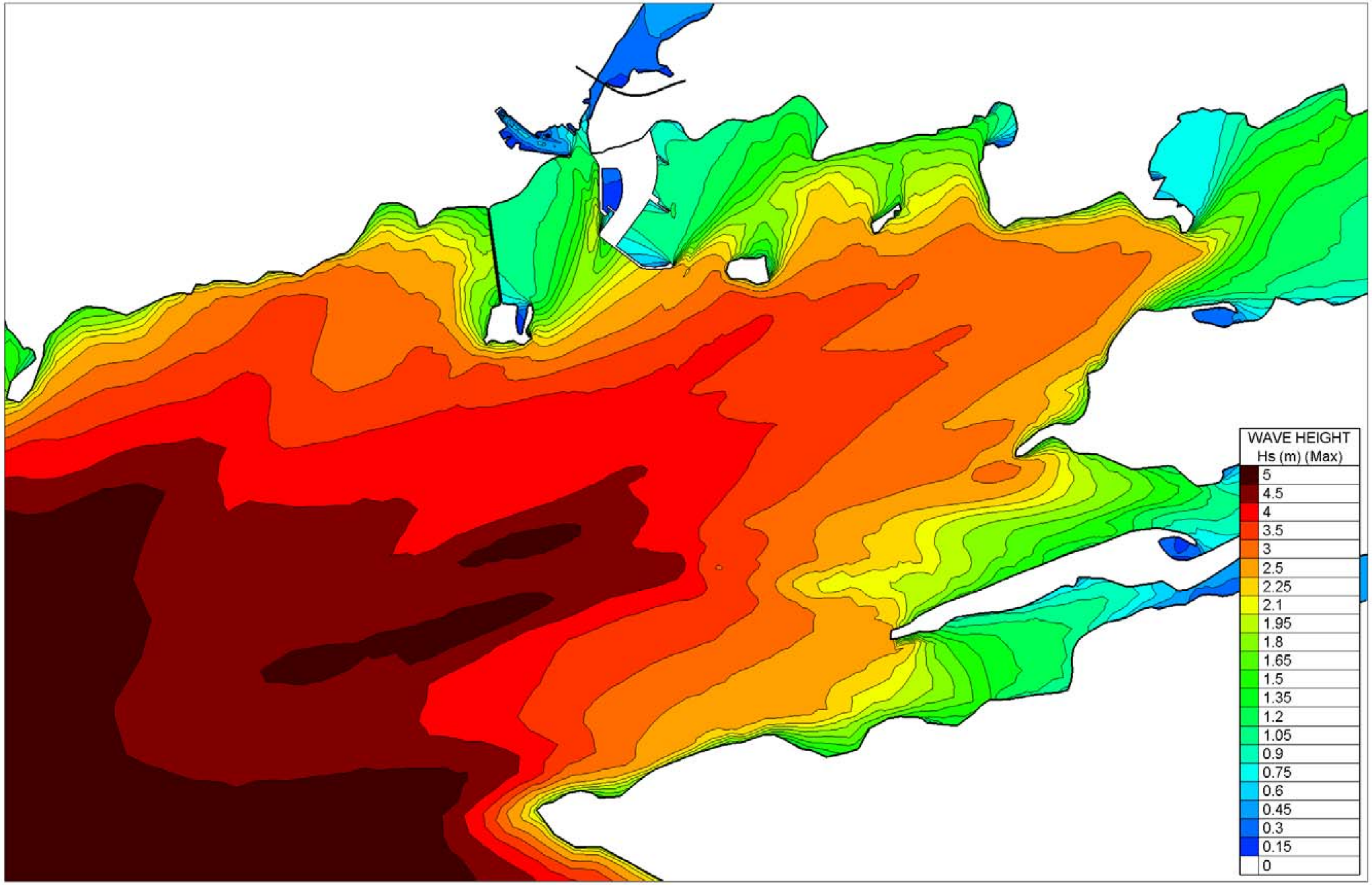


Figure 4.4.38 Computed Maximum Significant Wave Heights – Proposed Harbour Case (all on shore directions W to ESE combined local and Atlantic storm swell wave climate runs)

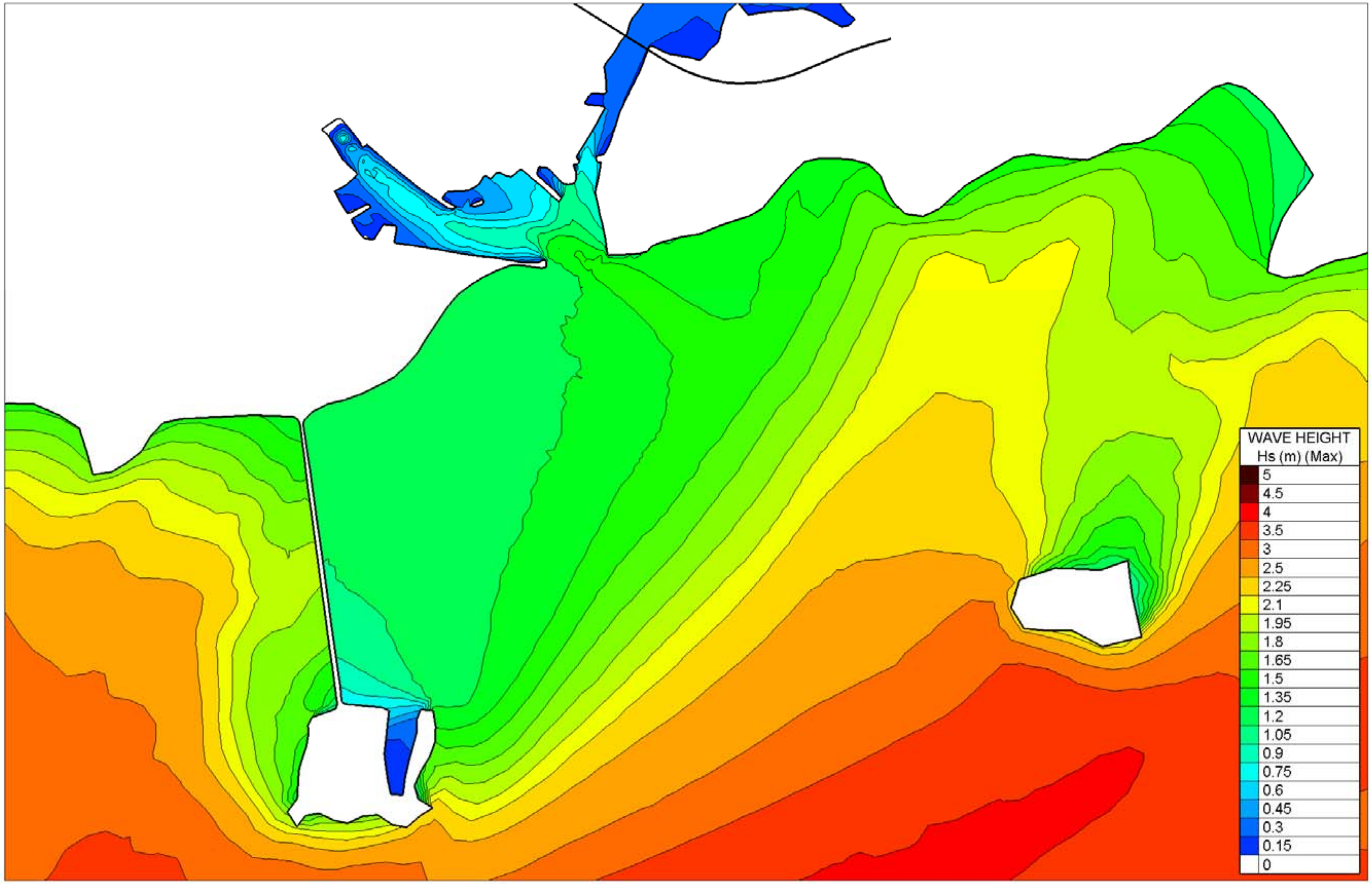


Figure 4.4.39 Computed Maximum Significant Wave Heights – Existing Case (all on shore directions W to ESE) – Harbour Area (Close up of Fig 4.4.37).

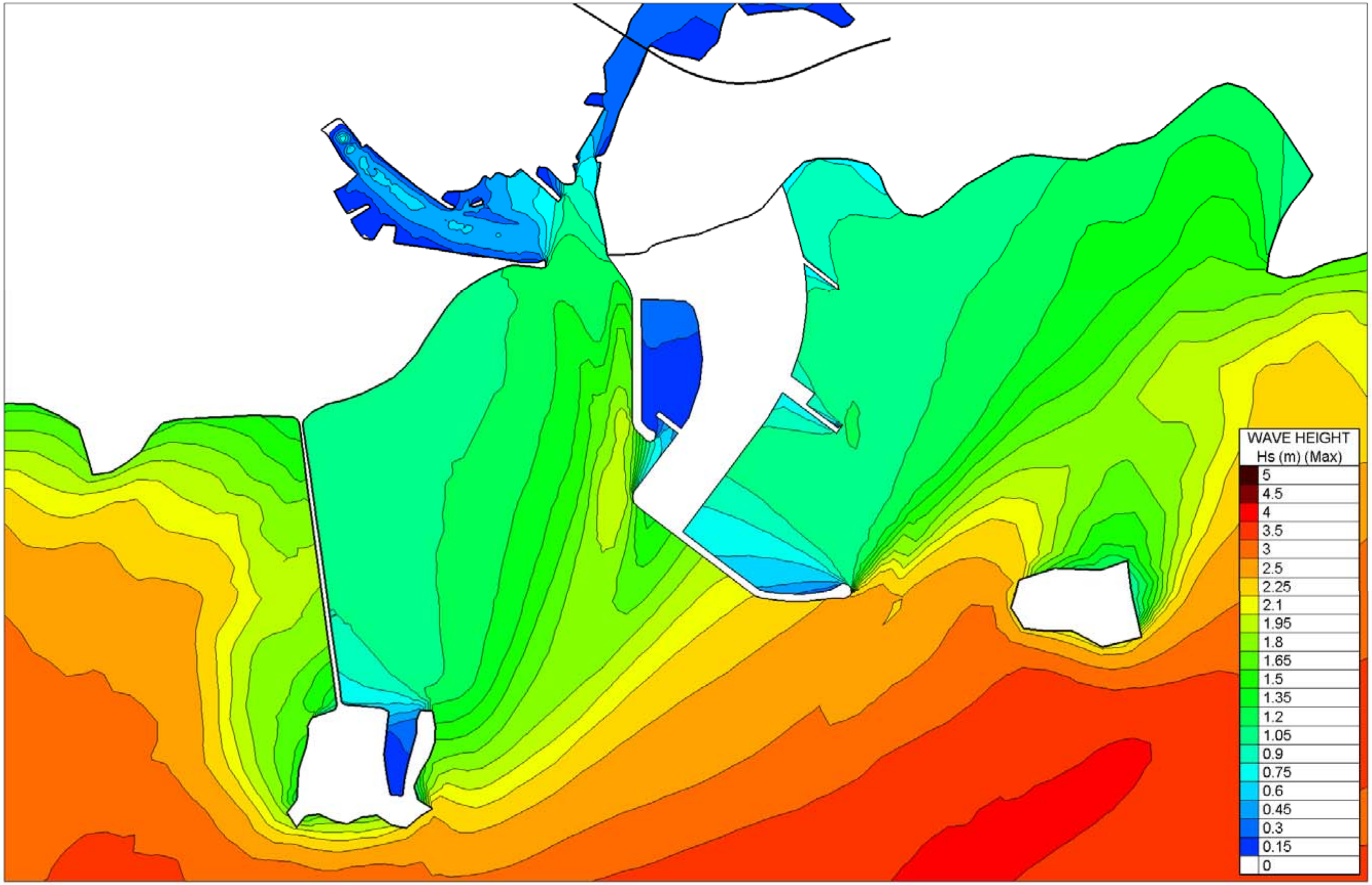


Figure 4.4.40 Computed Maximum Significant Wave Heights – Proposed Case (all on shore directions W to ESE) – Harbour Area (Close up of Fig 4.4.38).

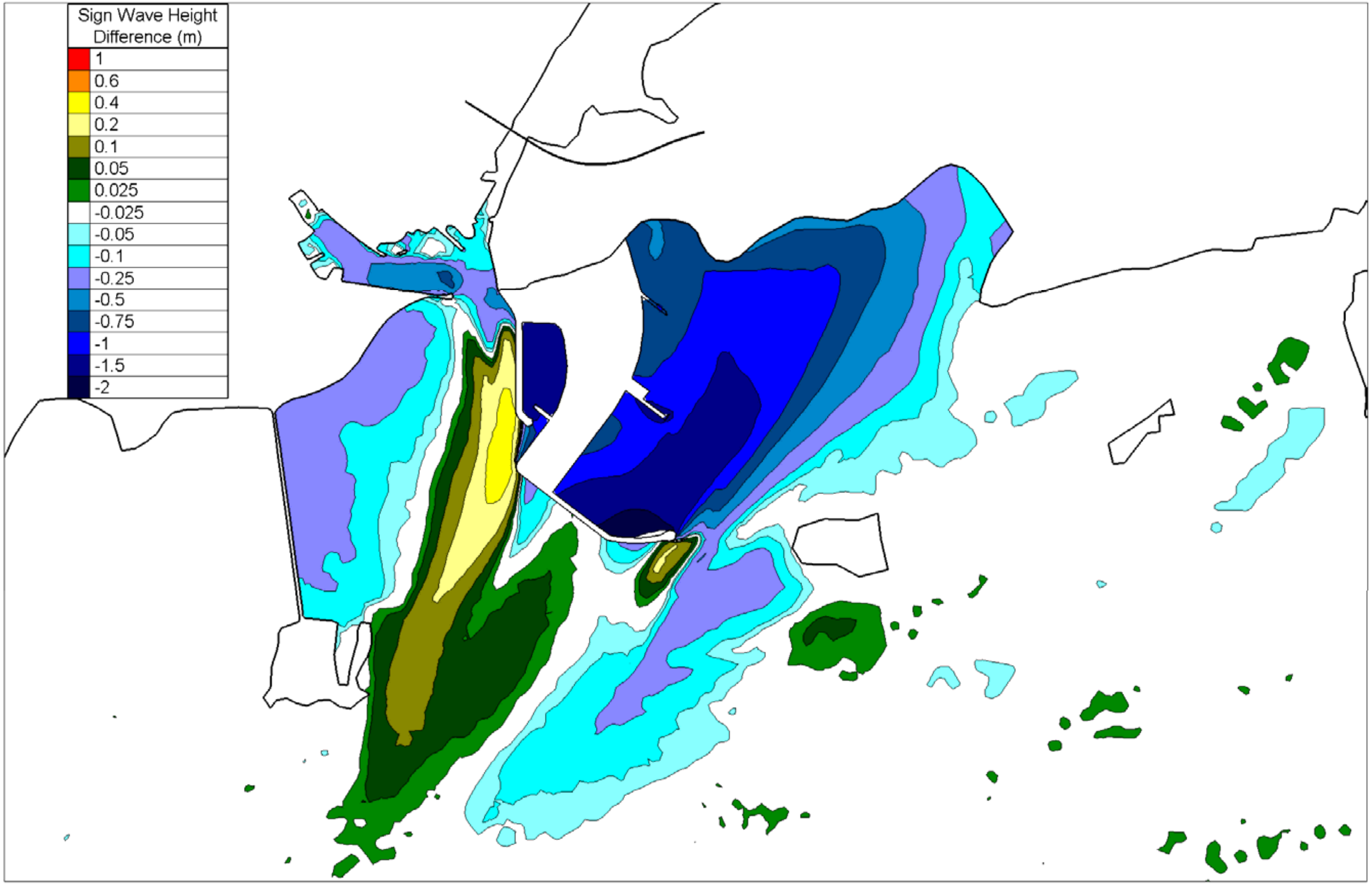


Figure 4.4.41 Difference plot of maximum predicted Wave heights existing and Proposed Wave climate for all onshore directions (West to ESE)

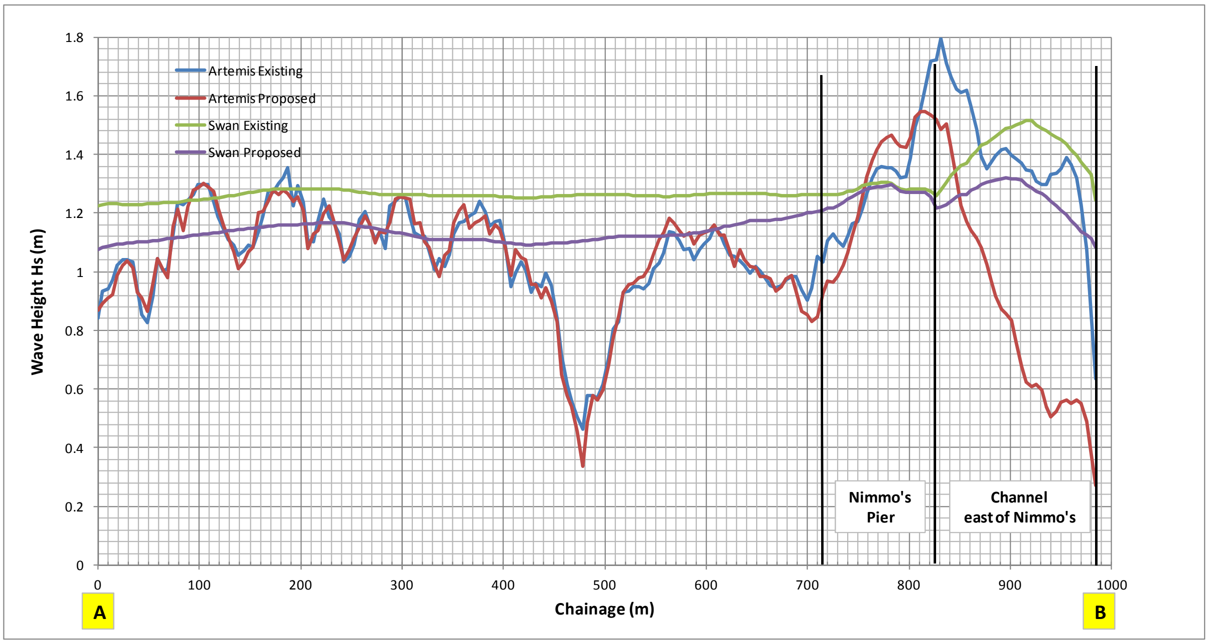


Figure 4.4.42 Computed maximum wave heights for all onshore directions West to ESE along Section A-B (refer to Figure 4.43) showing the SWAN and ARTEMIS Wave Climate model results for Southpark Shoreline and Corrib Entrance.

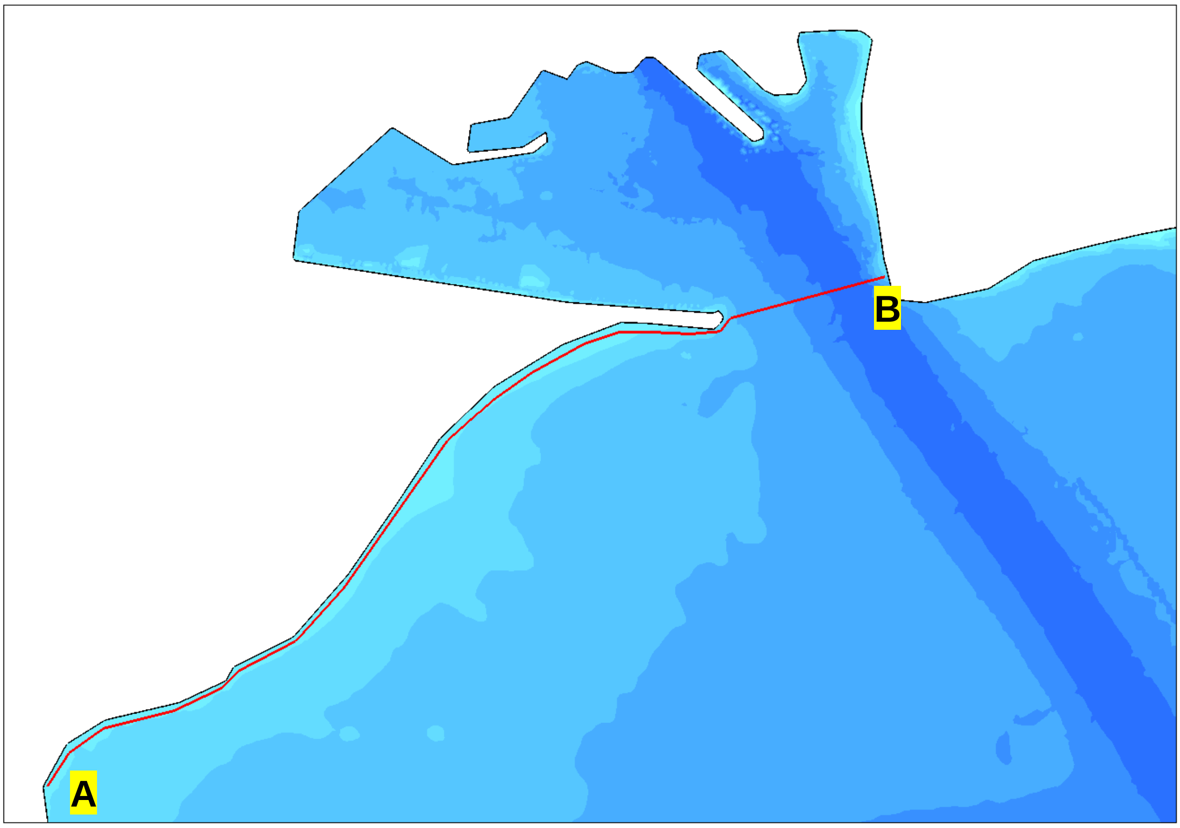


Figure 4.4.43 Shoreline Section A-B along Southpark, Nimmo's Pier and entrance to GalwayDocks / Claddagh Basin.

4.5 COASTAL AREAS LIKELY TO BE AFFECTED BY WIND WAVES

Query:

Will the wind waves approach the breaking point and under such a scenario could the radiation stresses increase the wave level further inland, thus creating the risk of flooding in coastal areas and if so which coastal areas are particularly at risk?

Response:

4.5.1 Introduction

The only inland tidal / estuarine areas that potentially could be affected by the proposed development and generation of radiation stresses of breaking waves is between the Mutton Island Causeway and the Harbour Development which includes the Southpark Shoreline, the Claddagh Basin including the Docks and Lough Atalia areas. To the east of the development the vulnerable area to wave set up is at Ballyloughaun Beach. In respect to Ballyloughaun Beach the wave climate study shows generally a reduction in wave exposure for this beach and shoreline area and thus not adversely affected by the proposed development in respect to wave climate and wave set up due to breaking waves in the Surf Zone. To the west of Mutton Island there are no predicted changes to the tidal circulation and wave climate along the Grattan and Salthill promenade vulnerable shoreline areas and consequently they are not considered in respect to the influence of high radiation stresses on increased mean water level and the impact of the development on same.

Therefore the focus is on the potential effect of radiation stresses and such changes to water level in the sheltered waters within the Claddagh Basin and the near shore waters along the Southpark shoreline.

The Claddagh Basin has quay walls which allow the tide water to reach at least 3.3 to 3.5m O.D. before overtopping on to the roadways.

The Galway Docks area is gated but vulnerable to flooding and wave action and Lough Atalia is liable to inundate properties towards its northern end only from local wind generated waves on the Lough itself and not affected by downstream changes to Wave climate at the Harbour development.

The above listed areas are only at risk towards high water during a large storm surge event. The predicted maximum waves in this area immediately south of the Corrib entrance are of the order of 1.2 to 1.6m in height of varying wave period from 4 to 8seconds. The geometry of the foreshore area does not represent a shoaling beach and given the relatively low wave amplitude predicted there will not break until almost on land where a large portion of wave force will be absorbed on to land.

At much lower tidal stages there may be opportunity for some shoaling and breaking on the foreshore area giving rise to larger radiation stresses that could affect the upstream flow field and water levels, but such conditions apply to both the proposed development case and the existing case and at such tide levels are not critical to upstream flooding or flood risk in these vulnerable areas.

The Wave climate models allow for the calculation and output of the radiation force terms in the x and y direction (easting and northing direction) and the Telemac2d and 3D allow for the inclusion of such output in the hydraulic analysis. Radiation vectors in units of acceleration are presented in Figures 4.5.1 and 4.5.2 for a southerly storm wind waves approaching highwater with and without the proposed development. These plots show relatively low radiation force terms in the approaches to the Corrib entrance. A flood Simulation was run with the radiation force terms included and showed no discernible change in upstream flood level within the Claddagh Basin area. This was run for a 20m/s south Wind, a Storm Surge event producing a 3.5m OD highwater and Corrib 100year flood flow (refer to Figures 6.12 and 6.13 showing no discernible impact by the radiation stress terms on highwater elevation). Maximum water levels will therefore not increase as a consequence of additional wave breaking.

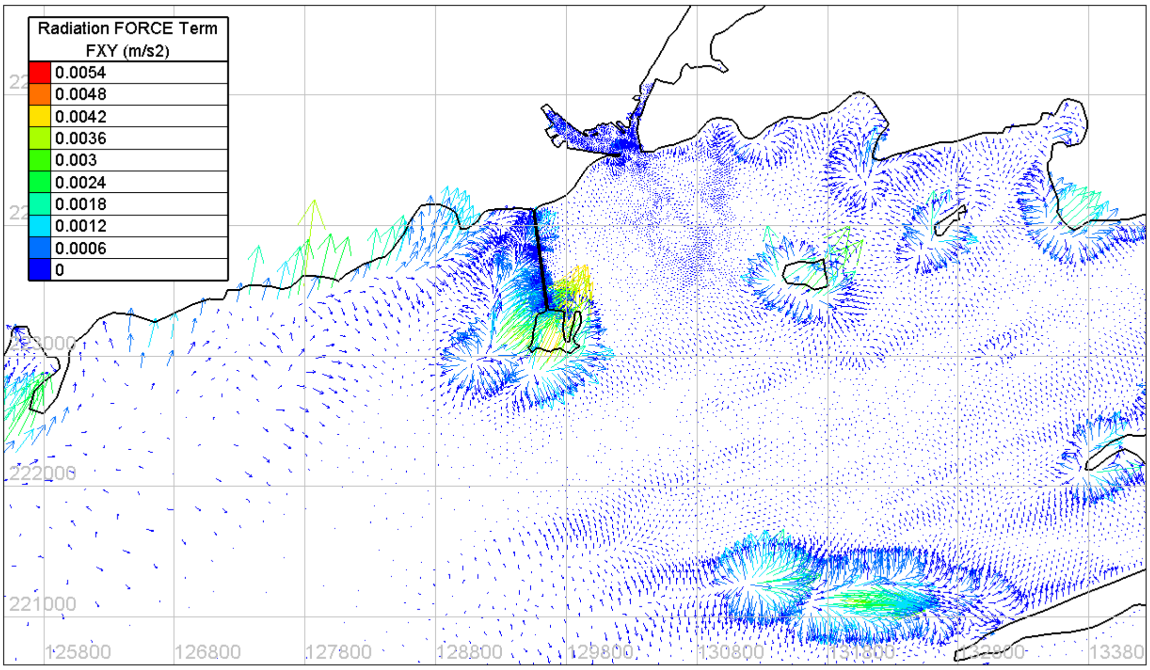


Figure 4.5.1 Radiation Force vector for existing Case

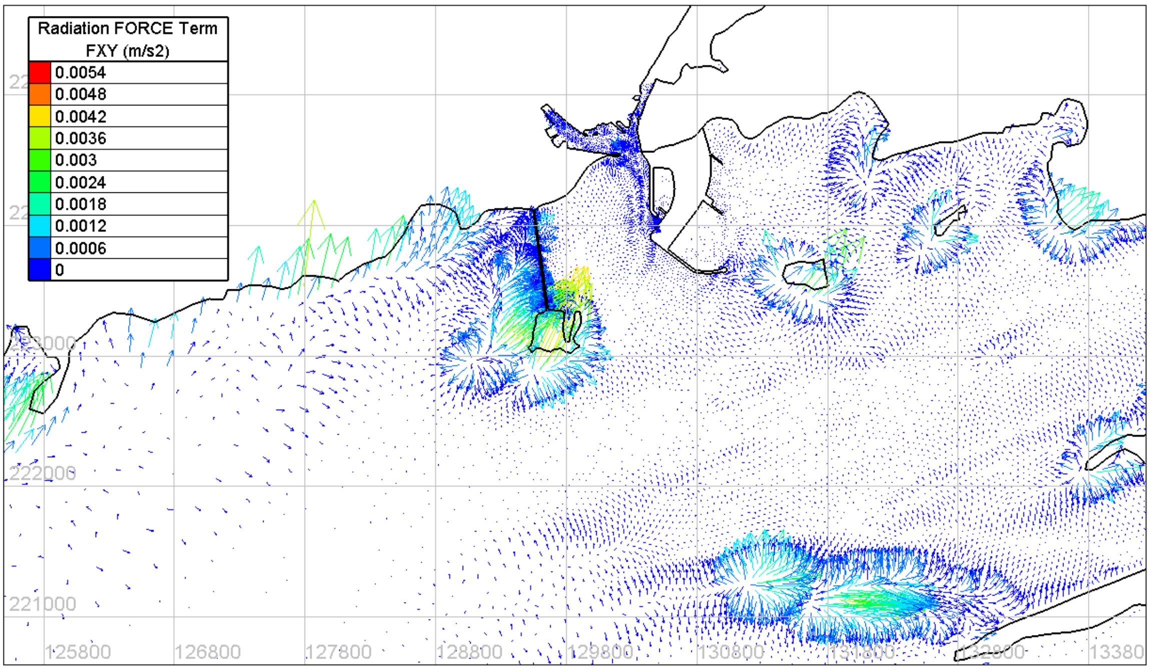


Figure 4.5.2 Radiation Force Vectors for Proposed Case

4.6 FLOW RESISTANCE:

Effects of Sea-Bed Roughness

Query:

As an input into the flow resistance modeling, details of the sea-bed roughness is required. Is the bed roughness kept constant in all runs, and how sensitive are the results regarding the choice of this value, say changing it by a factor of 10 and 100?

Response:

4.6.1 Background

In the Telemac hydrodynamic model the law of friction used to model bed roughness is the Manning Equation which is combined with the k-epsilon turbulence model. In the Telemac system other friction laws are available namely Haaland, Chezy, Stickler, Nikuradse, Colebrook-White and a frictionless option.

In the hydrodynamic modelling for the Galway Docks project the roughness coefficient was set at a constant Manning’s n of 0.03 for the coastal area and a Manning’s n of 0.035 within the slightly rougher Claddagh / Corrib Estuary and Lough Atalia inlet channels. A Manning’s n of 0.035 for the Corrib channel agrees with typical values from literature and other studies for modelling river and estuarine reaches (Chow 1959, HEC etc.). Values of 0.02 to 0.04 are typical of the manning’s bed roughness used in coastal modelling studies. It is common with coastal modelling studies to use a single composite Manning n value.

The shoreline sections of Galway Bay are quite variable in terms of roughness length with limestone rock outcrops, rock armoured groynes and breakwaters, stone and cobble shoreline areas and sandy and silty beds present. Such variability could merit the establishing of zones of different Manning’s n values. The degree of variability is significant, subjective and difficult to measure and consequently a single value of n was applied to the coastal waters outside of the Corrib Entrance. The justification for a single value is that the hydrodynamics (velocities and depths) in the opensea are not very sensitive to the bed roughness given the generally large ratio between water depth and roughness length and the relatively low tidal velocities present in the bay. Outside of the shoreline area the study domain can be characterised as moderately deep coastal waters consisting of a silty sandy bed.

4.6.2 Roughness Sensitivity Testing

It is assumed that factors of 10 and 100 recommended for sensitivity testing of the roughness coefficient relate to the Nikuradse sand roughness length as opposed to the Manning’s n, as such increases in Manning’s n represent unrealistic roughness lengths particularly for the factor of 100 if applied directly. The relationship between Nikuradse roughness length and the Manning n can be approximated as follows:

$n = k_s^{1/6} / 25.4$ using the Chezy friction equation.

The roughness length k_s, using the Soulsby (1997) relationship can be related to the median grain diameter (d_{50}) as approximately $k_s = 2.5*d_{50}$ over flat homogenous beds.

	Sensitivity Factor		
Roughness coeff	1	10	100
n	0.020	0.030	0.043
ks (m)	0.018	0.18	1.8
d50 (m)	0.0072	0.072	0.72

Table 4.6.1 Soulsby Relationship between Manning n, Nikuradse sand Roughness and the median grain diameter size for the Sensitivity Test

For this R.F.I. comparison purposes additional hydrodynamic model runs were carried out for a 3.5m O.D. Tidal Surge highwater on a spring tidal range of 4.5m , 100year + Climate Change (CC) flood flow in the Corrib (549 Cumec) and calm wind conditions. Manning'n n of 0.02, 0.03 and 0.043 representing factors of 1, 10 and 100 for Nikuradse roughness scale (refer to Table 4.6.1 above) were specified in the model runs. The simulations were run over two complete tidal cycles and comparisons carried out. The previous runs had used the factor of 10.

For comparison purposes five observation reference locations were selected to demonstrate the sensitivity of computed tidal velocities and elevations to varying roughness factors. The reference locations are presented in Figure 4.6.1 and the times series plots for the five locations are presented in Figures 4.6.2 to 4.6.6 for water elevations and 4.6.7 to 4.6.11 for velocity magnitude and direction. These roughness sensitivity runs were carried out for the proposed development case.

4.6.3 Discussion

The impact of varying the roughness coefficient on tidal elevations at peak highwater levels is negligible in the open waters of Galway Bay (refer to sites 2 to 5 in Figures 4.6.3 to 4.6.6). Within the Claddagh Basin where the river is in full spate (100year Flood Flow including CC) the change in peak water level at highwater is relatively small at 0.13 m range over the three roughness values. As expected at low water periods a considerably larger difference in water level of 0.77m is predicted over the roughness range at the Claddagh basin site 1. This is due to the reduced depth of flow where the tidal influence has ebbed and the presence of high flow velocities giving rise to increase friction loss. It is important to point out where a difference occurs in water level within the Claddagh basin between the different roughness simulations, no discernible difference is predicted between the existing and proposed model runs for a given roughness, refer to Figure 4.6.12. In the open water the effect of the roughness coefficient (within the range tested) on the tidal curve is found to be negligible (at both high and low water).

At the 5 location sites the velocity and direction time series were generated for the three roughness values. As expected in the Claddagh reach the velocity magnitude varies significantly with roughness factor with the direction remaining almost unchanged due to the rectilinear nature of the flow. In the open sea some variation is present in respect to speed and direction and the most noticeable effect is on reducing the friction to lower value of 0.02 with the higher coefficient of 0.03 and 0.043 showing little difference at the higher roughness, refer to Figures 4.6.7 to 4.6.11.

Overall the effect of varying the roughness is not significant and less significant when used as a comparison tool between the proposed development flow field and the existing flow field.

In conclusion, the hydrodynamics within Inner Galway Bay are not overly sensitive (reasonably robust) to changes in roughness coefficient at the magnitudes tested. It is considered reasonable for the open coastal waters to vary the Manning's n from c. 0.02 to 0.04, above 0.04 the roughness becomes unrealistic even after accounting for storm wind wave effects through ripple formation on the bed roughness (refer to Section 7). The predicted water levels in the model including the estuarine flow area of the Claddagh Basin for highwater level are not very sensitive to the roughness coefficient as the depth of flow minimises the effect of friction. Velocity magnitude and direction are more sensitive to changes in Manning's n, particularly to reductions in the Manning n from 0.03 to 0.02, but the overall effect on the ambient flow field is not considered to be significant.

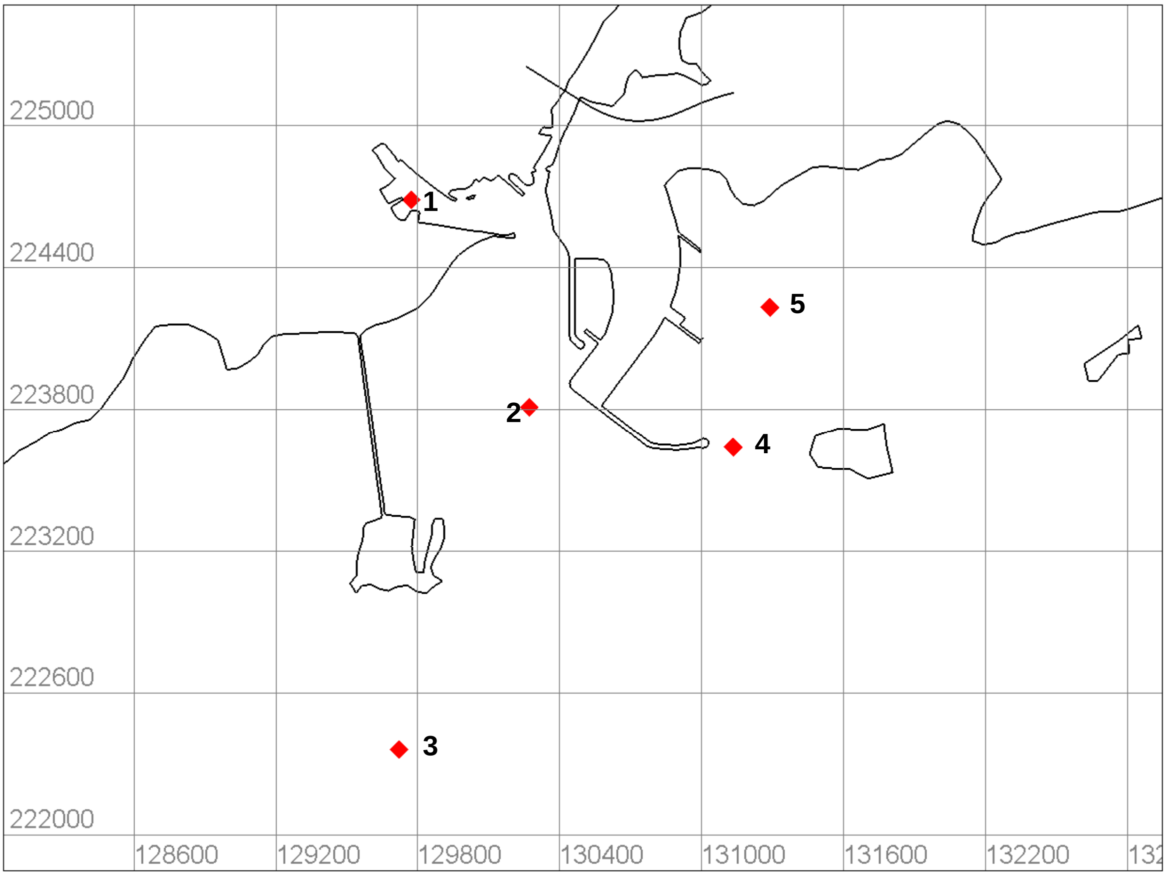


Figure 4.6.1 Location of reference points for roughness sensitivity

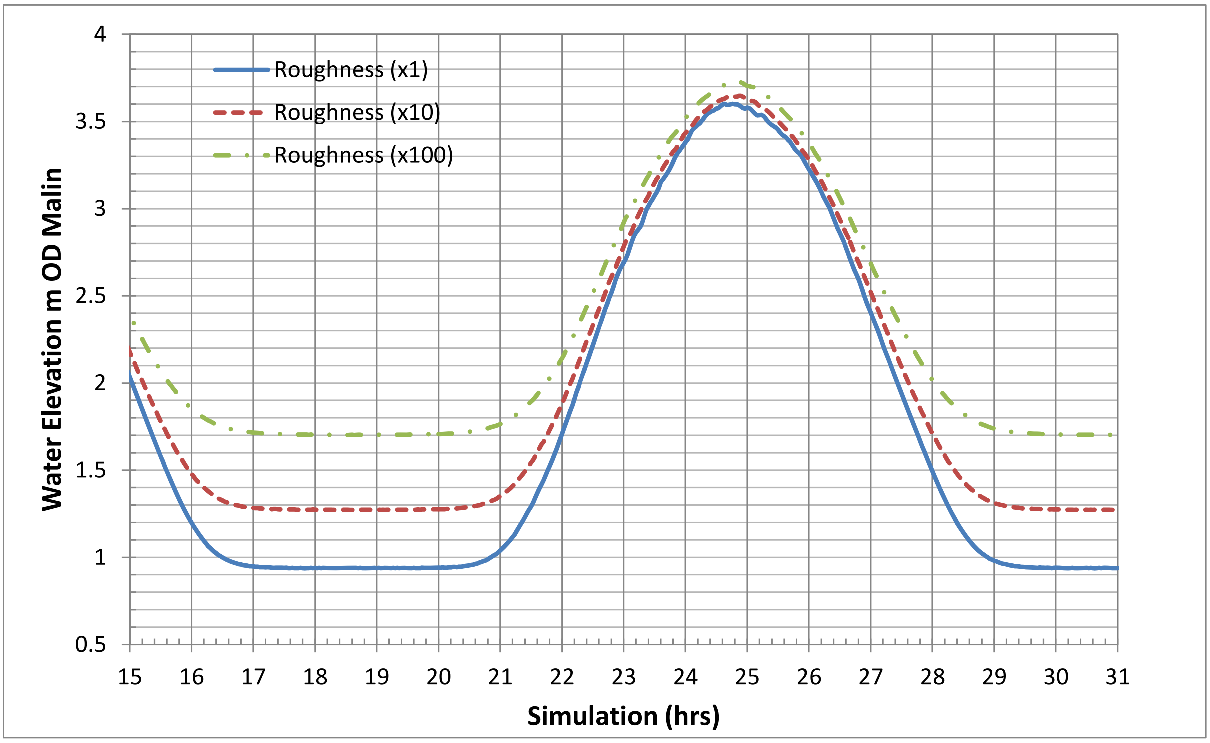


Figure 4.6.2 Sensitivity of elevation to Roughness factor at Site 1

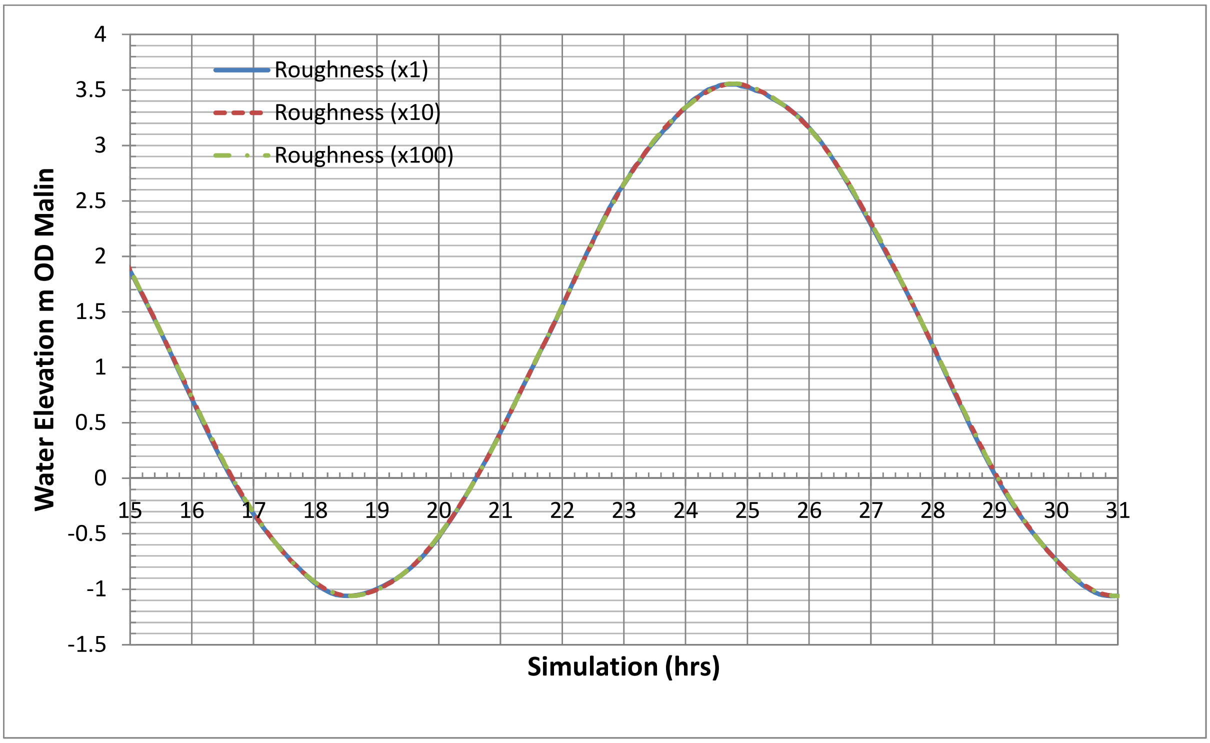


Figure 4.6.3 Sensitivity of elevation to Roughness factor at Site 2

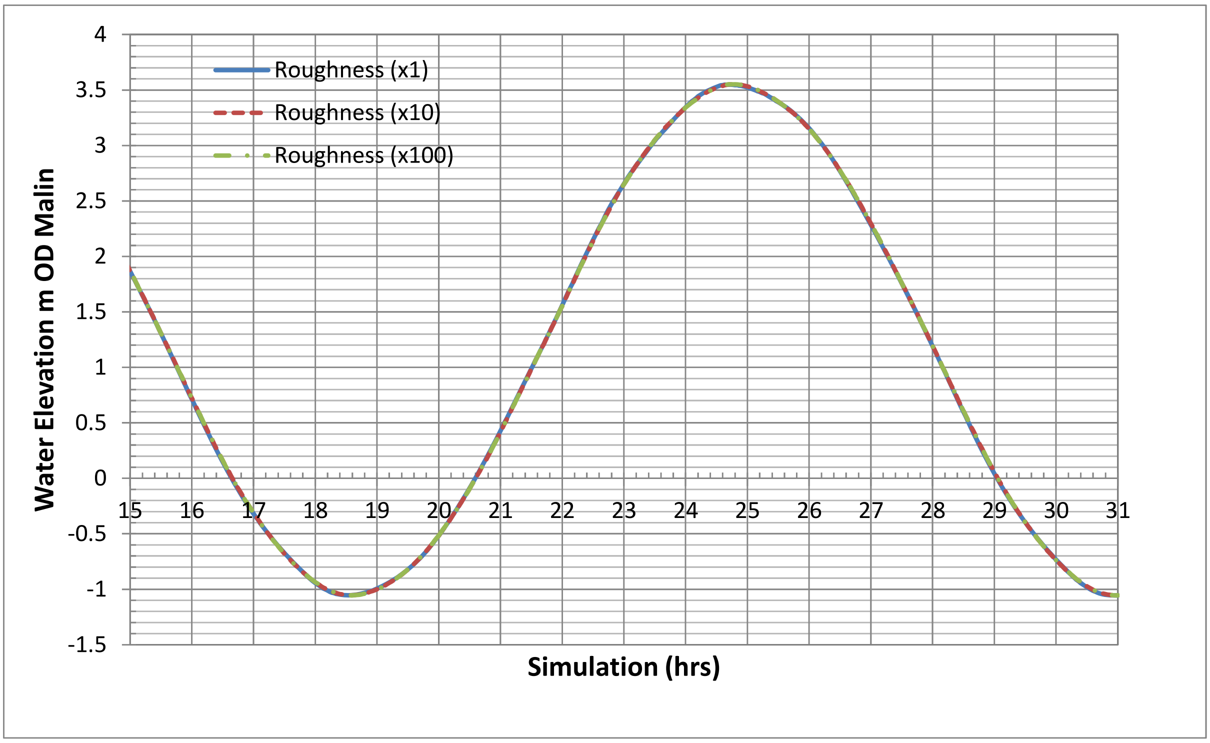


Figure 4.6.4 Sensitivity of elevation to Roughness factor at Site 3

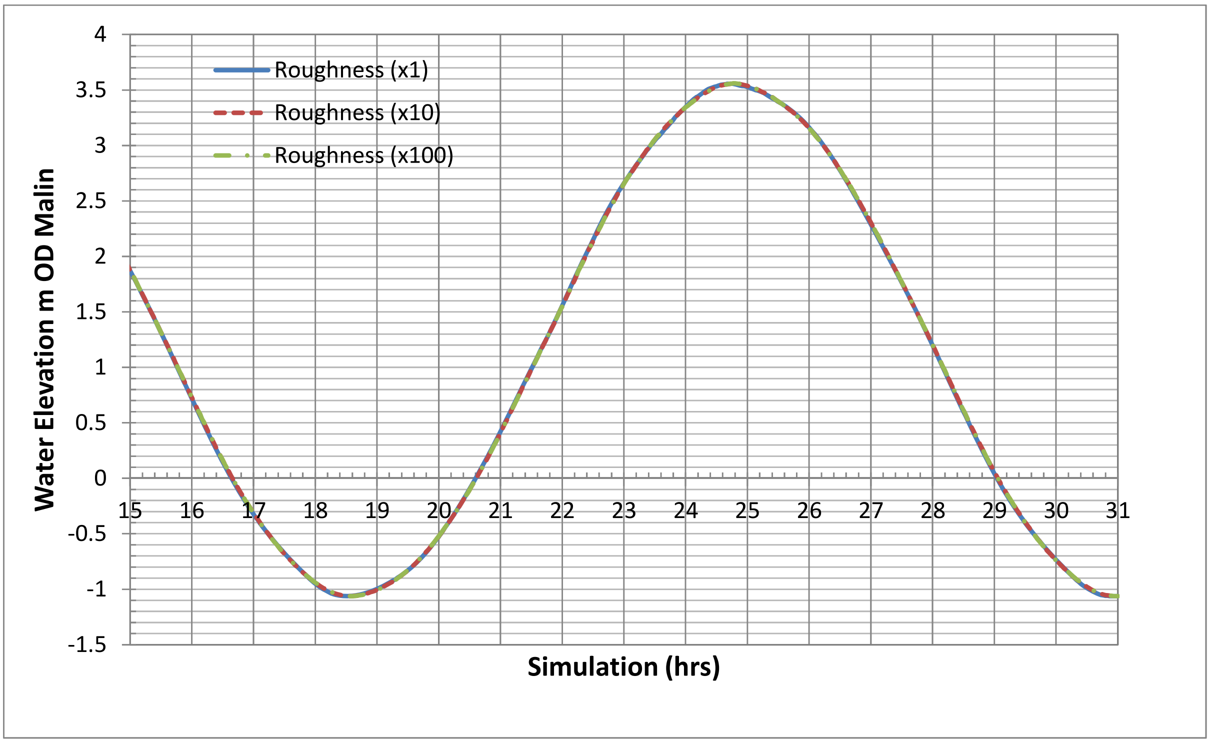


Figure 4.6.5 Sensitivity of elevation to Roughness factor at Site 4

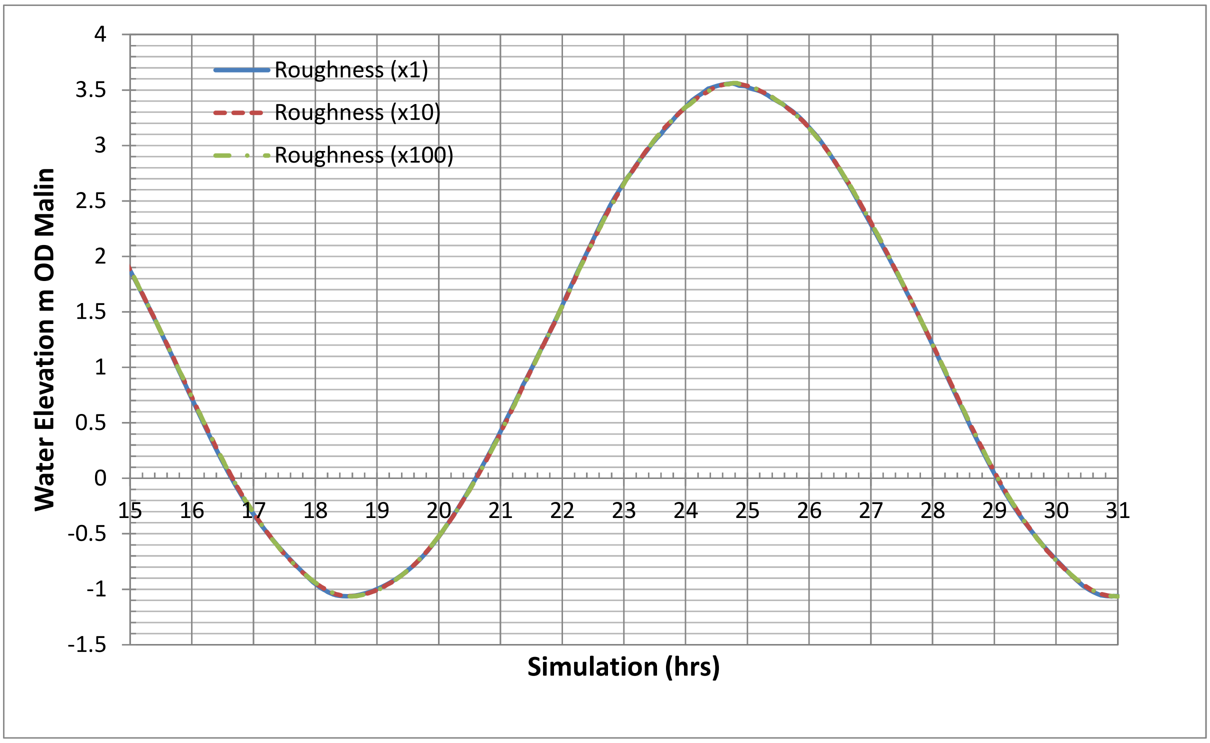


Figure 4.6.6 Sensitivity of elevation to Roughness factor at Site 5

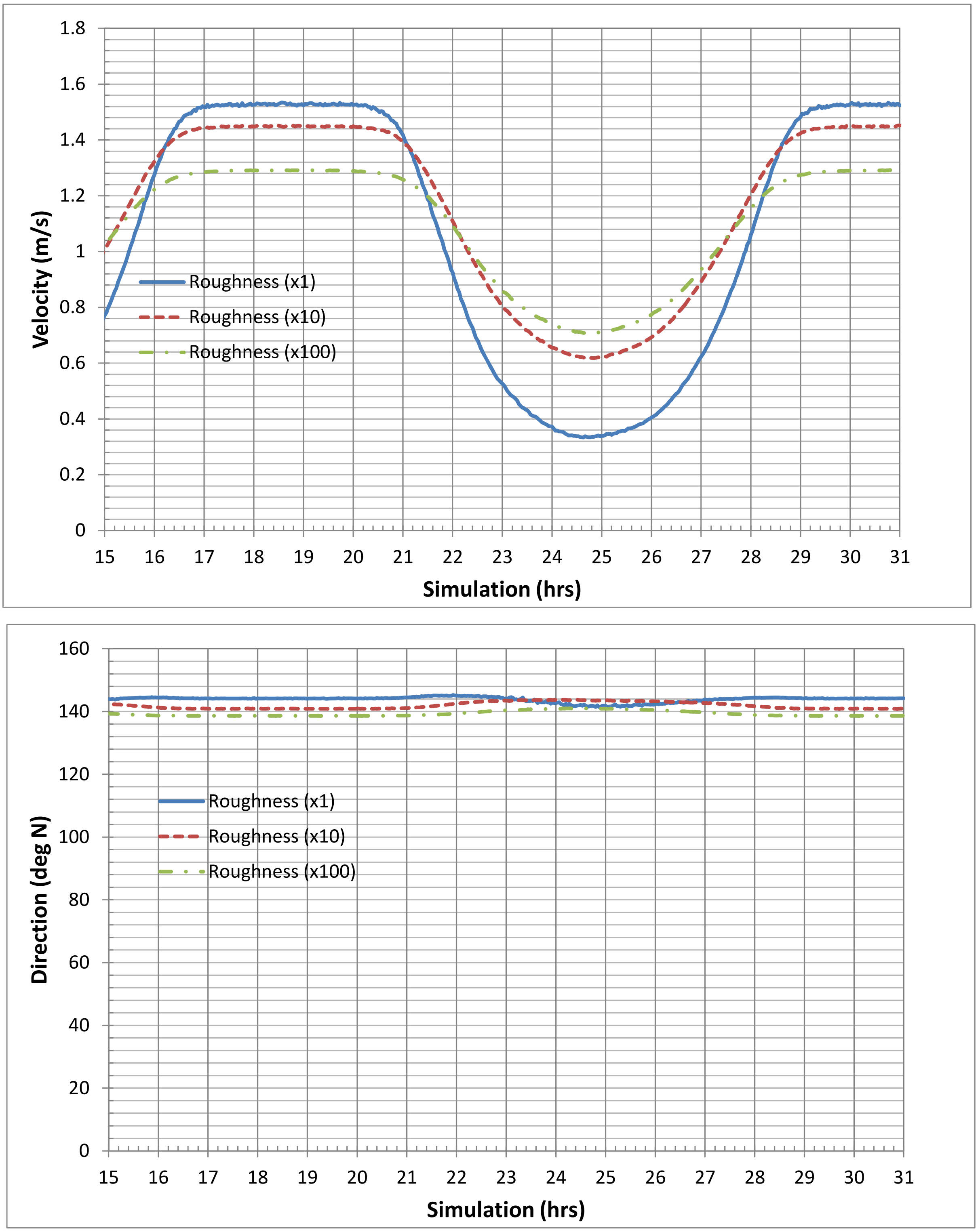
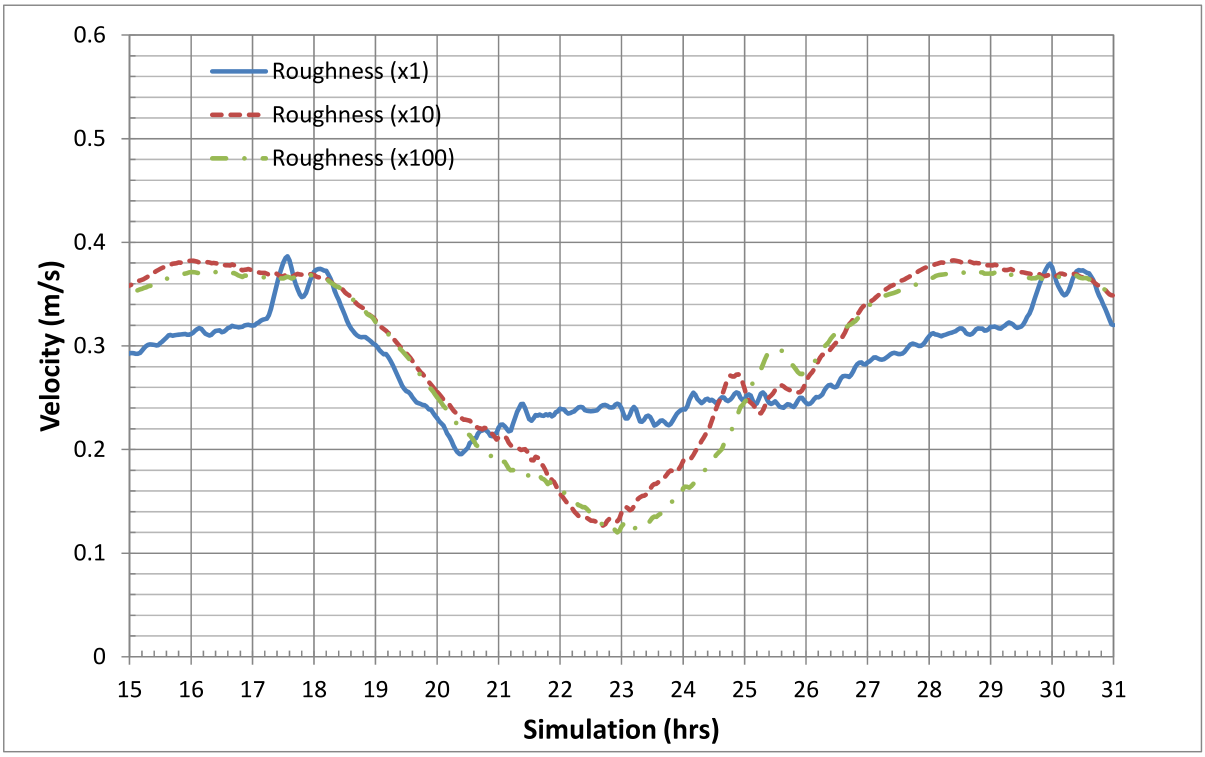


Figure 4.6.7 Sensitivity of Velocities to Roughness factor at Site 1



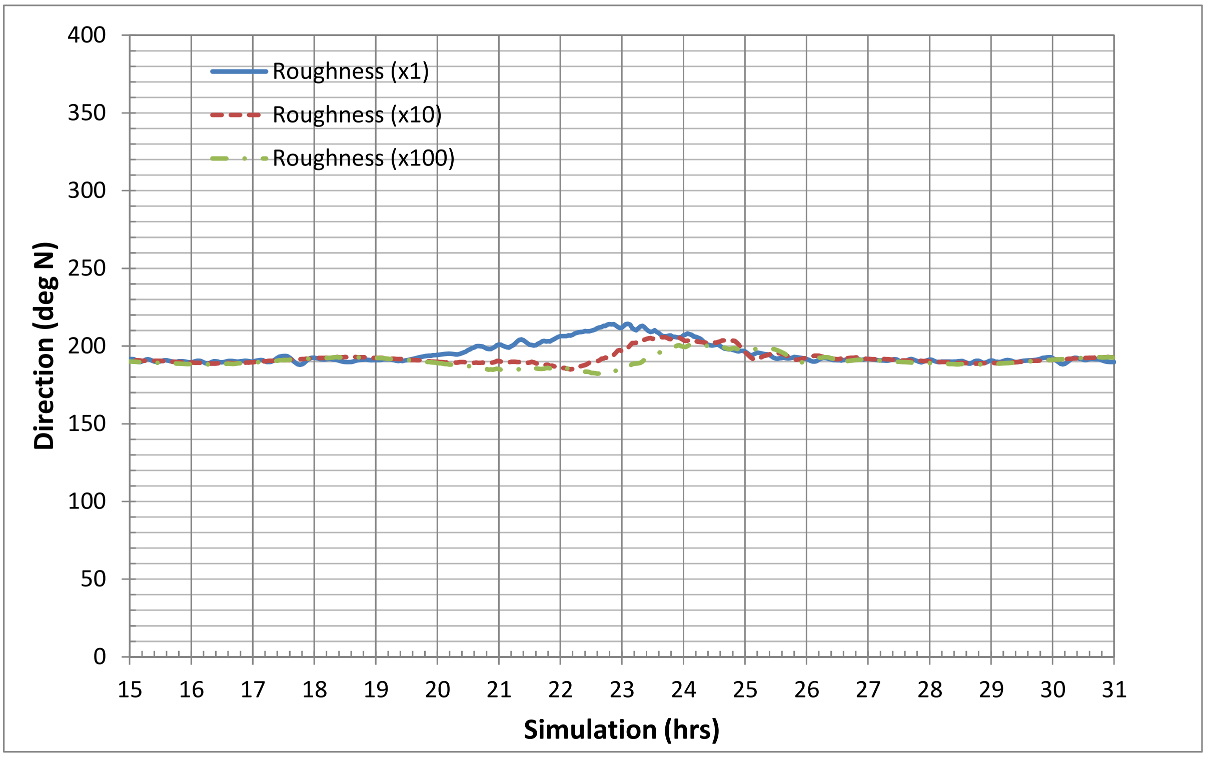


Figure 4.6.8 Sensitivity of Velocities to Roughness factor at Site 2

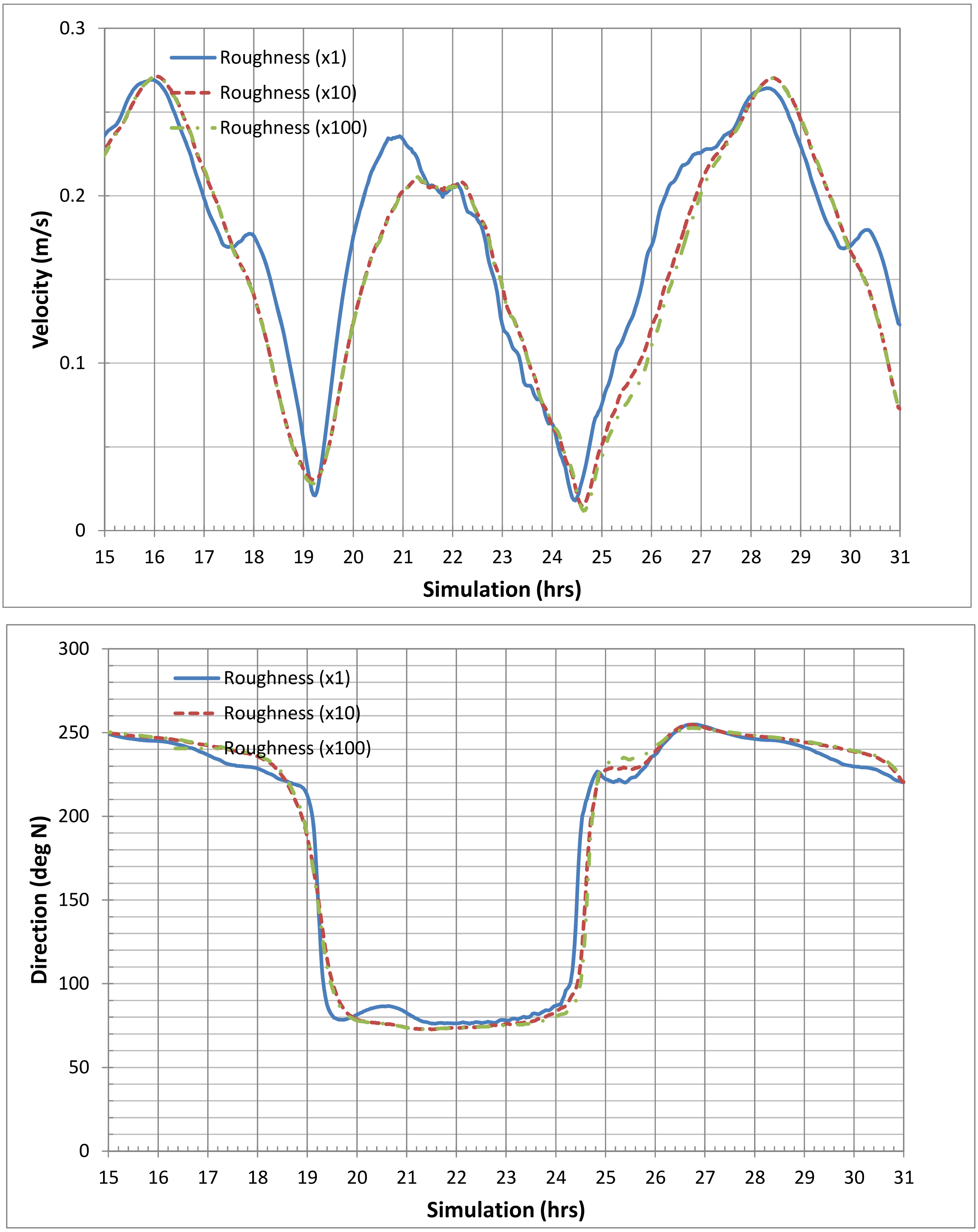


Figure 4.6.9 Sensitivity of Velocities to Roughness factor at Site 3

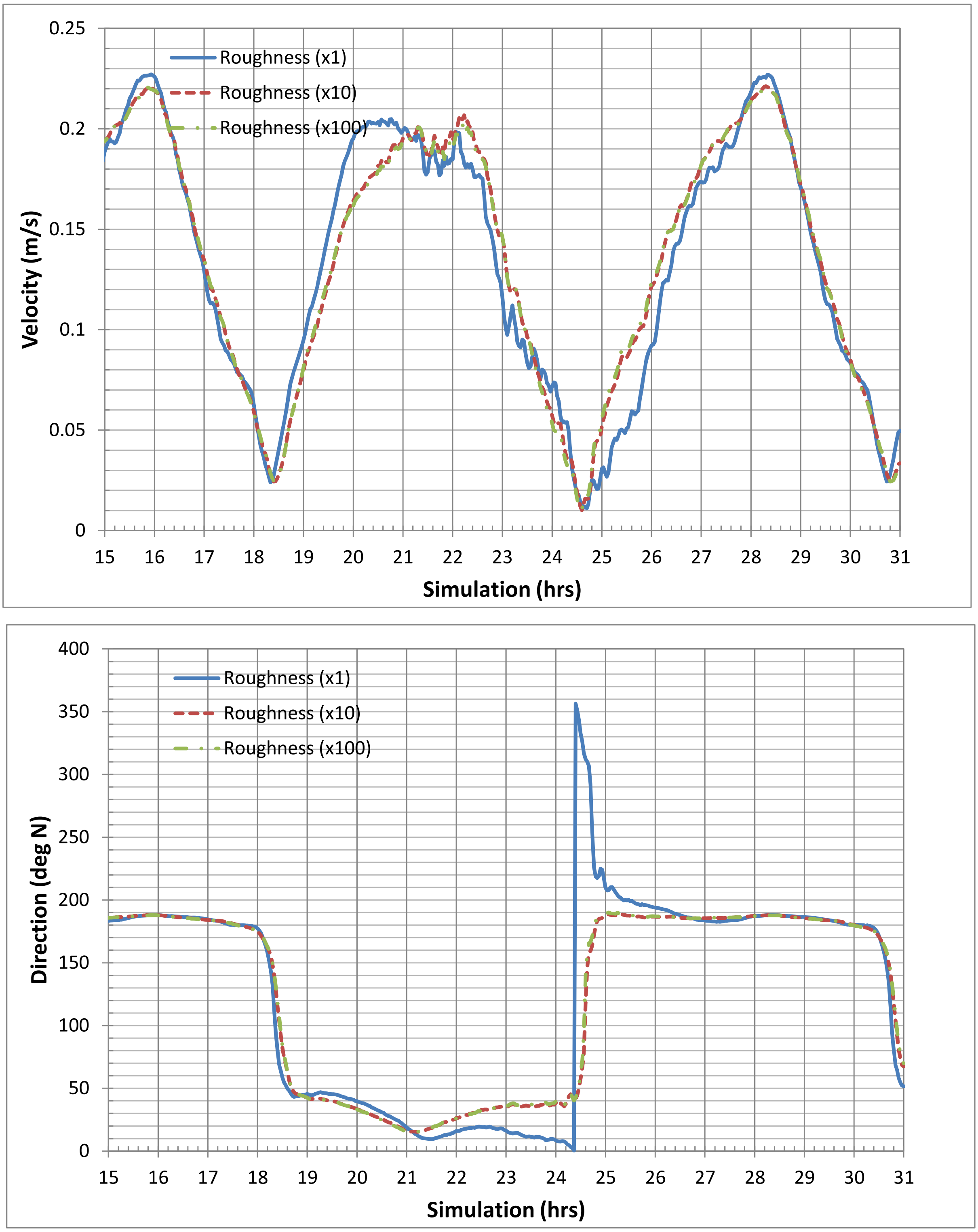
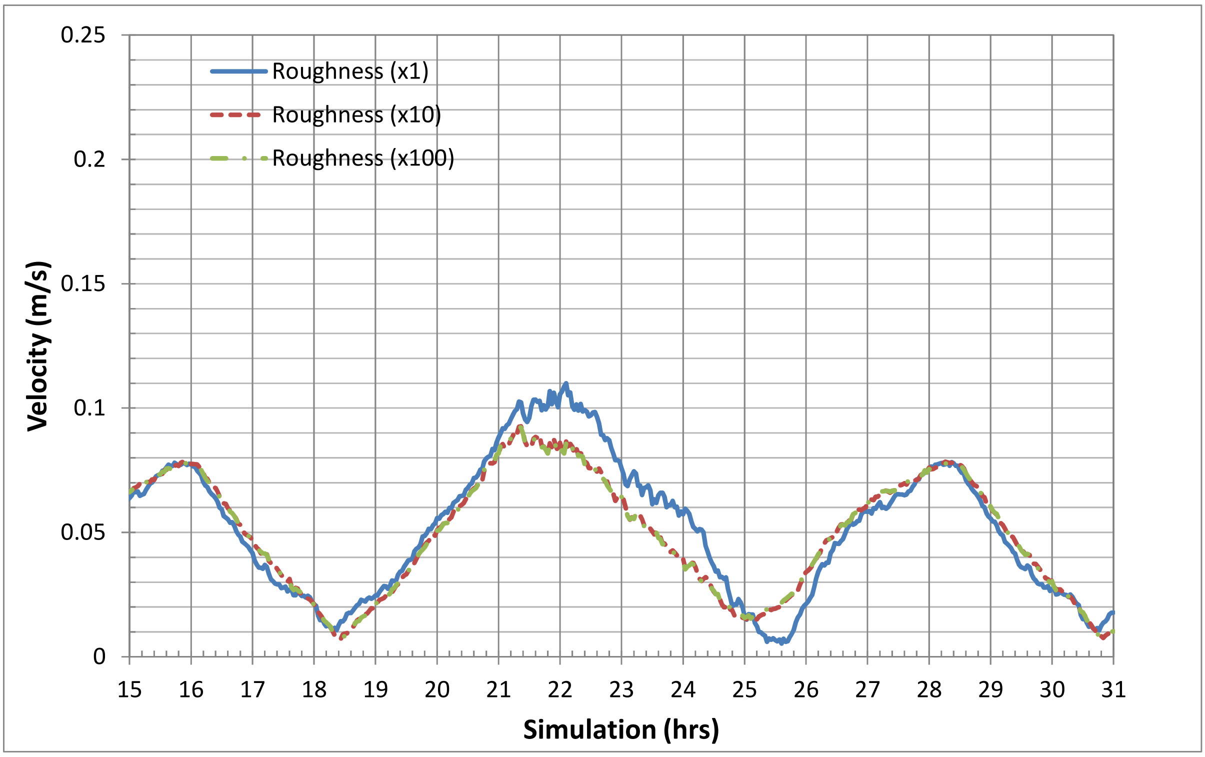


Figure 4.6.10 Sensitivity of Velocities to Roughness factor at Site 4



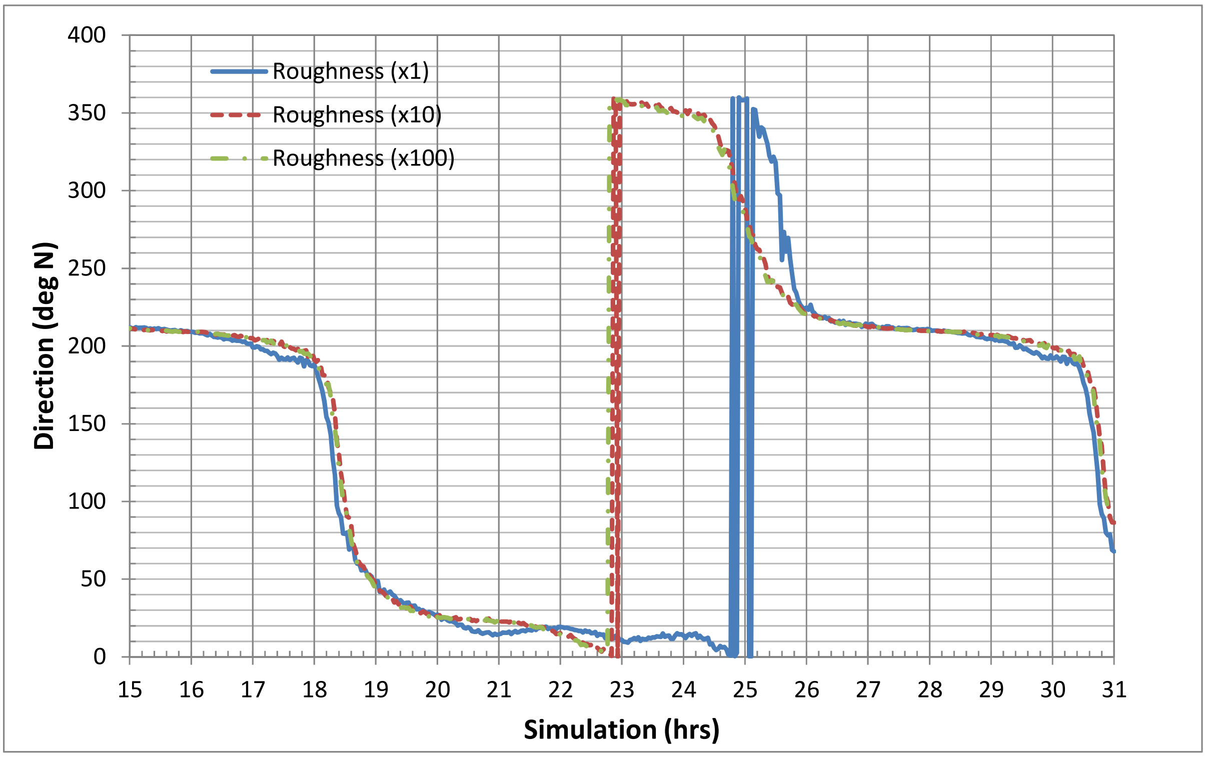


Figure 4.6.11 Sensitivity of Velocities to Roughness factor at Site 5

4.6.3.1 Design Flood Simulation for Cladagh basin including Wind shear and Wave radiation forces

A design flood simulation to examine the potential impact of the development on upstream elevations in the Cladagh Basin is presented in Figure 4.6.12 using the original modelled roughness coefficient of n = 0.03 in the open sea and n = 0.035 in the Claddagh Basin. The simulation was carried out for a 3.5m O.D. Tidal Surge wave, 100year + CC flood flow in the Corrib (549 Cumec), and with a southerly onshore wind force of 20m/s and the inclusion of the wind – wave radiation forces. In the hydrodynamic model the surface wind drag coefficient C_D specified in the surface stress term is $C_D = \rho_{air}/\rho_{sea} 0.0012615$ (for 5m/s<Wind<20m/s and measured 10m above surface).

The simulation showed a small increase in the storm surge from 3.5m highwater to 3.695m highwater in the Claddagh Basin (Site 1 of figure 4.6.1) due to the wind and river flow contribution. Importantly, the model results showed no discernible difference in computed water elevations between the existing and proposed cases for these conditions (refer to Figure 4.6.12 and 4.6.13).

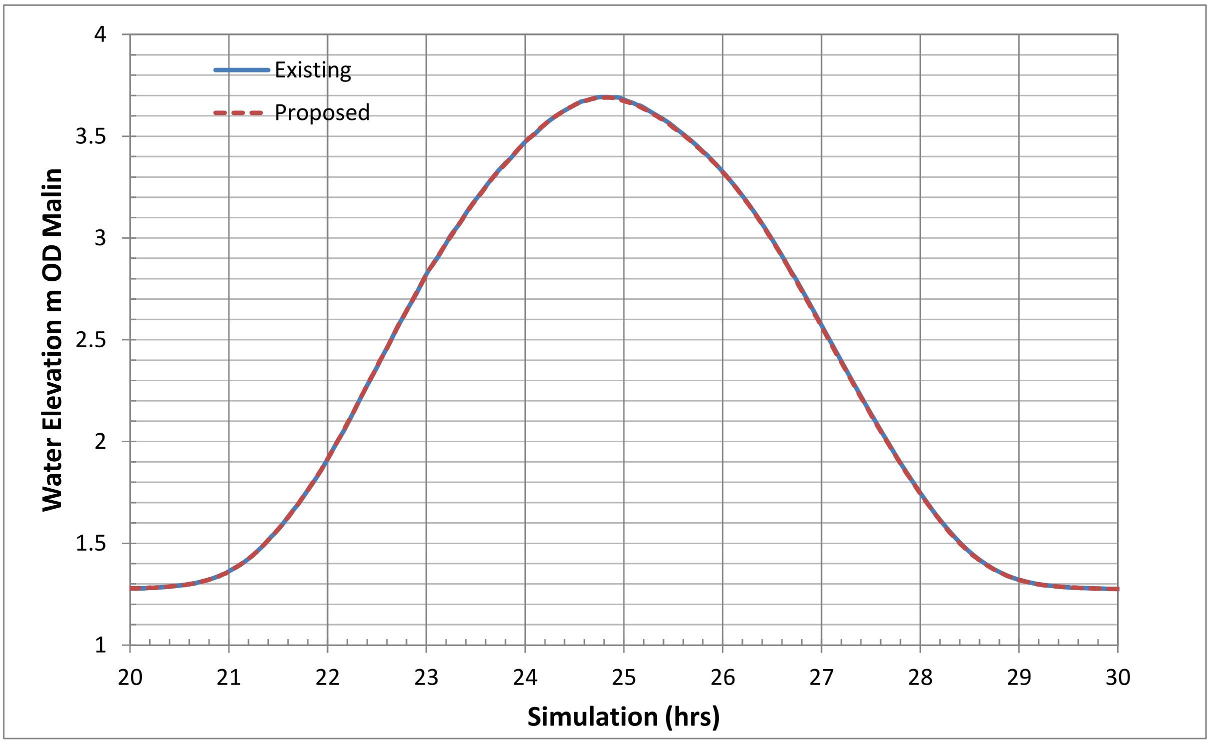


Figure 4.6.12 Comparison of Tide level at Site 1 Claddagh Basin for proposed and existing case under 3.5m tidal surge, 100year Corrib flood Flow and 20m/s southerly wind for proposed and existing scenarios (Existing and Proposed overlapping)

A difference plot of computed peak water level for the above hydrodynamic conditions was generated at 1cm resolution to demonstrate the negligible impact that the proposed development has on combined tidal and fluvial flooding in Galway Bay and in the Claddagh Basin area, refer to Figure 4.6.13.

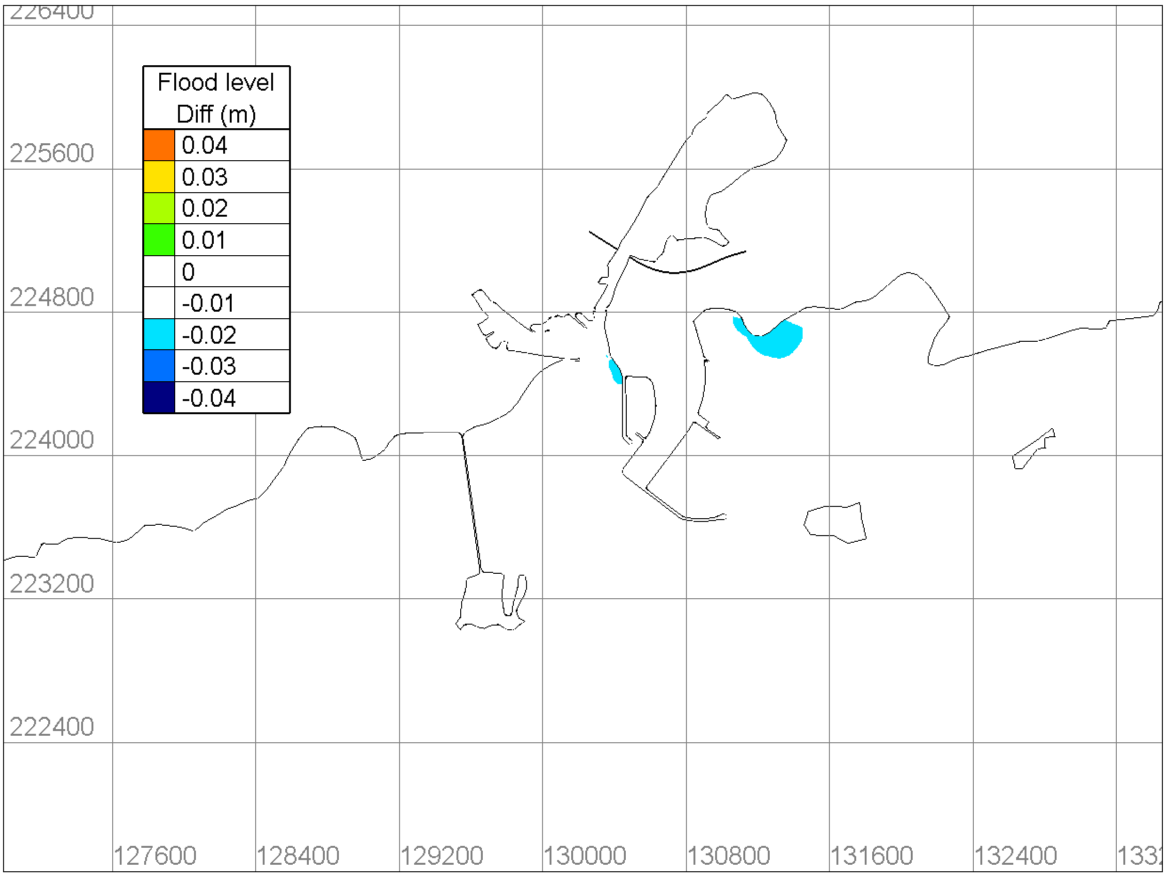


Figure 4.6.13 Difference Plot between predicted existing and Proposed peak flood levels

4.7 IMPACT OF WIND WAVES ON FRICTION

Query:

Has the impact of wind waves been incorporated into this friction, or is that effect negligible?

Response:

4.7.1 Introduction

The effect of wind waves have been incorporated as a source term (surface shear stress through a wind drag coefficient) and through inclusion of radiation stresses inputted to the hydrodynamic model. The effect of wind waves have not been incorporated into modifying the bed roughness coefficient either dynamically or as a manual adjustment to the friction factors. For the normal case of prevailing winds under spring / neap tides the wind wave effect on bed resistance will be relatively minor given the small wave heights relative to water depth that are predicted and thus producing relatively small orbital velocities and diameters to effect the bed conditions and the near bed flows.

4.7.2 Modification of Friction Factor By Waves

Outside of the surf zone wave induced ripples on the sea floor can form the size of which depend on the wave climate and hydrodynamics. These ripples increase the roughness length and thus increase the bed friction coefficient. The dimensions of these ripples can be predicted as a function of the Waves orbital velocity U_o and wave period T for a given sediment diameter and given wave climate conditions based on the procedure of Wiberg & Harris (1994). Under moderate wave conditions, as is the case in the Inner Galway Bay area in the vicinity of the proposed harbour area, the ripple dimensions (wave length λ and height η) will be proportional to the wave Orbital Diameter D_o : Wilberg and Harris, 1994 provide following method for evaluating the friction coefficient for wave induces sand ripples:

$$\lambda = 0.62\, D_o, \qquad \eta = 0.17\lambda$$

Where $D_o = 2U_o/\omega$ $\quad \omega = 2\pi/T_p$ and $U_o = \frac{H_s \omega}{2\sinh(kh)}$ $\quad \omega^2 = gk\tanh(kh)$

where k is the wave number, h is the water depth, H_s is the significant wave height, T_p is the Peak Period, ω is the intrinsic angular frequency and U_o is the wave orbital velocity and g the gravitational acceleration.

The effect of the ripples is to increase the bed roughness producing a Nikuradse roughness length expressed as follows (based on the Bijker's formula):

$k_s = \max(\eta, 3d_{50})$ where d_{50} is the sand grain roughness.

Using a water depth of 10m, a significant wave height H_s of 4m and a peak period T_p of 8seconds the ripple roughness k_s is 0.419m which represents a Manning roughness of n = 0.034 which is well within the sensitivity range demonstrated in Section 6.

Using a depth of 5m, a H_s of 2m, a T_p of 6seconds the ripple roughness k_s from the above equations is 0.228m representing a Manning's roughness n = 0.031 which is well within the sensitivity range demonstrated in Section 6 and is close to the Manning Value of 0.03 used in the simulations.

The above formulation is only applicable to oscillatory flow conditions and does not account for the effect of superimposed mean current. A correction factor σ to the wave orbital velocity following Tanaka and Dung can be applied to include the effect of the mean current.

4.7.3 Conclusion

In conclusion Wind Wave effects from large storm events will modify the bed roughness (defined by Manning n value) through rippling. This change in roughness is not significant in terms of the hydrodynamics within the inner Galway Bay as demonstrated in the Roughness sensitivity analysis presented in Section 6.

References

Bijker E.W. 1968 “Mechanics of sediment transport by the combination of waves and current” In Design and Reliability of Coastal structures, 23rd int Conf. On Coastal Engineering 147-173.

Chow V (1959) “Opean Channel Hydraulics, McGraw-Hill New York

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Tanaka H and Dang VT 1996. Geometry of sand ripples due to combined wave – currents flows J. Of Waterway, Port, Coastal and Ocean Engineering, ASCE,122 (6),pp 298-300.

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Wiberg P.L. and Harris C.K., 1994. “Ripple geometry in wave dominated environments”, Journal of Geophysical research 99, pp 775-789.

4.8 OUTFALL DISPERSION STUDIES:

Potential for Wind Driven Surface Currents to Transport Treated Waste Water Towards the Corrib Entrance

Query:

Dispersion studies due to tidal flow have been analyzed for the existing Mutton Island outfall and the proposed Galway East outfall, applying a depth integrated model (TELEMAC-2D). The Corrib entrance is not impacted by the proposed Harbour extension according to these simulations. However, due to prevailing wind from SSW, a wind driven surface current may transport waste water from the Mutton Island Outfall towards the Corrib entrance, and the concentrations may be impacted by the harbor extension. Since the location is quite windy, as indicated from the wind data from the Belmullet station, presented in figure 8.4.123, a number of (5-10) runs should be made using TELEMAC-3D to consider whether this will create any potential issues in the in terms of pollution.

Response:

4.8.1 Introduction

The TELEMAC-3D hydrodynamic and dispersion model developed for the EIS Study is used to simulate a surface plume from the Mutton Island outfall in order to address the above concerns of An Bord Pleanála in respect to the potential impact of the Harbour development on the effluent plume characteristics under adverse wind conditions resulting in greater impact to the inshore waters at the Corrib entrance (Head of Nimmo's Pier). These additional model runs also investigate the potential impact to the Bathing Beach at Ballyloughaun to the northeast of the development under similar adverse wind conditions.

It should be noted that the Mutton Island outfall discharges via a 10 port diffuser system, with horizontal jets distributed over 100m to maximise dilution of the buoyant plume in the nearfield before it reaches the surface. This Diffuser system was designed by Hydro Environmental Ltd in 2001 and achieves 95-%ile and median dilutions in excess of 30 and 60 respectively at 3DWF (Tobin 2006). At 1dwf it is likely that a median dilution in excess of 100 is achieved by the diffuser before reaching the surface. In the 3D model surface plume simulations this dilution is not factored in and it models the effluent as if released without dilution at the water surface. This could only be a very rare occurrence corresponding with still water at the turn of the tide. In the light of the above design dilutions, the application of a diffuser dilution factor is appropriate.

Hydrodynamic and dispersion simulations were carried out for varying wind speed and direction as recommended. The critical hydrodynamic conditions for the transport of the plume inshore towards the Corrib entrance and towards Ballyloughaun Beach are southerly winds combined with spring tides and low river flow conditions in the Corrib. The wind directions are the southwest to south sector.

The study was also expanded to consider the implication of adverse wind conditions on the proposed Galway East outfall being transported northwards towards the Harbour area, Corrib Entrance and Ballyloughaun Beach area. Galway East outfall is located a further 2.4km to the southeast of Mutton Island outfall.

4.8.2 Methodology

In order to provide a robust method to assess the implications of the development on various water quality parameters in the effluent a conservative tracer was simulated. The Mutton Island outfall discharge was set at the EPA Licensed Population Loading of 170,000 PE (represents a dry weather flow (dwf) of 0.3542cumec) and the Galway East outfall was set at the proposed future Population Loading of 550,000 PE (dwf = 1.1458cumec). Each outfall was modelled separately so as to account for their individual impacts.

The Mutton Island outfall was specified at grid point 129628, 222729 and the Galway East proposed outfall at 131892, 222010. Note the finite element scheme for parallel processing requirements translates the outfall locations to the nearest computational node point which are 129645, 222727 and 131909, 222033 for the Telemac3D model respectively.

In the 3-D hydrodynamic model the outfall discharge was input at the surface layer so as to commence the simulation with a surface plume as would be expected from a large freshwater discharge to the more dense tidal waters during dry weather flow conditions.

The Corrib Low flow was specified as the 95-percentile low flow of 26.2cumec.
Simulations were carried out for the following Hydrodynamic and meteorological conditions under existing and proposed development cases and represents a total of 14 model runs (7 each for proposed and existing scenarios):

Existing Mutton Island outfall - 170,000 PE

1. Spring tide and Corrib low flow and Calm Wind Conditions (8.1 – 8.6)
2. Spring Tide and Corrib Low Flow with 5 m/s from South West (8.7 – 8.12)
3. Spring Tide and Corrib Low Flow with 5 m/s from South-South West (8.13 – 8.18)
4. Spring Tide and Corrib Low Flow with 5 m/s from South (8.19 – 8.24)
5. Spring Tide and Corrib Low Flow with 15 m/s from South West (8.25 – 8.30)
6. Spring Tide and Corrib Low Flow with 15 m/s from South-South West (8.31 – 8.36)
7. Spring Tide and Corrib Low Flow with 15 m/s from South (8.37 – 8.42)

Faecal coliform simulations for the Mutton Island outfall were carried out for the following hydrodynamic conditions:

8. Spring tide and Corrib low flow and Calm Wind Conditions (8.43 – 8.45)
9. Spring Tide and Corrib Low Flow with 15 m/s from South-South West (8.46 – 8.48)

The Faecal Coliform simulations modelling 170,000 PE, a final effluent concentration of 300,000 cfu/100ml and a die-off rate set at a T_{90} of 24hours.

The Galway East outfall is a further 2.4km southeast of Mutton Island outfall and thus stronger adverse winds are required to transport the plume northwards towards Galway City. Consequently simulations modelling 15m/s winds from the SW, S and SE were carried out for the existing and proposed cases (representing 6 model runs, 3 per existing and proposed cases).

Proposed Galway East Outfall - 550,000 P.E.

10. Spring Tide and Corrib Low Flow with 15 m/s from South West (8.49 – 8.54)
11. Spring Tide and Corrib Low Flow with 15 m/s from South (8.55 – 8.60)
12. Spring Tide and Corrib Low Flow with 15 m/s from South East (8.61-8.66)

4.8.3 Water Quality Simulation Results

Simulations were modelled for a continuous outfall discharge over 112 hours (9 tidal cycles) to allow for a build up of pollutant and ensure a conservative assessment in terms of the impact of the development on the discharge plume during adverse winds.

The tracer concentration results are presented as a percentage of the discharge concentration. This approach allows for the interpretation within the flow field of the concentration of any given water quality parameter, assuming that it is does not die-off or decay (conservative solute). For example a 1% concentration contour relative to an outfall effluent BOD concentration of 25mg/l represents a concentration of 0.25mg/l BOD..

This approach is reasonable for assessment of the implication on BOD, ammonia, nitrates etc. Where die-off is important such as faecal coliforms the concentrations more remote from the outfall will be over estimated.

Plots of predicted instantaneous maximum tracer concentration and the tidal mean tracer concentration (i.e averaged over the full tidal cycle) in the surface layer are presented for each of the simulations showing existing and proposed harbour development cases. For each of the hydrodynamic scenarios a difference plot between development and existing case is produced showing the increase / decrease in tracer concentration expressed as a percentage of the outfall effluent concentration.

4.8.4 Mutton Island Outfall Simulations

4.8.4.1 Spring tide and Corrib low flow and Calm Wind Conditions

Figure 4.8.1 to 4.8.6 presents the concentration plume and difference plots for calm wind conditions.

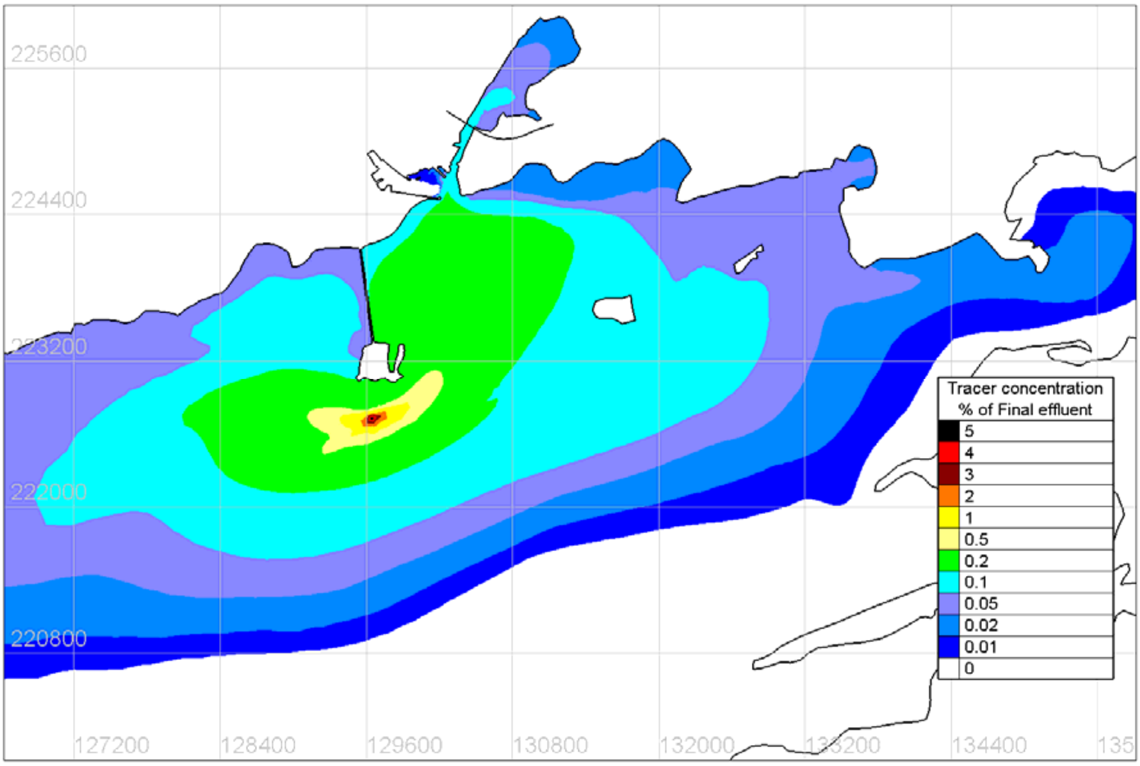


Figure 4.8.1 Maximum surface concentration of Tracer under calm wind conditions – Existing Case

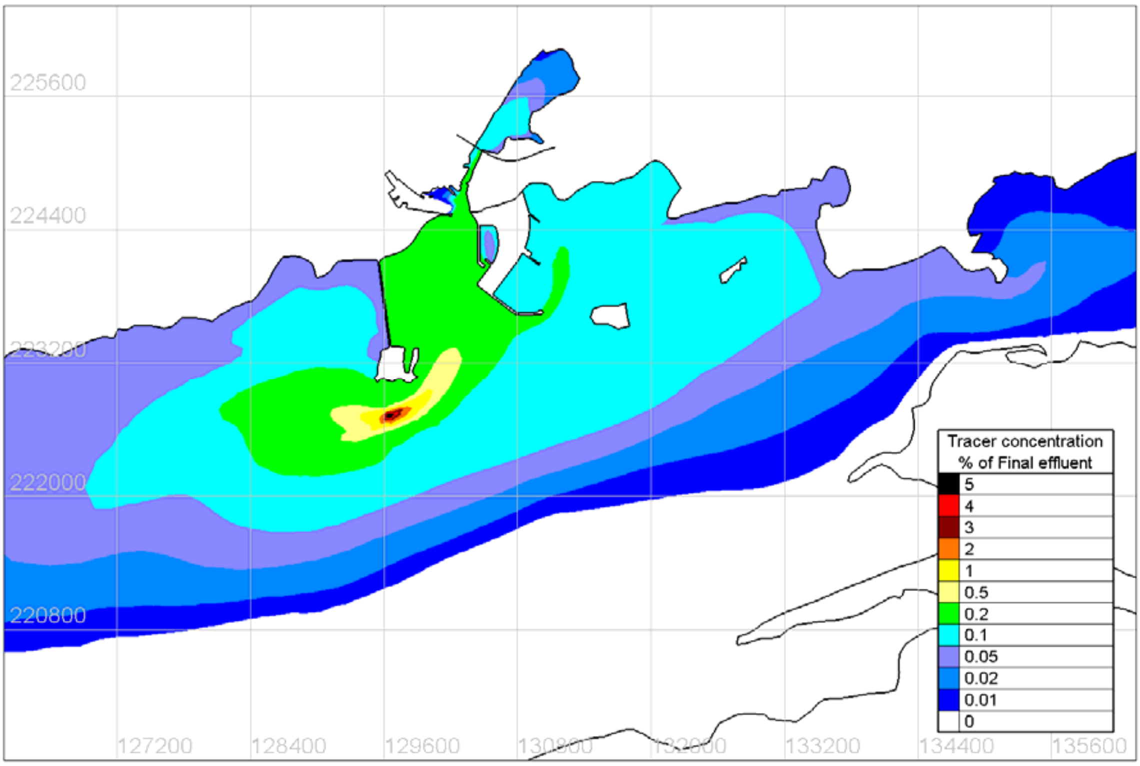


Figure 4.8.2 Maximum surface concentration of Tracer under calm wind conditions– Proposed Case

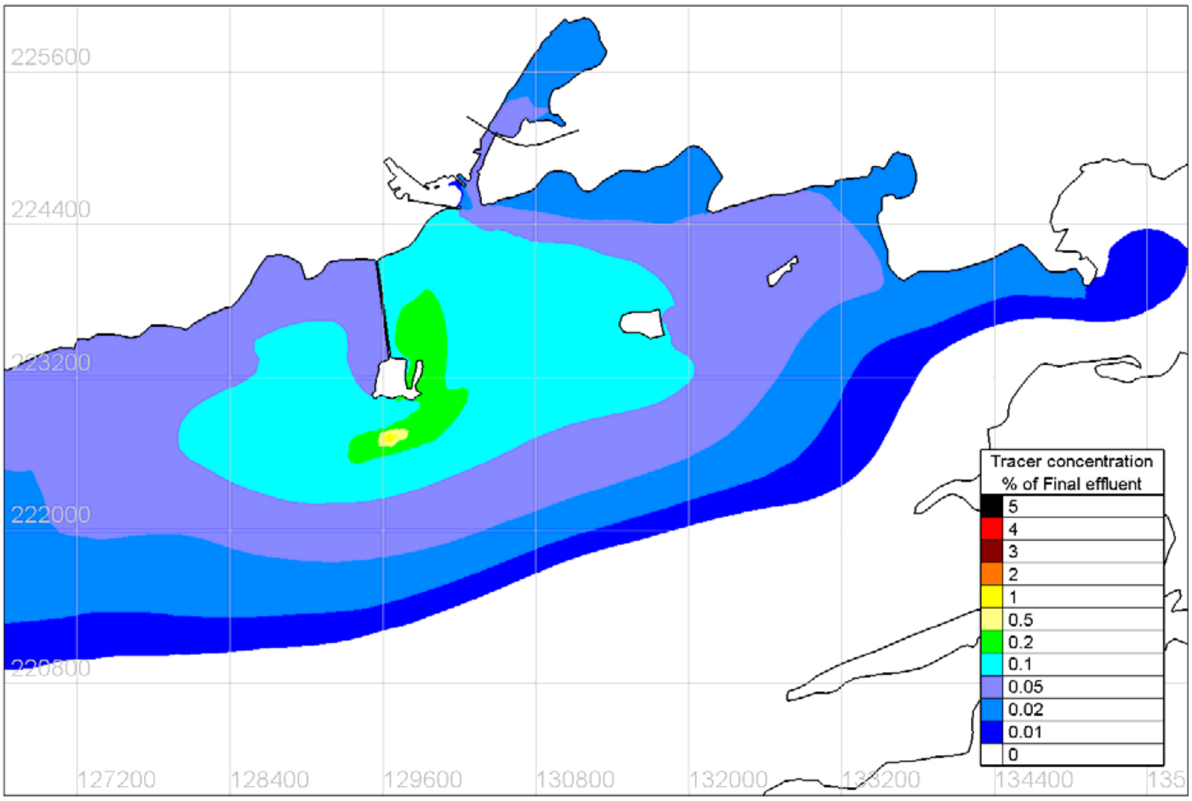


Figure 4.8.3 Tidal mean tracer concentration under calm wind conditions – Existing Case

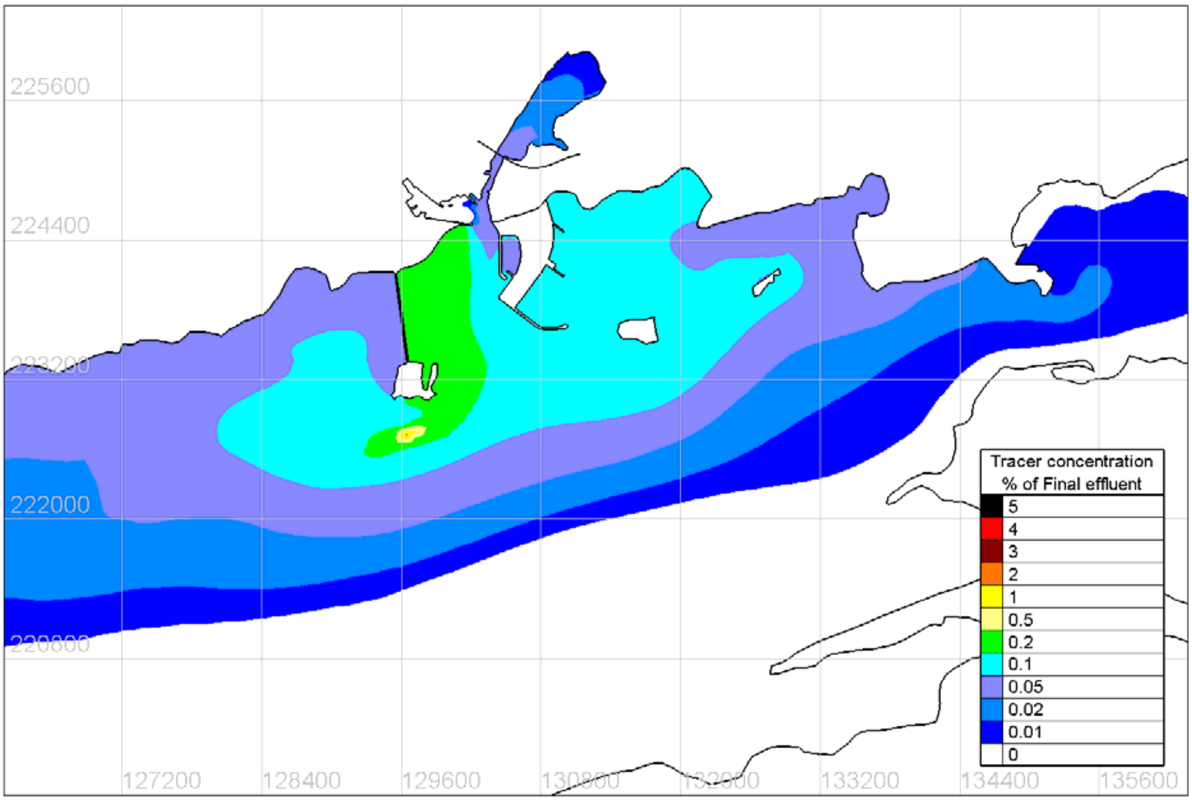


Figure 4.8.4 Tidal mean tracer concentration under calm wind conditions – Proposed Case

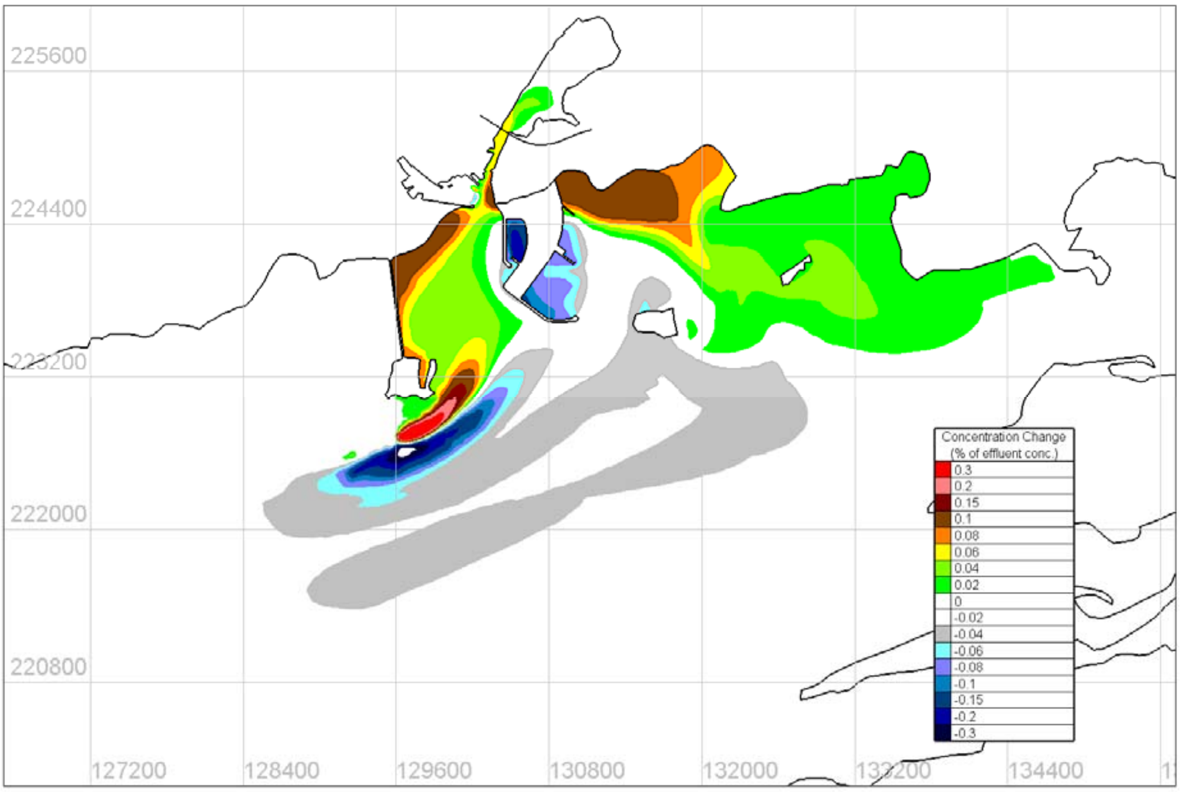


Figure 4.8.5 Predicted change in maximum surface tracer concentration – Calm Wind Conditions

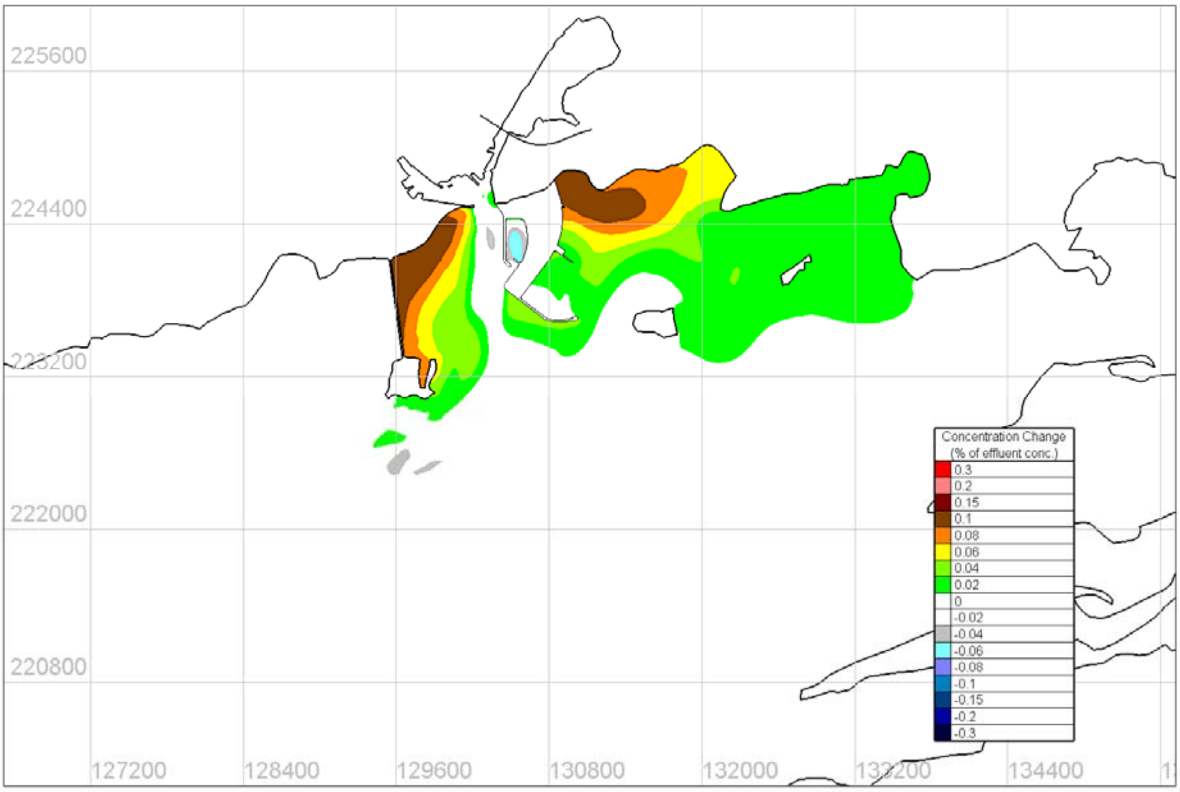


Figure 4.8.6 Predicted change in tidal mean tracer concentration – Calm Wind Conditions

4.8.4.2 Spring Tide and Corrib Low Flow with 5 m/s from SW

Figure 4.8.7 to 4.8.12 presents the concentration plume and difference plots for 5m/s wind from SW.

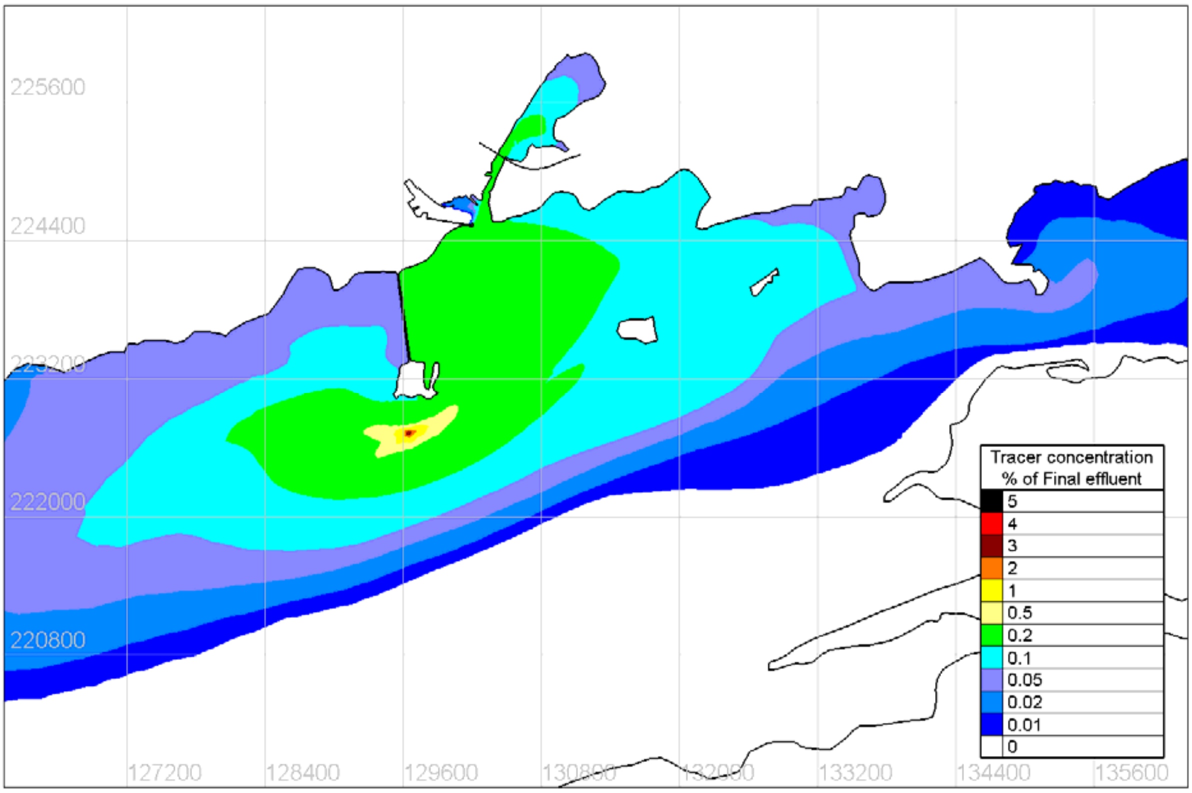


Figure 4.8.7 Maximum surface concentration of Tracer under under SW 5m/s wind conditions– Existing

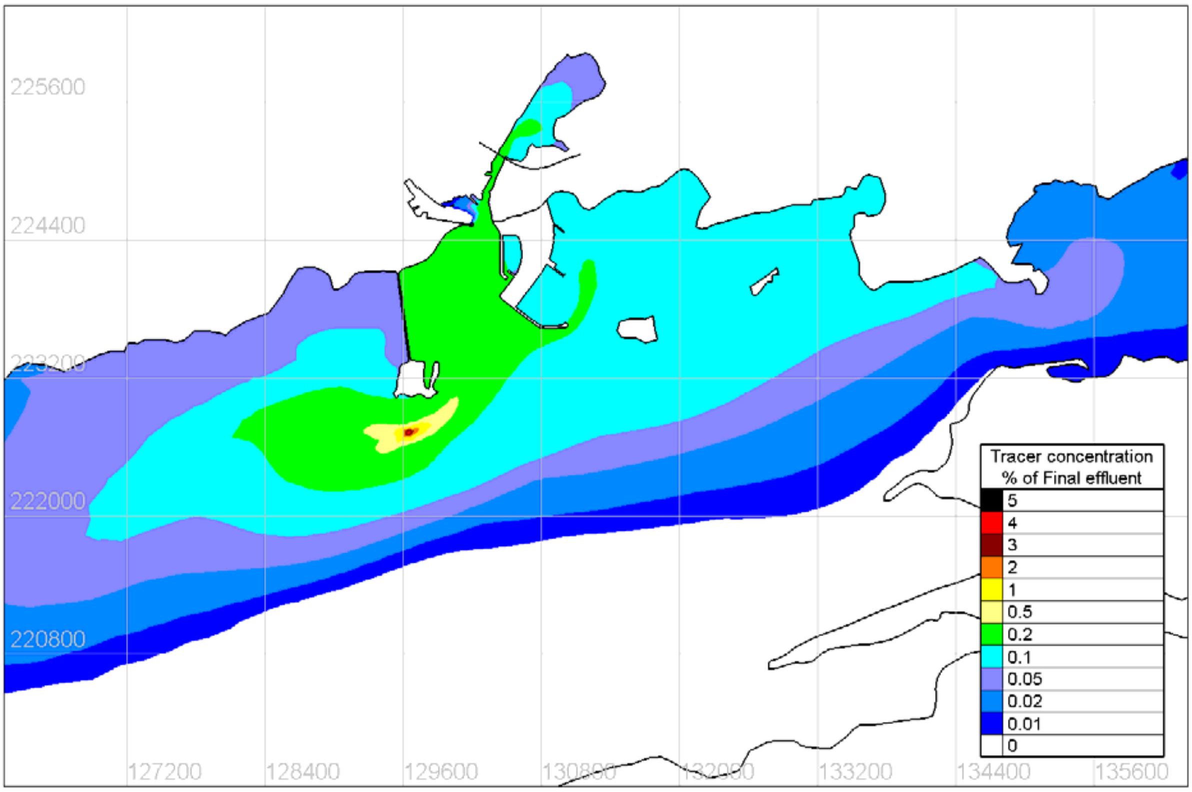


Figure 4.8.8 Maximum surface concentration of Tracer under under SW 5m/s wind conditions– Proposed

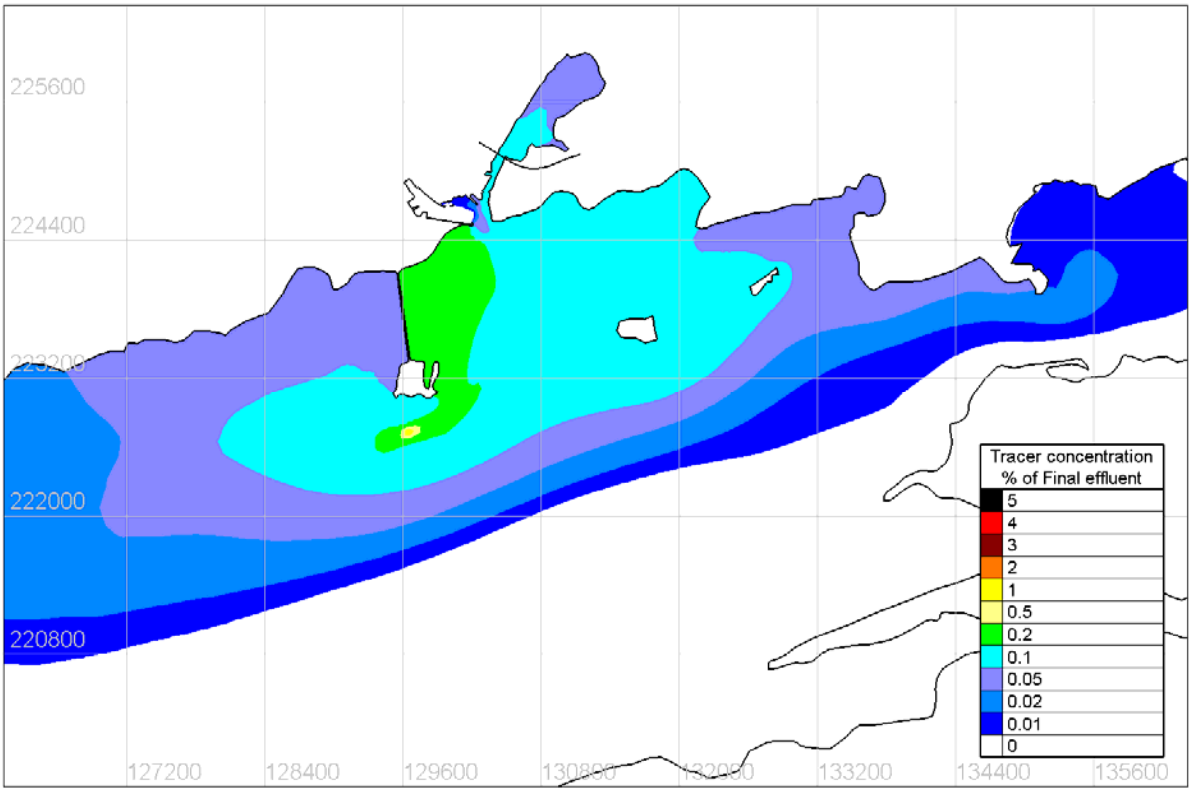


Figure 4.8.9 Tidal mean tracer concentration under SW 5m/s wind conditions – Existing Case

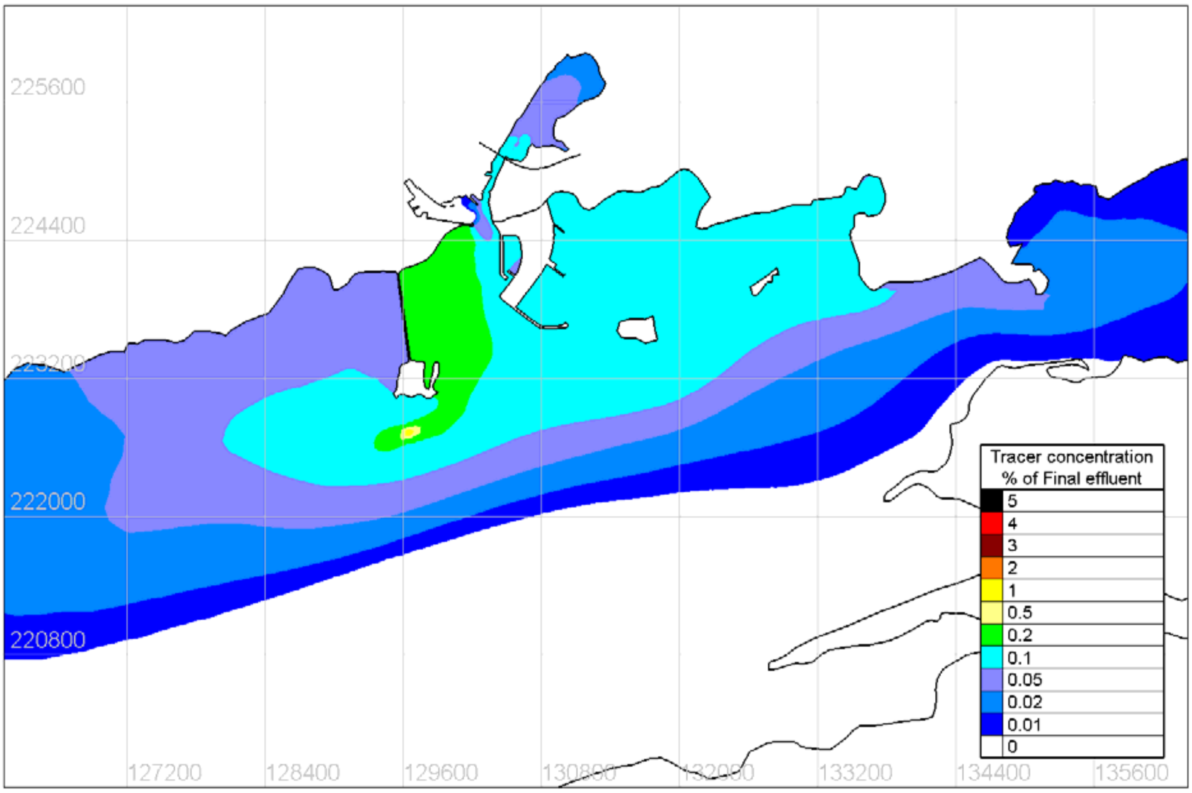


Figure 4.8.10 Tidal mean tracer concentration under SW 5m/s wind conditions – Proposed Case

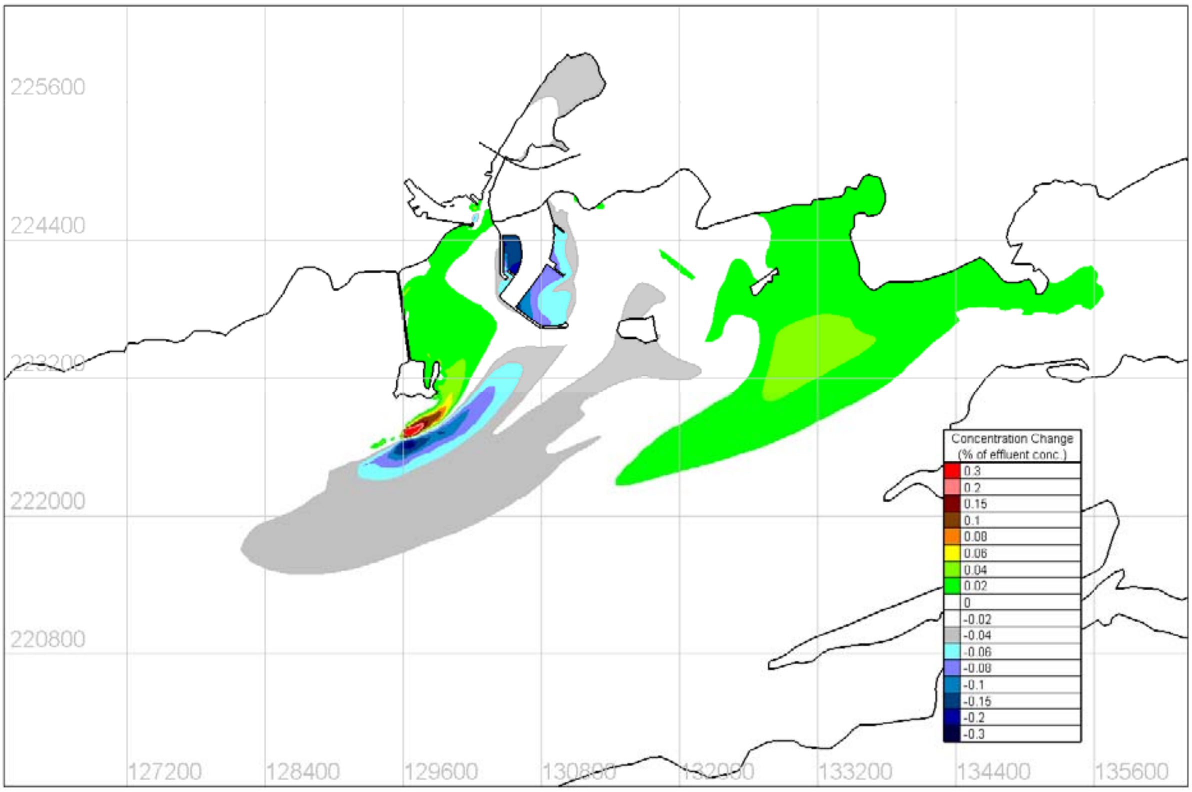


Figure 4.8.11 Predicted change in maximum surface tracer concentration – SW 5m/s Wind Conditions

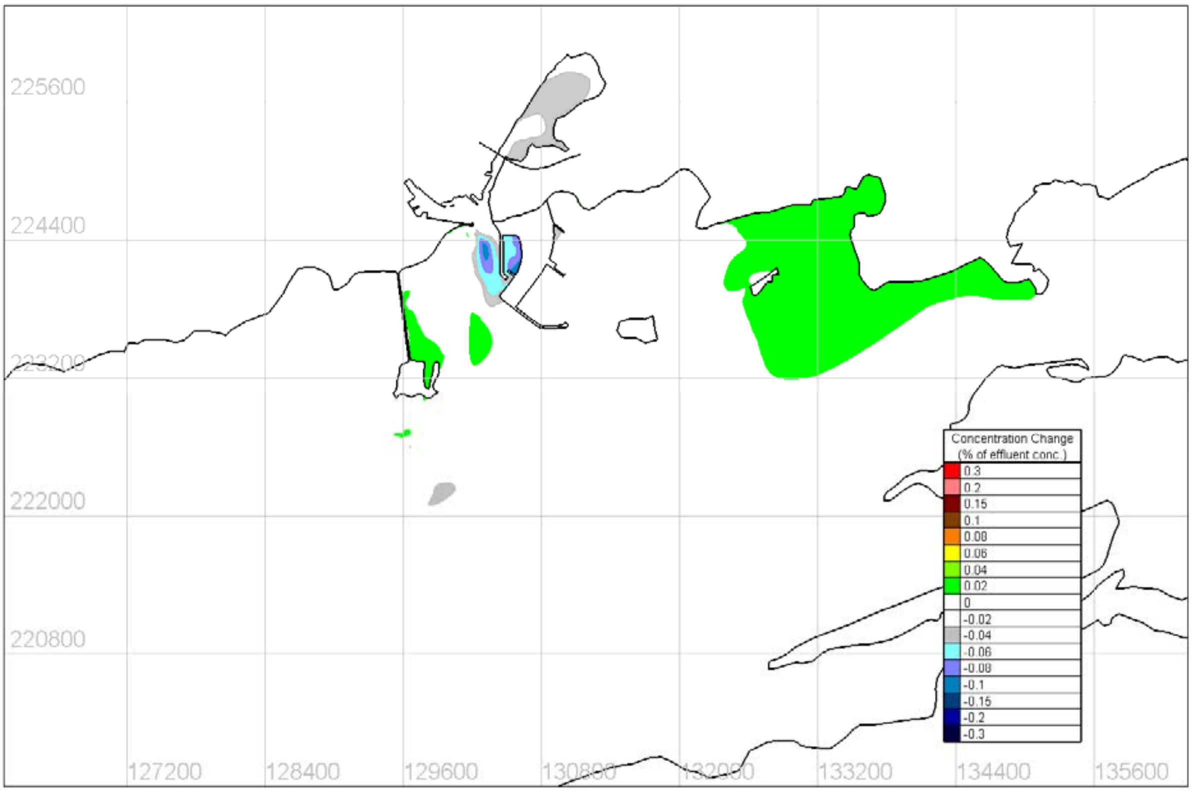


Figure 4.8.12 Predicted change in tidal mean tracer concentration – SW 5m/s Wind Condition

4.8.4.3 Spring Tide and Corrib Low Flow with 5 m/s from SSW

Figure 4.8.13 to 4.8.18 presents the concentration plume and difference plots for 5m/s wind from SSW.

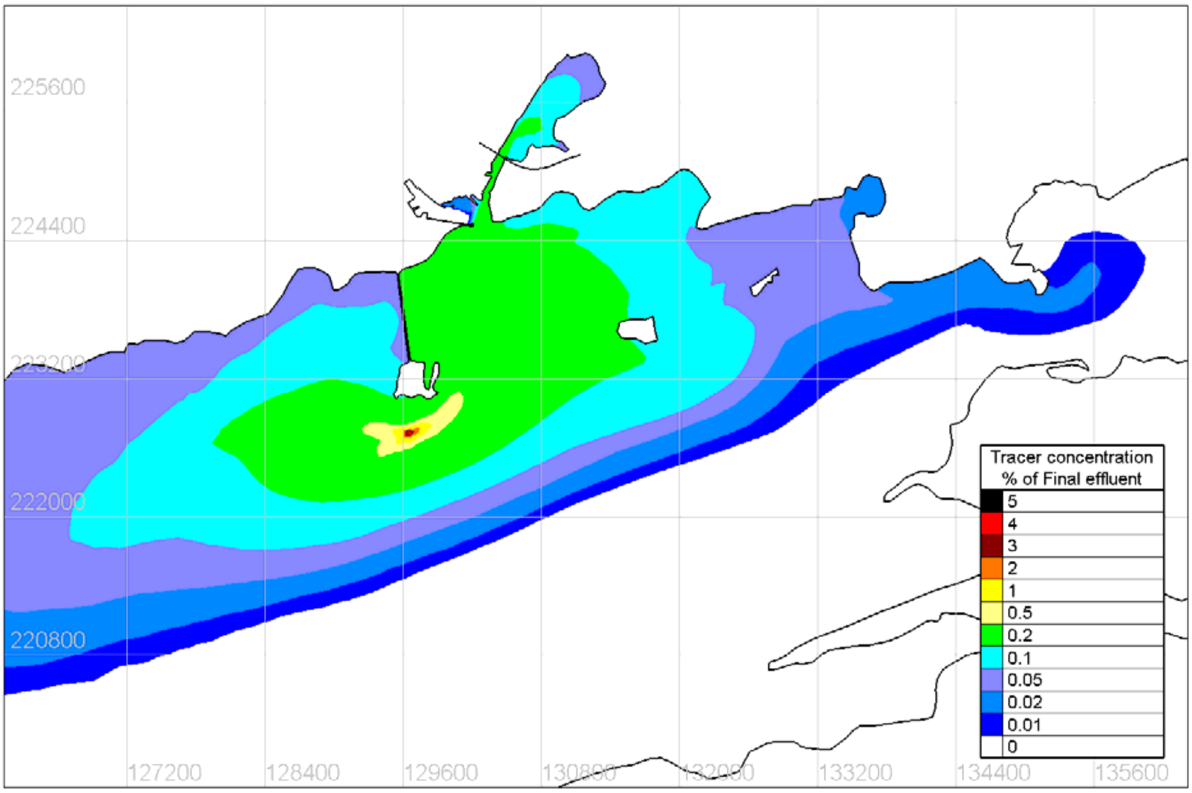


Figure 4.8.13 Maximum surface concentration of Tracer under SSW 5m/s wind conditions– Existing

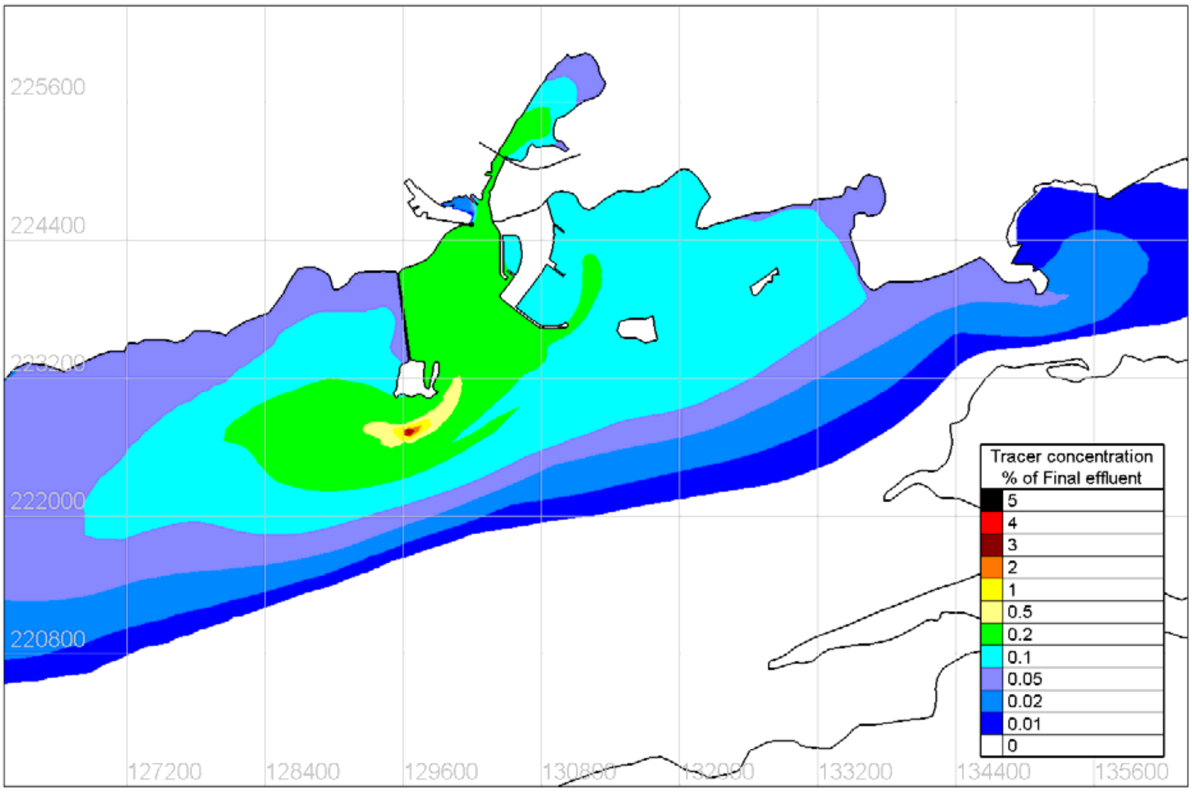


Figure 4.8.14 Maximum surface concentration of Tracer under SSW 5m/s wind conditions– Proposed

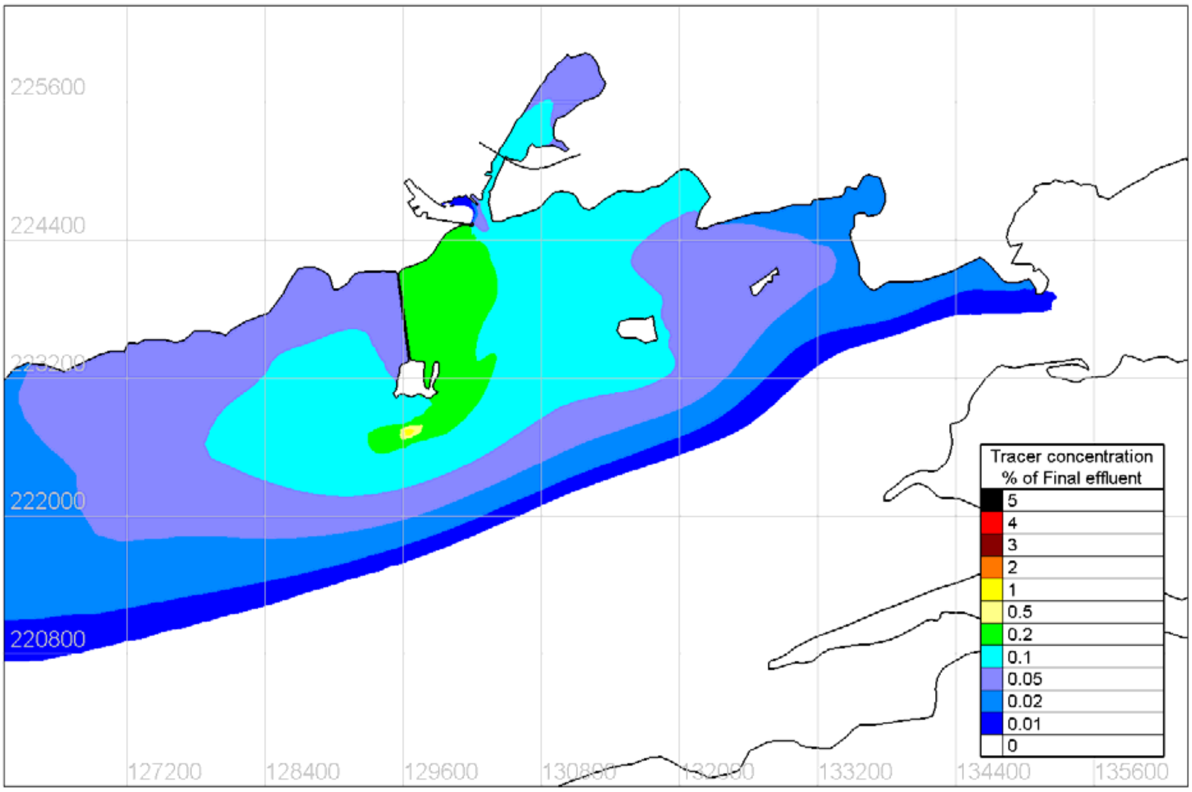


Figure 4.8.15 Tidal mean tracer concentration under SSW 5m/s wind conditions – Existing Case

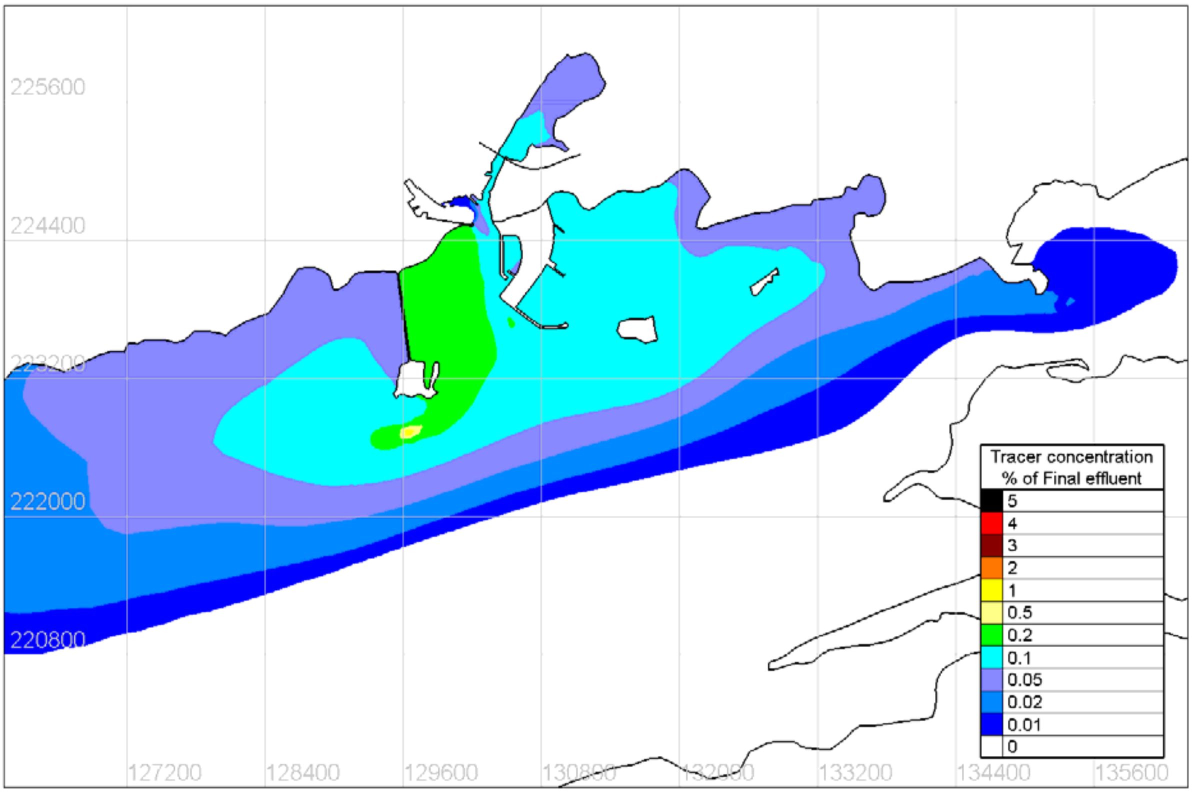


Figure 4.8.16 Tidal mean tracer concentration under SSW 5m/s wind conditions – Proposed Case

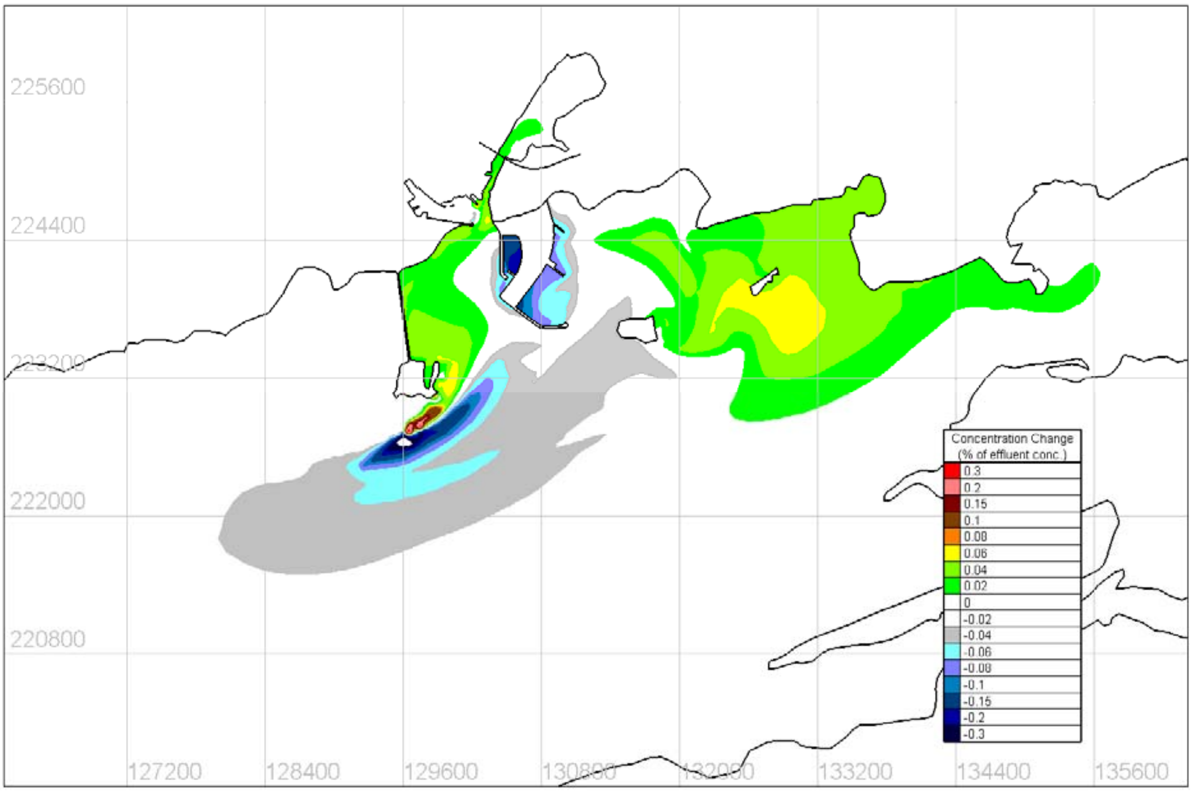


Figure 4.8.17 Predicted change in maximum surface tracer concentration – SSW 5m/s Wind Conditions

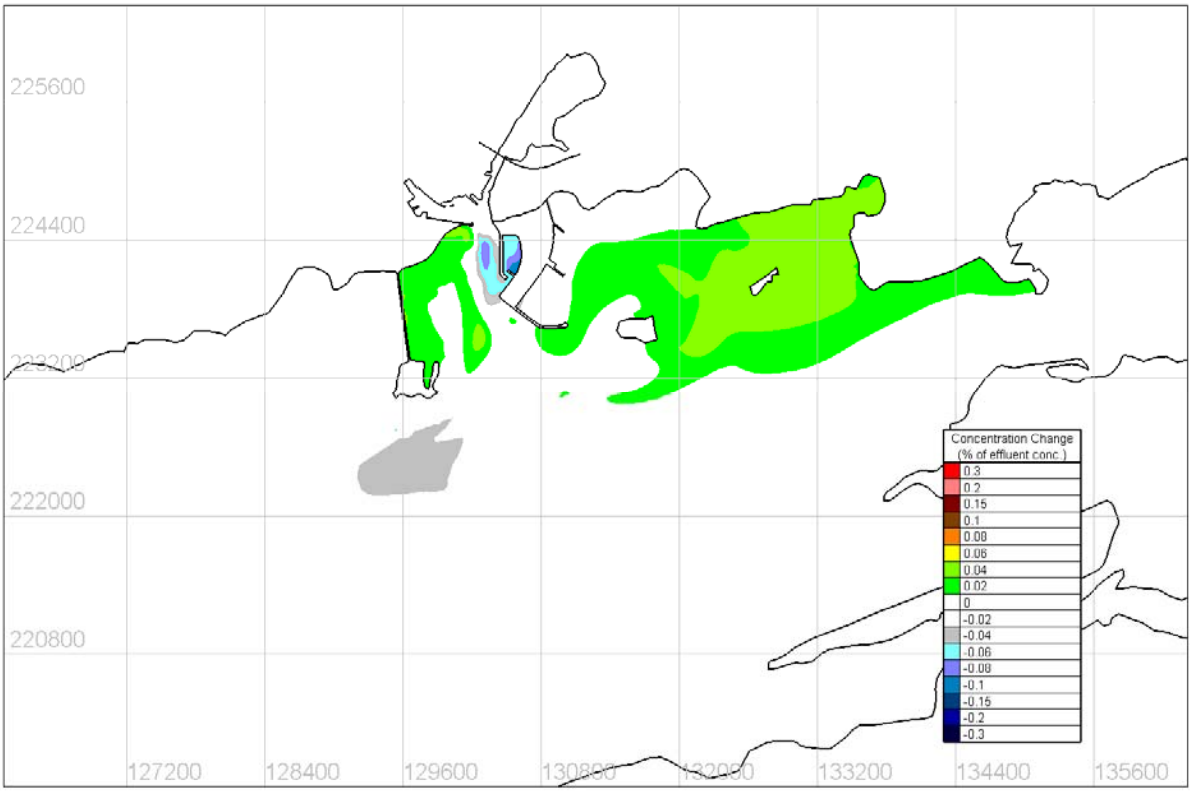


Figure 4.8.18 Predicted change in tidal mean tracer concentration – SSW 5m/s Wind Condition

4.8.4.4 Spring Tide and Corrib Low Flow with 5 m/s from South

Figure 4.8.19 to 4.8.24 presents the concentration plume and difference plots for 5m/s wind from South.

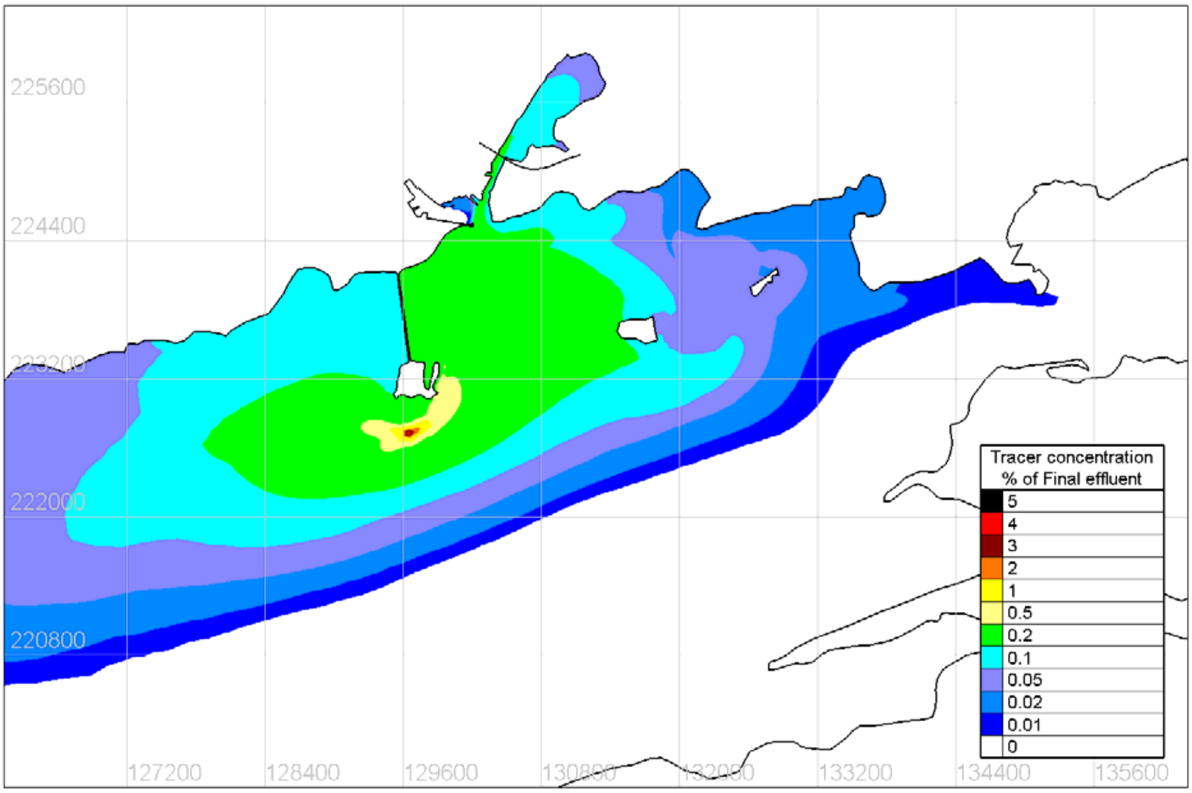


Figure 4.8.19 Maximum surface concentration of Tracer under South 5m/s wind conditions– Existing

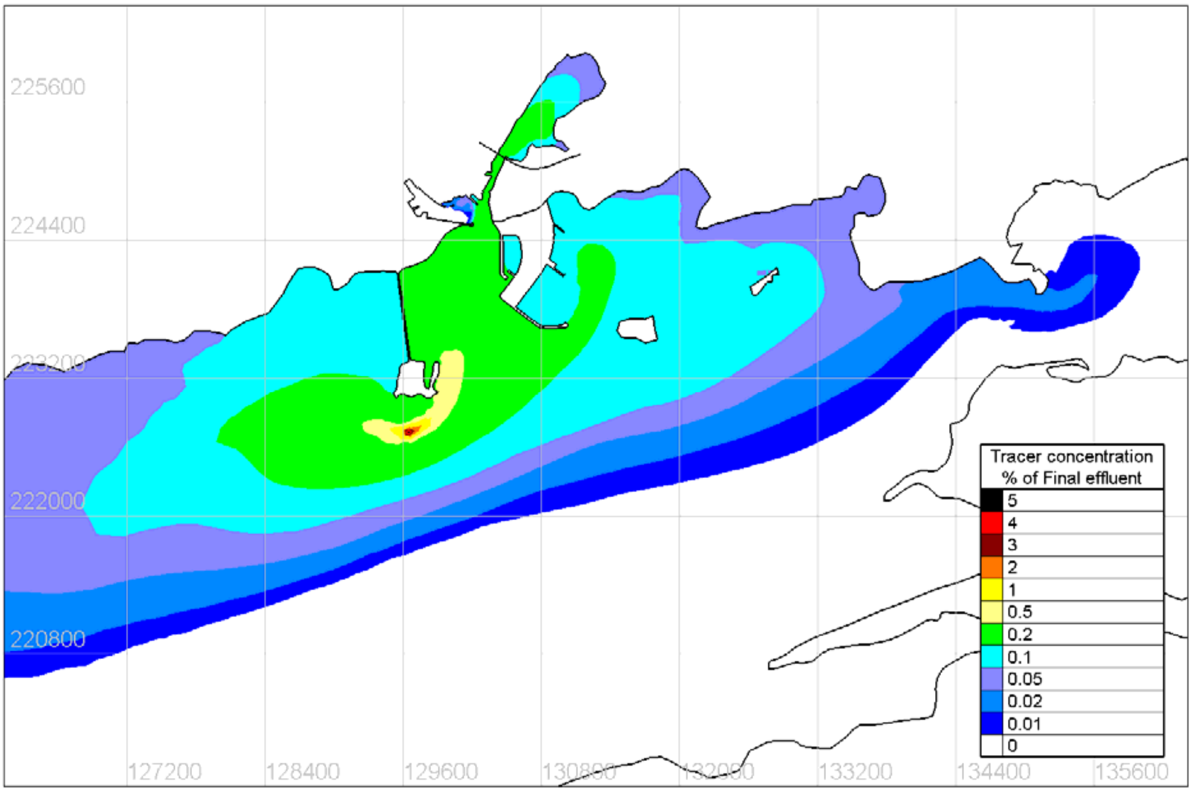


Figure 4.8.20 Maximum surface concentration of Tracer under South 5m/s wind conditions– Proposed

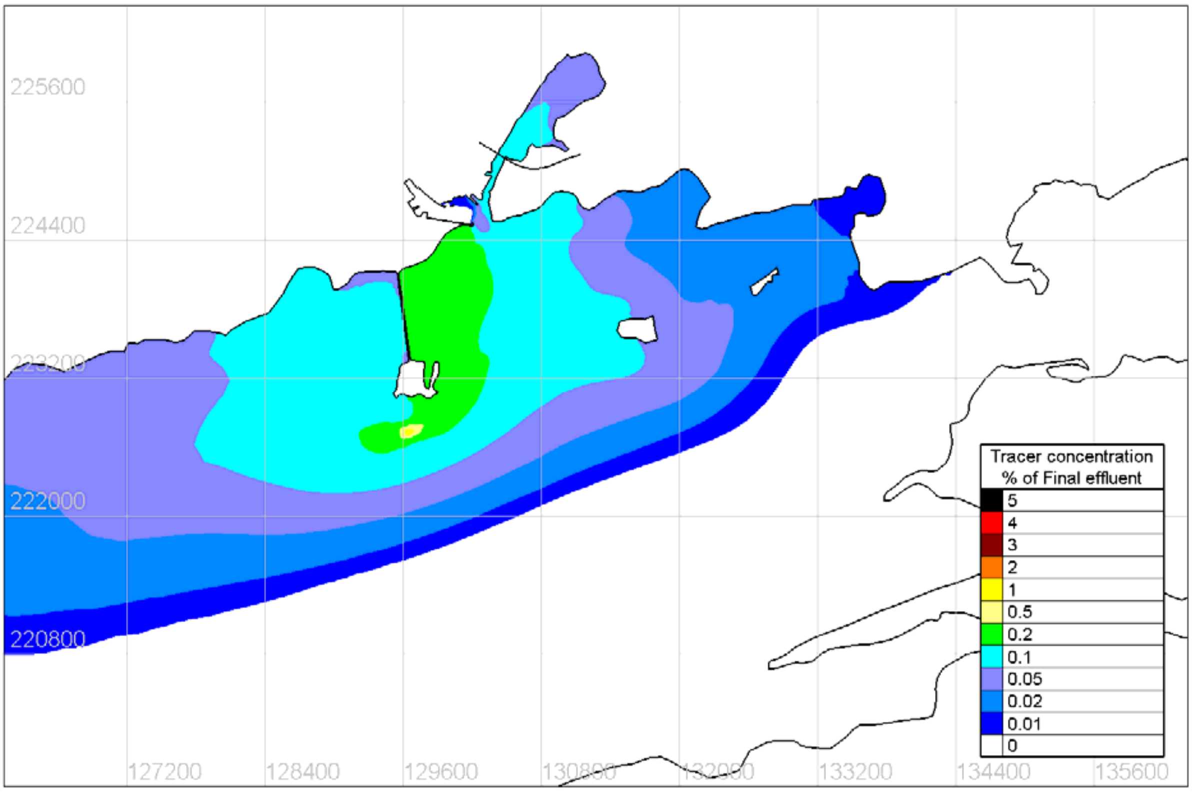


Figure 4.8.21 Tidal mean tracer concentration under South 5m/s wind conditions – Existing Case

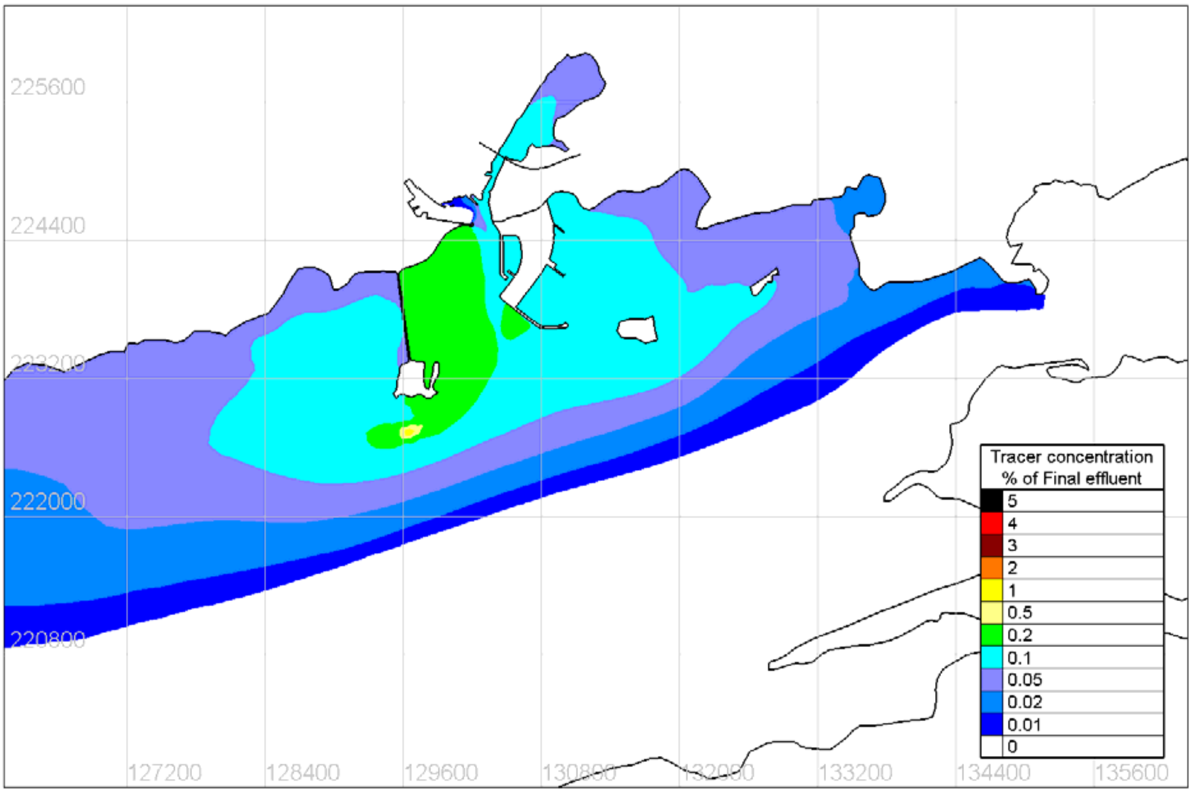


Figure 4.8.22 Tidal mean tracer concentration under South 5m/s wind conditions – Proposed Case

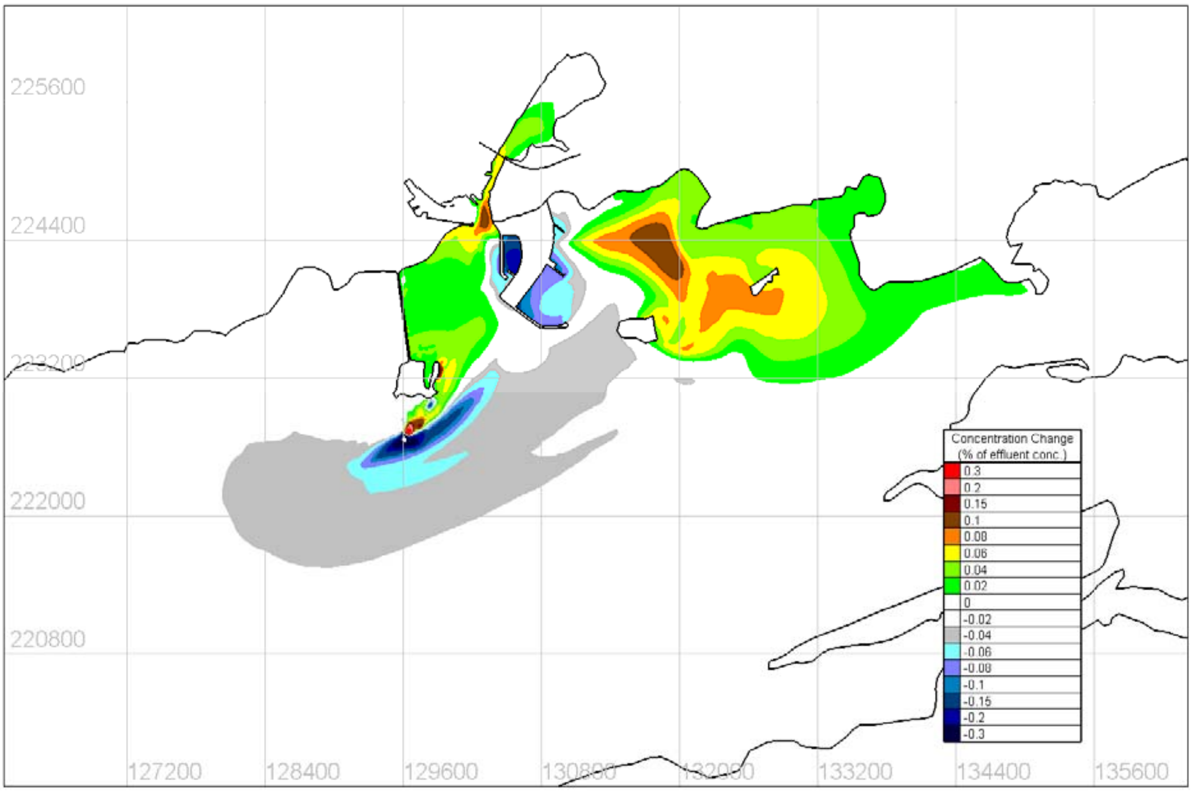


Figure 4.8.23 Predicted change in maximum surface tracer concentration – South 5m/s Wind Conditions

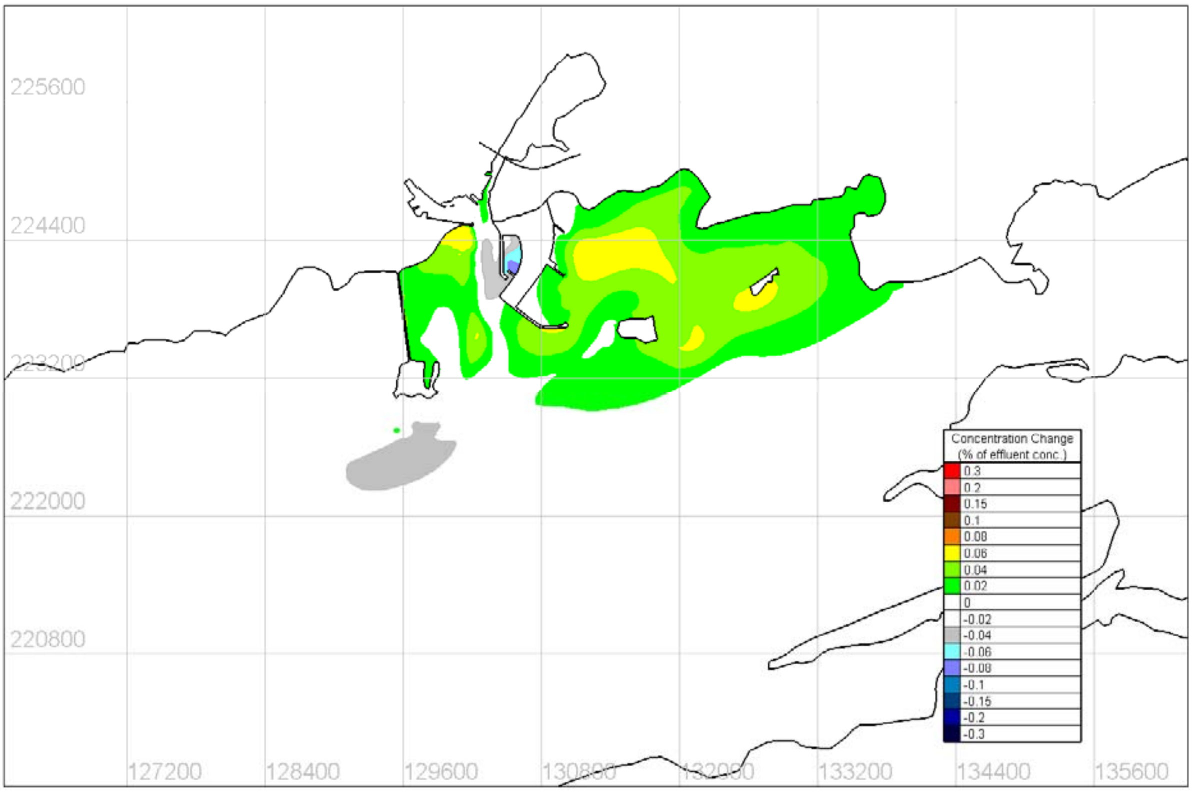


Figure 4.8.24 Predicted change in tidal mean tracer concentration – South 5m/s Wind Condition

4.8.4.5 Spring Tide and Corrib Low Flow with 15 m/s from SW

Figure 4.8.25 to 4.8.30 presents the concentration plume and difference plots for 15m/s wind from SW.

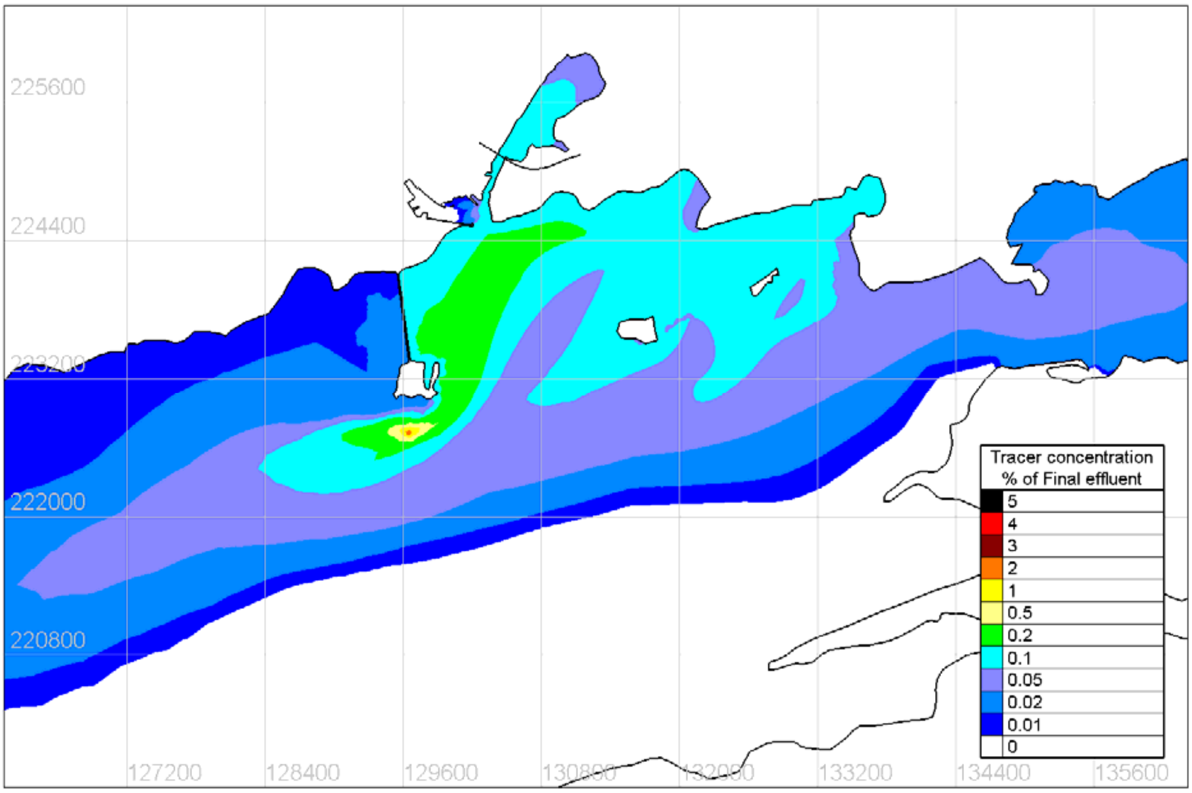


Figure 4.8.25 Maximum surface concentration of Tracer under SW 15m/s wind conditions– Existing

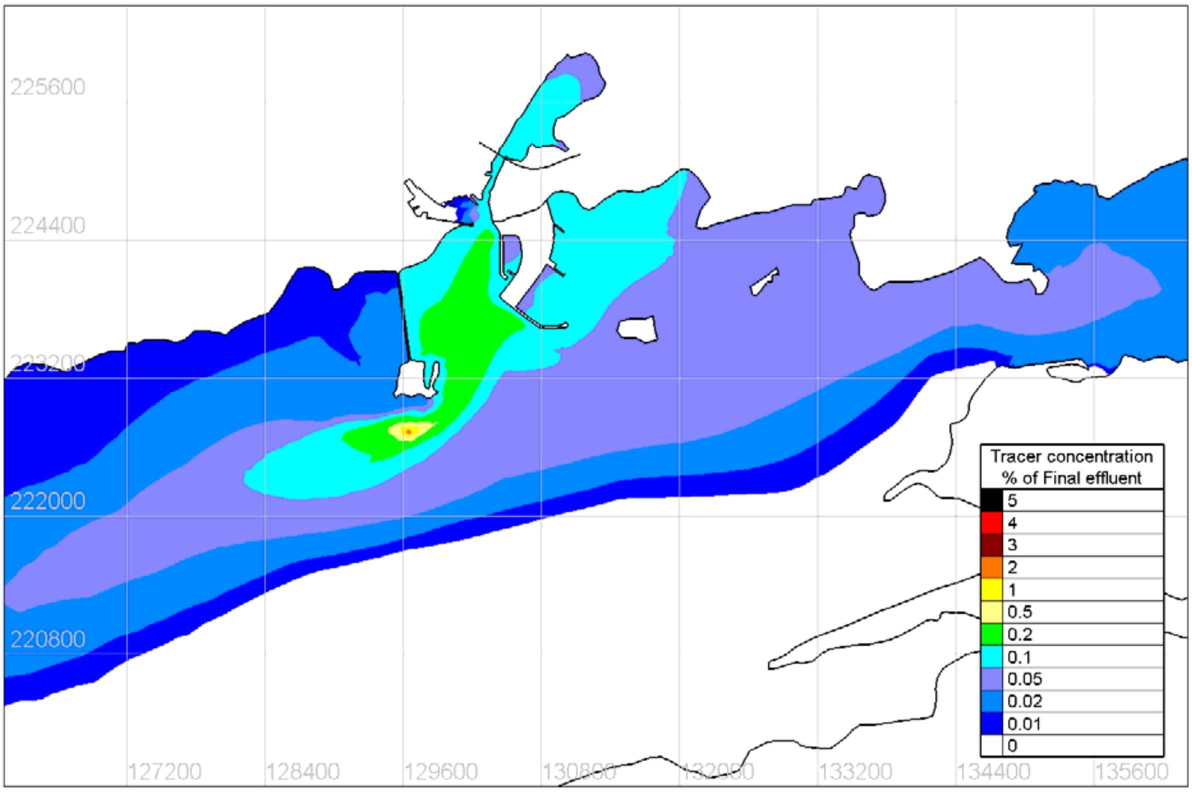


Figure 4.8.26 Maximum surface concentration of Tracer under SW 15m/s wind conditions– Proposed

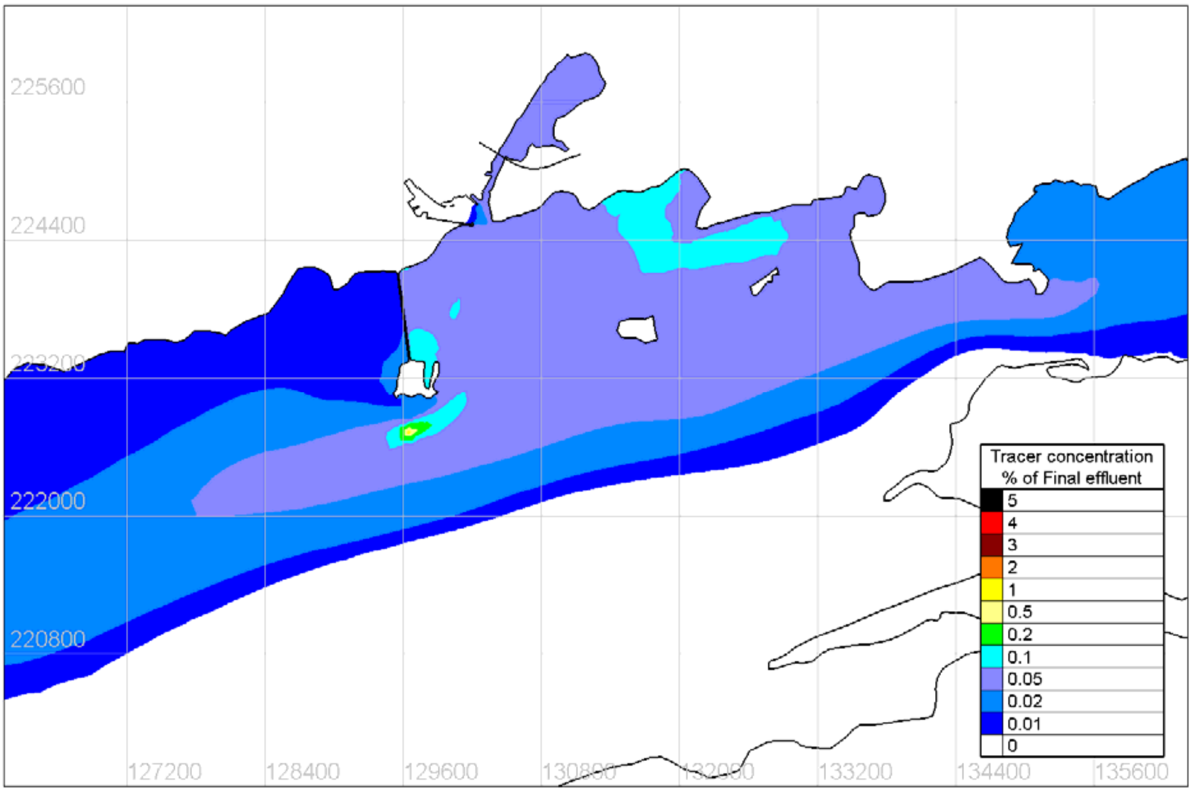


Figure 4.8.27 Tidal mean tracer concentration under SW 15m/s wind conditions – Existing Case

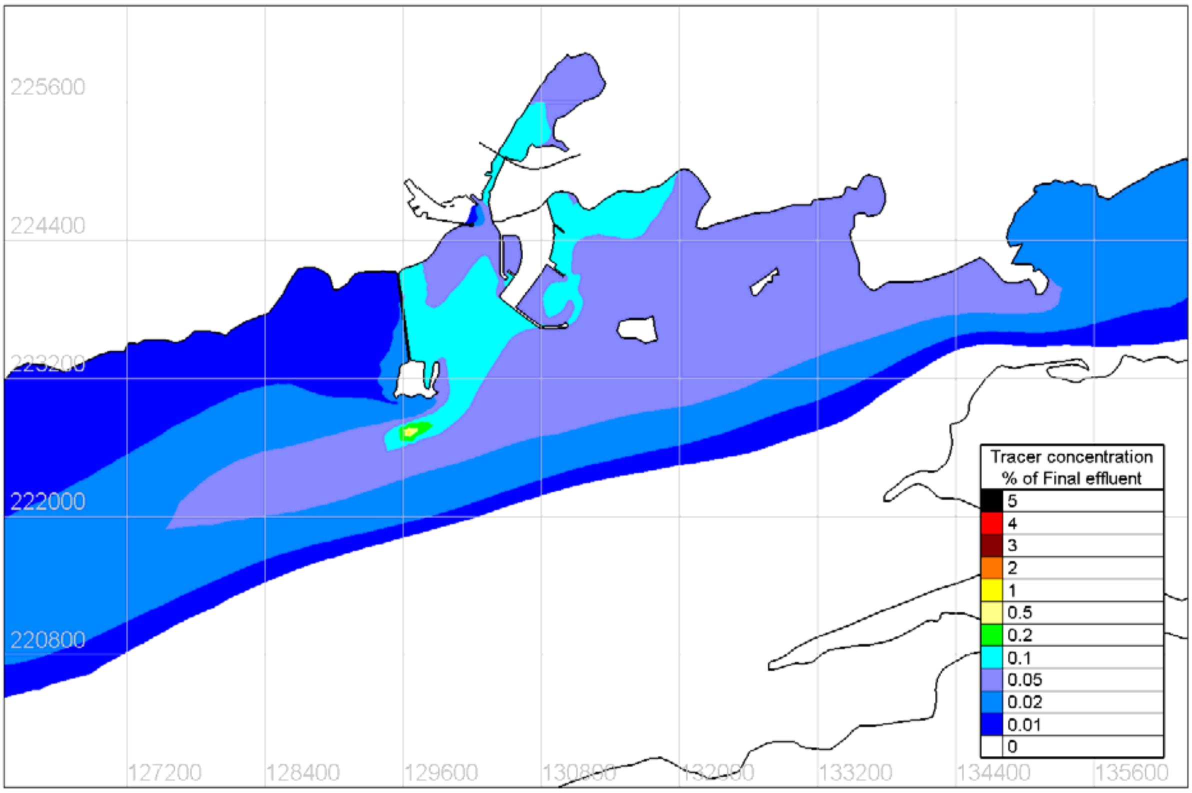


Figure 4.8.28 Tidal mean tracer concentration under SW 15m/s wind conditions – Proposed Case

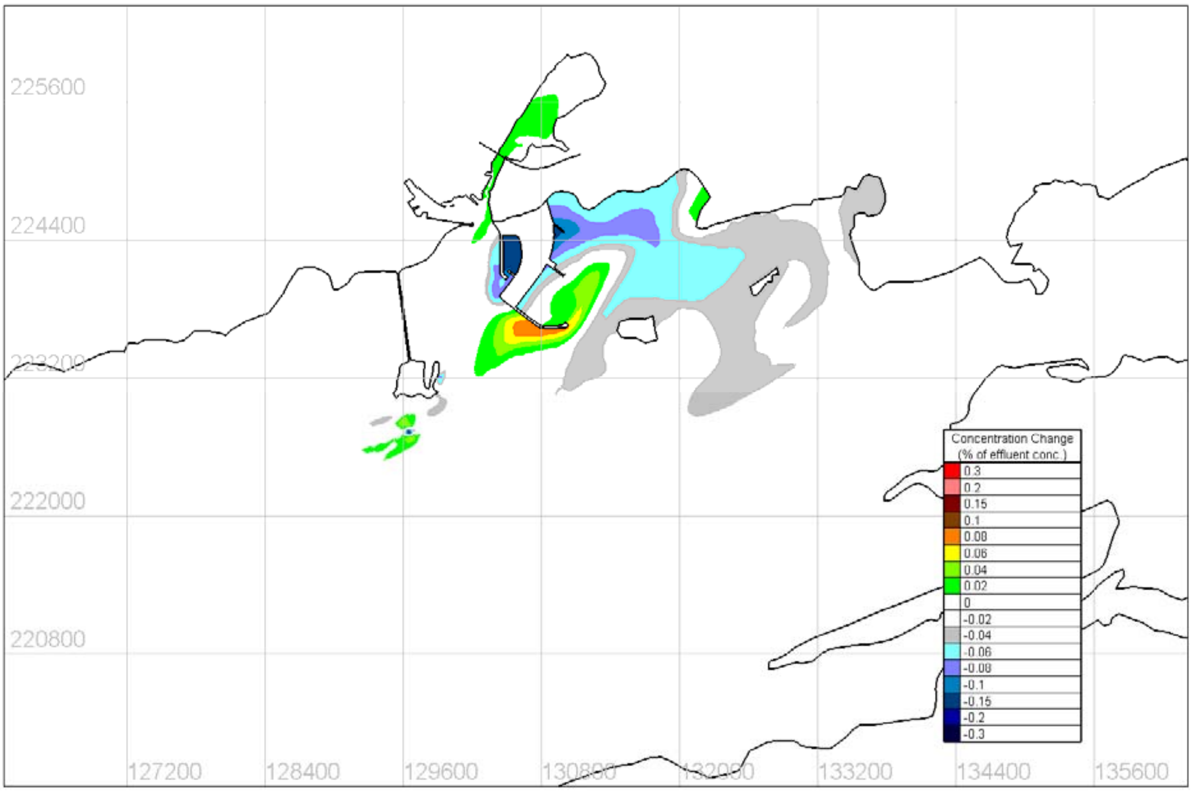


Figure 4.8.29 Predicted change in maximum surface tracer concentration – SW 15m/s Wind Conditions

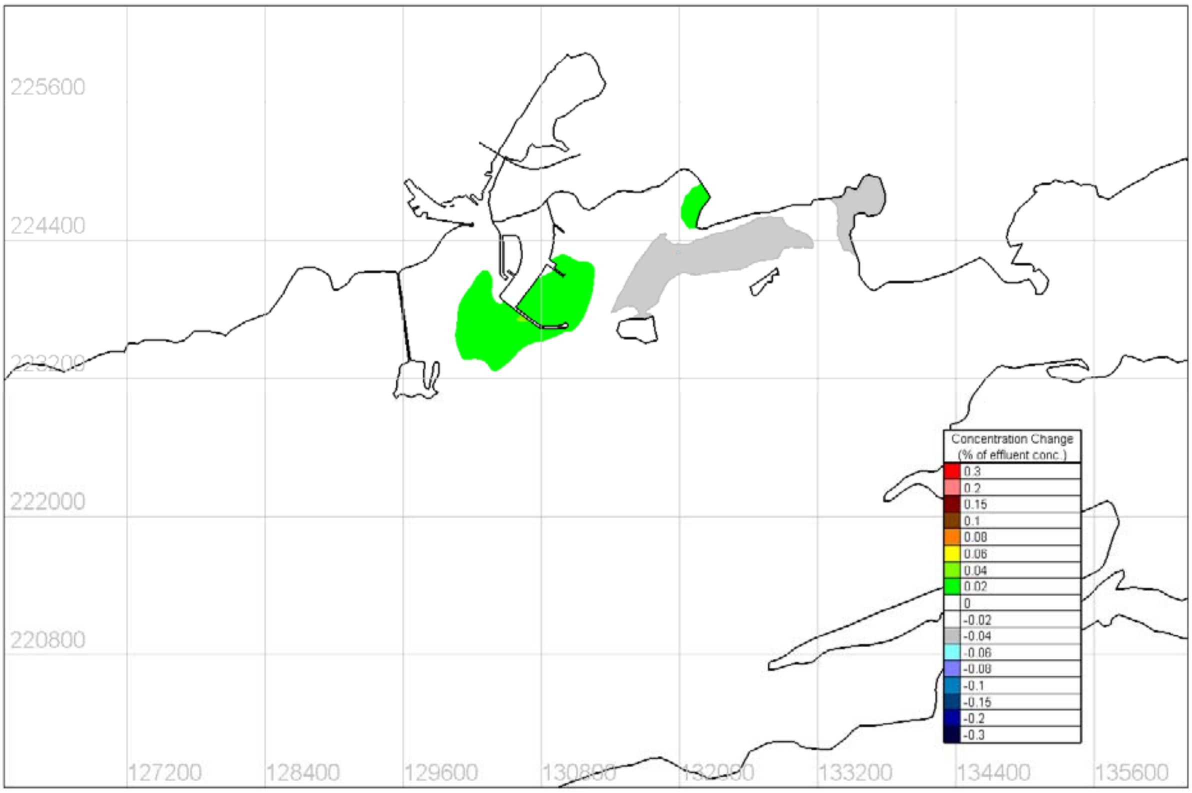


Figure 4.8.30 Predicted change in tidal mean tracer concentration – SW 15m/s Wind Condition

4.8.4.6 Spring Tide and Corrib Low Flow with 15 m/s from SSW

Figure 4.8.31 to 4.8.36 presents the concentration plume and difference plots for 15m/s wind from SSW.

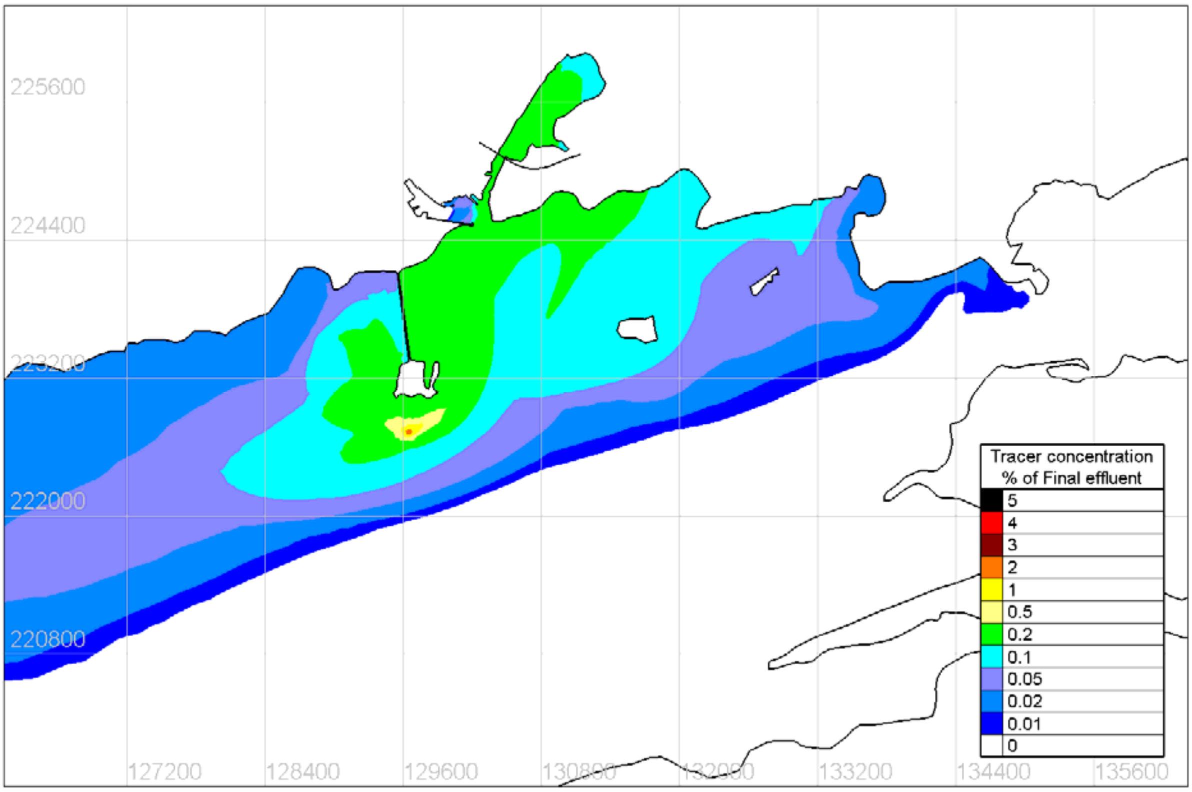


Figure 4.8.31 Maximum surface concentration of Tracer under SSW 15m/s wind conditions– Existing

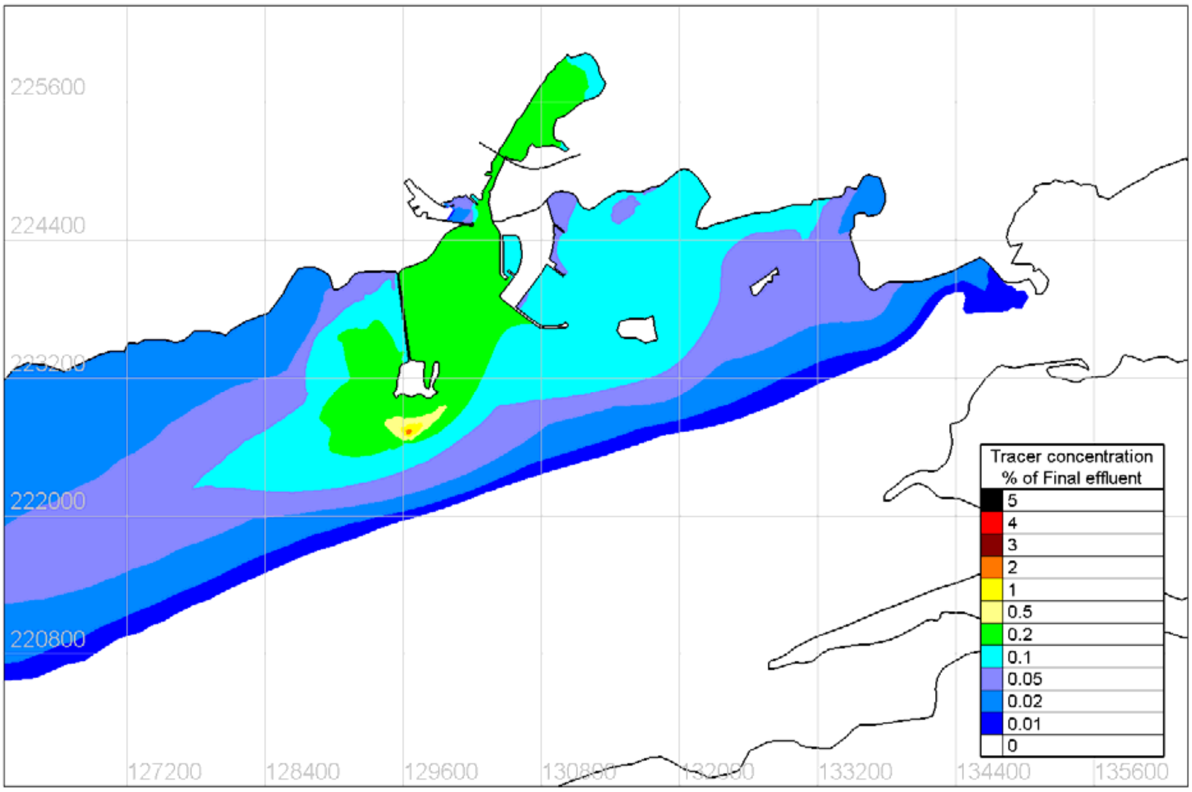


Figure 4.8.32 Maximum surface concentration of Tracer under SSW 15m/s wind conditions– Proposed

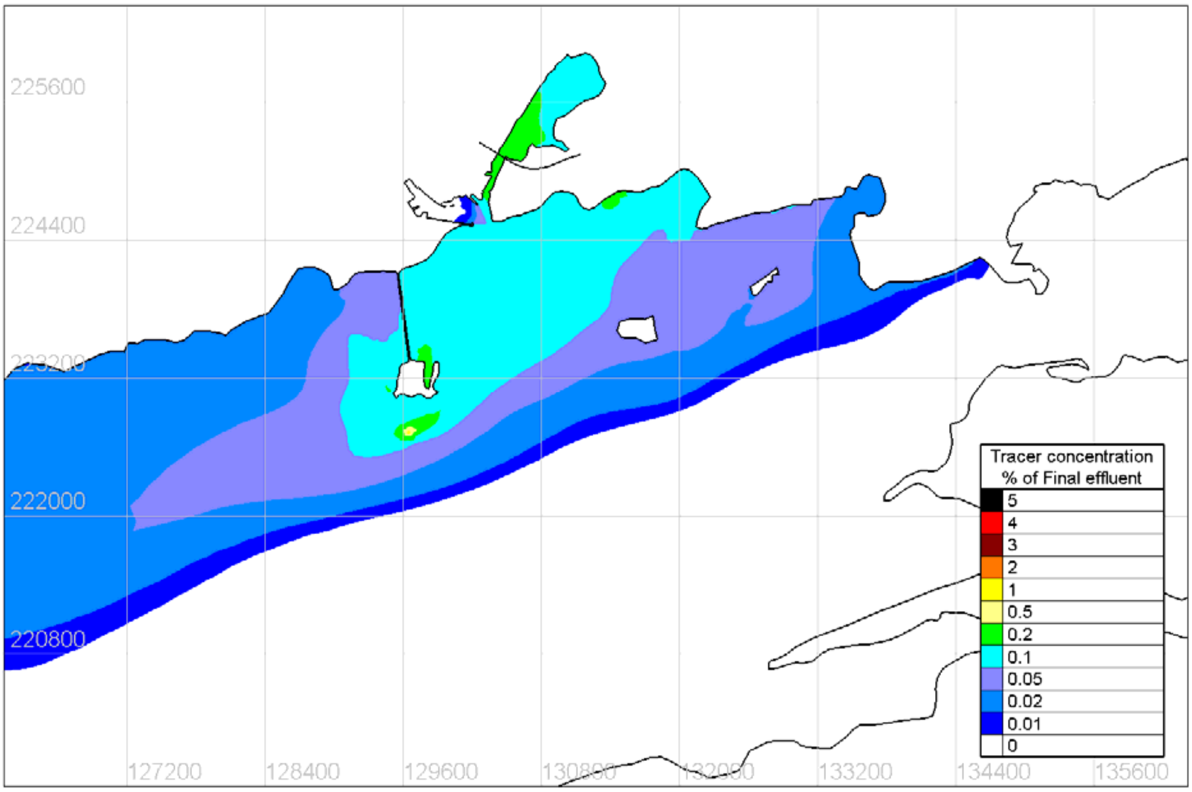


Figure 4.8.33 Tidal mean tracer concentration under SSW 15m/s wind conditions – Existing Case

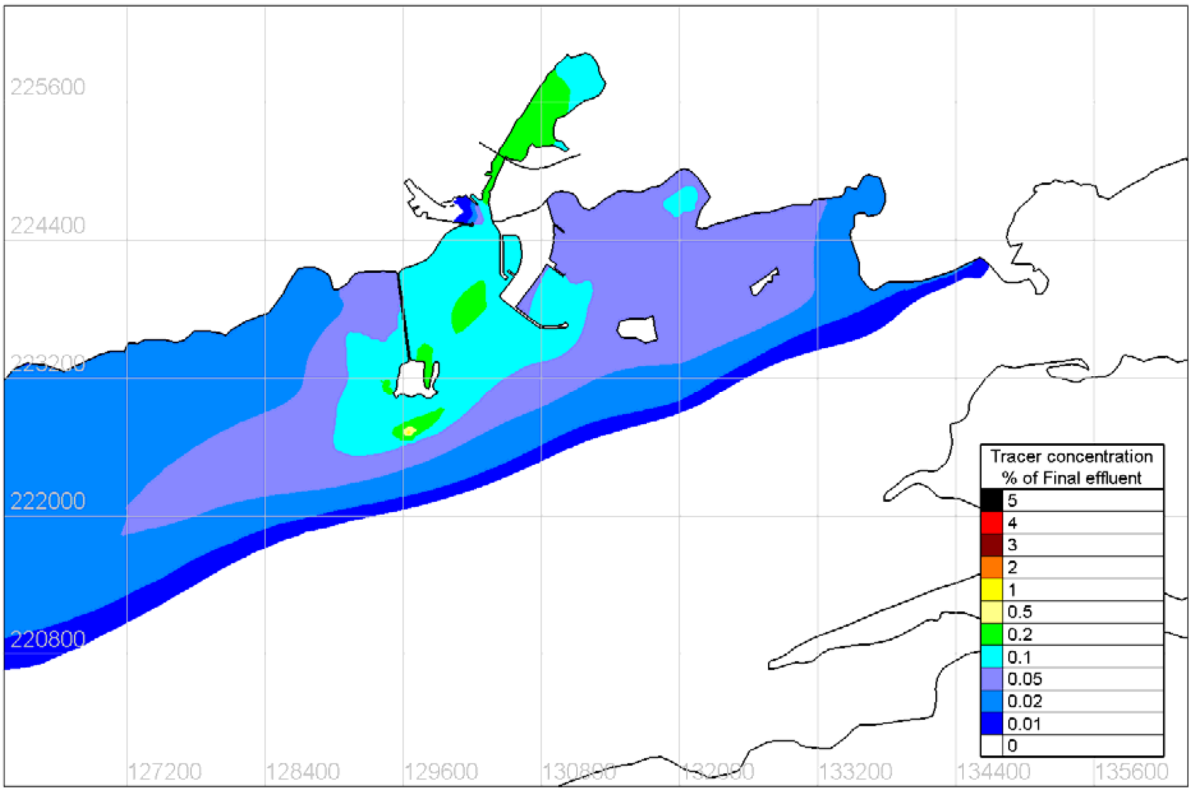


Figure 4.8.34 Tidal mean tracer concentration under SSW 15m/s wind conditions – Proposed Case

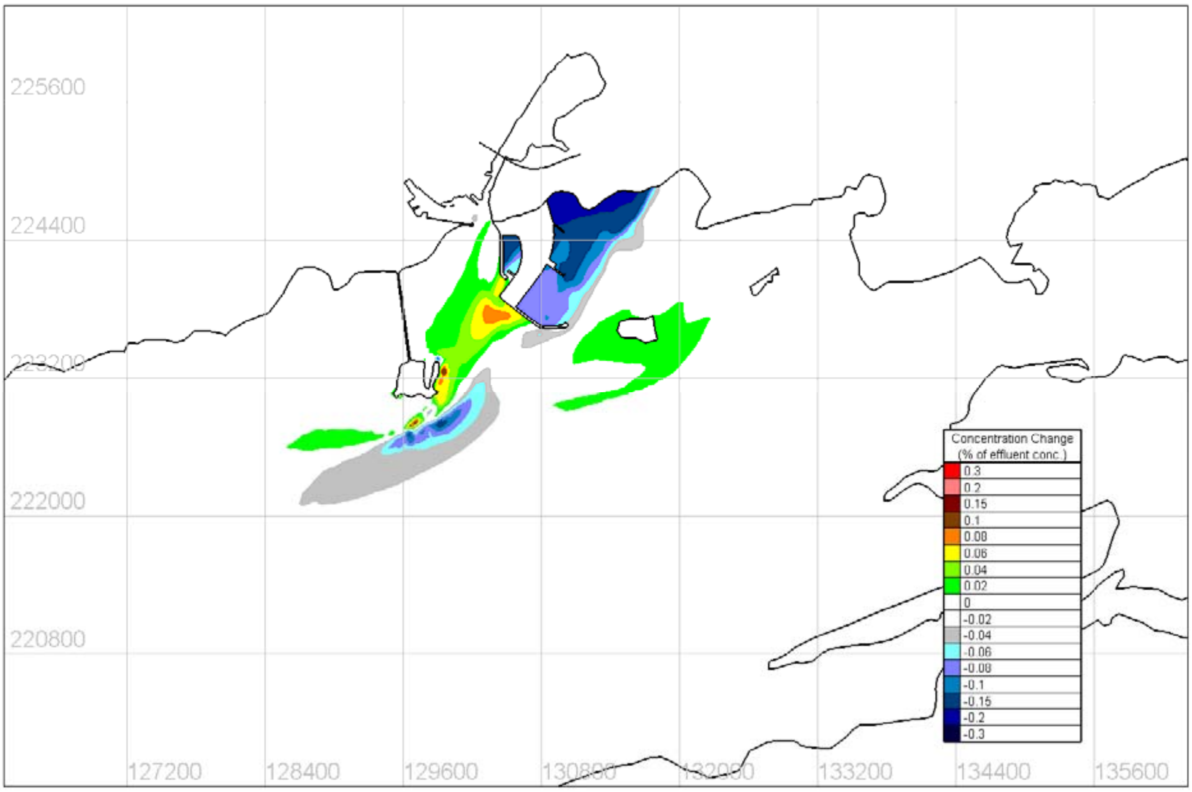


Figure 4.8.35 Predicted change in maximum surface tracer concentration – SSW 15m/s Wind Conditions

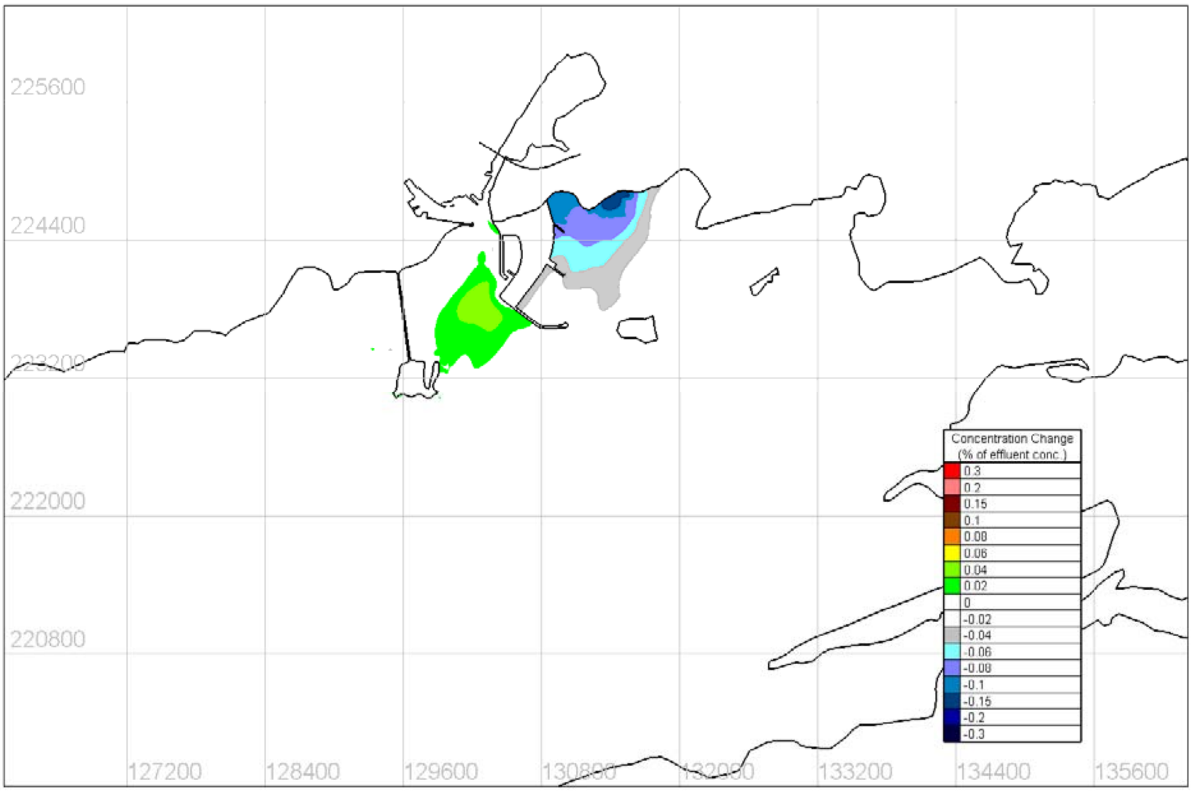


Figure 4.8.36 Predicted change in tidal mean tracer concentration – SSW 15m/s Wind Condition

4.8.4.7 Spring Tide and Corrib Low Flow with 5 m/s from South

Figure 4.8.37 to 4.8.42 presents the concentration plume and difference plots for 15m/s wind from South.

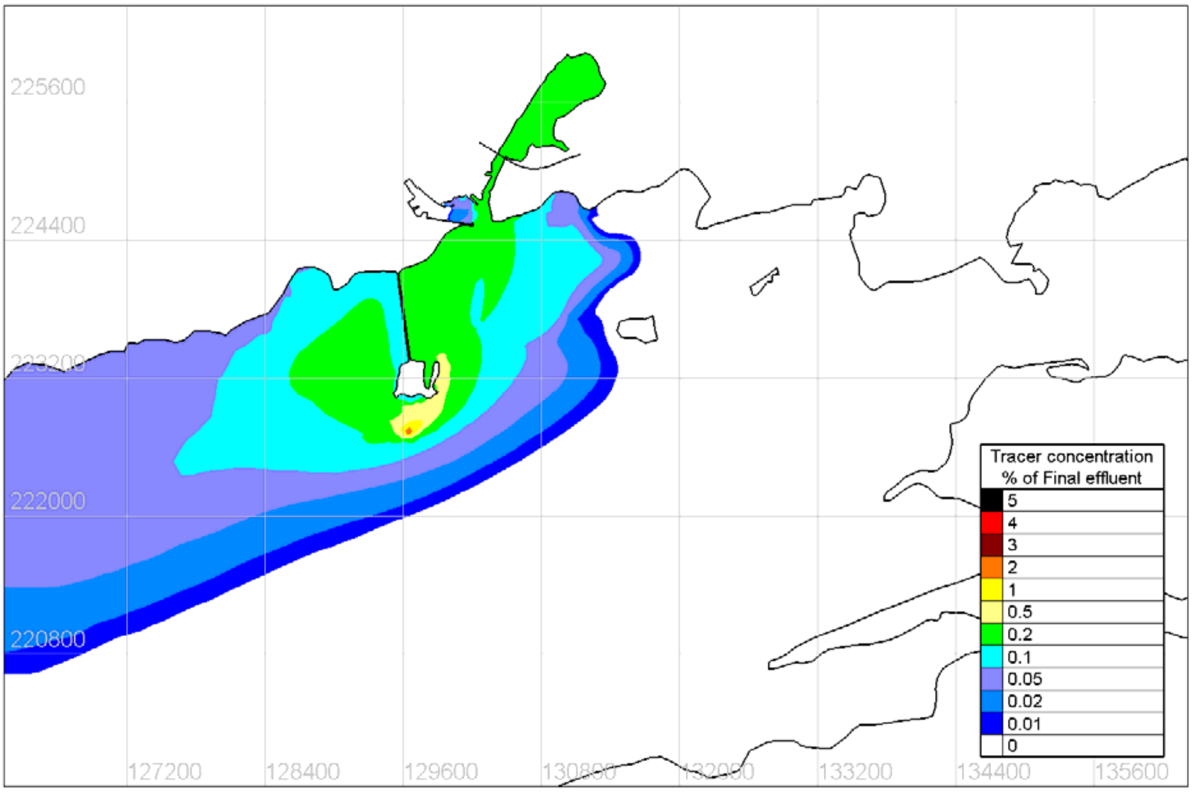


Figure 4.8.37 Maximum surface concentration of Tracer under S 15m/s wind conditions– Existing

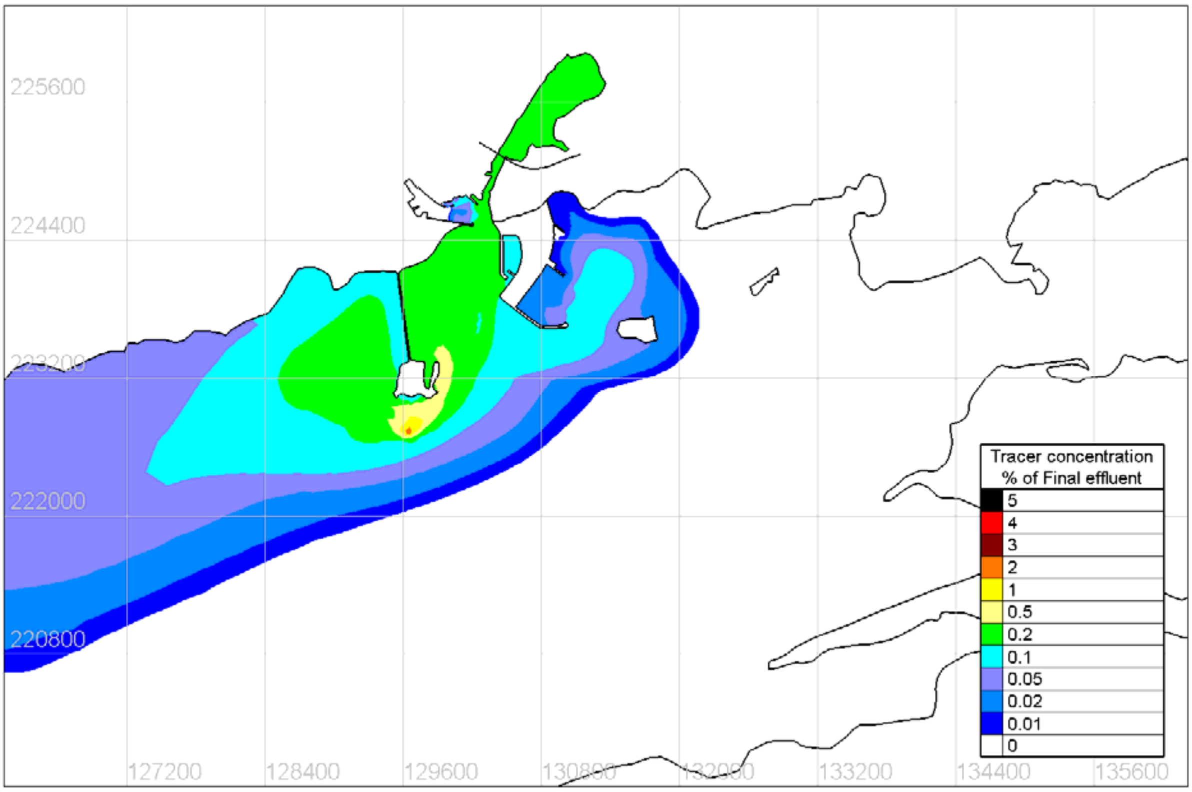


Figure 4.8.38 Maximum surface concentration of Tracer under S 15m/s wind conditions– Proposed

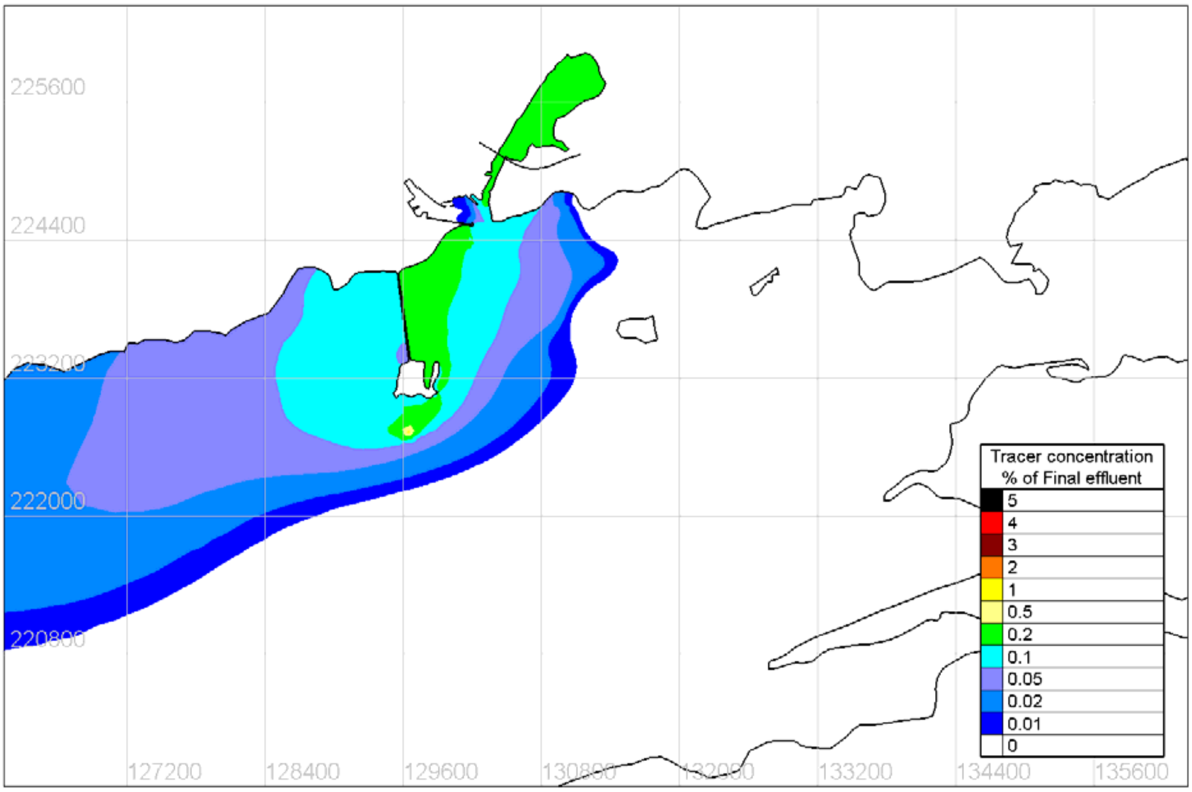


Figure 4.8.39 Tidal mean tracer concentration under S 15m/s wind conditions – Existing Case

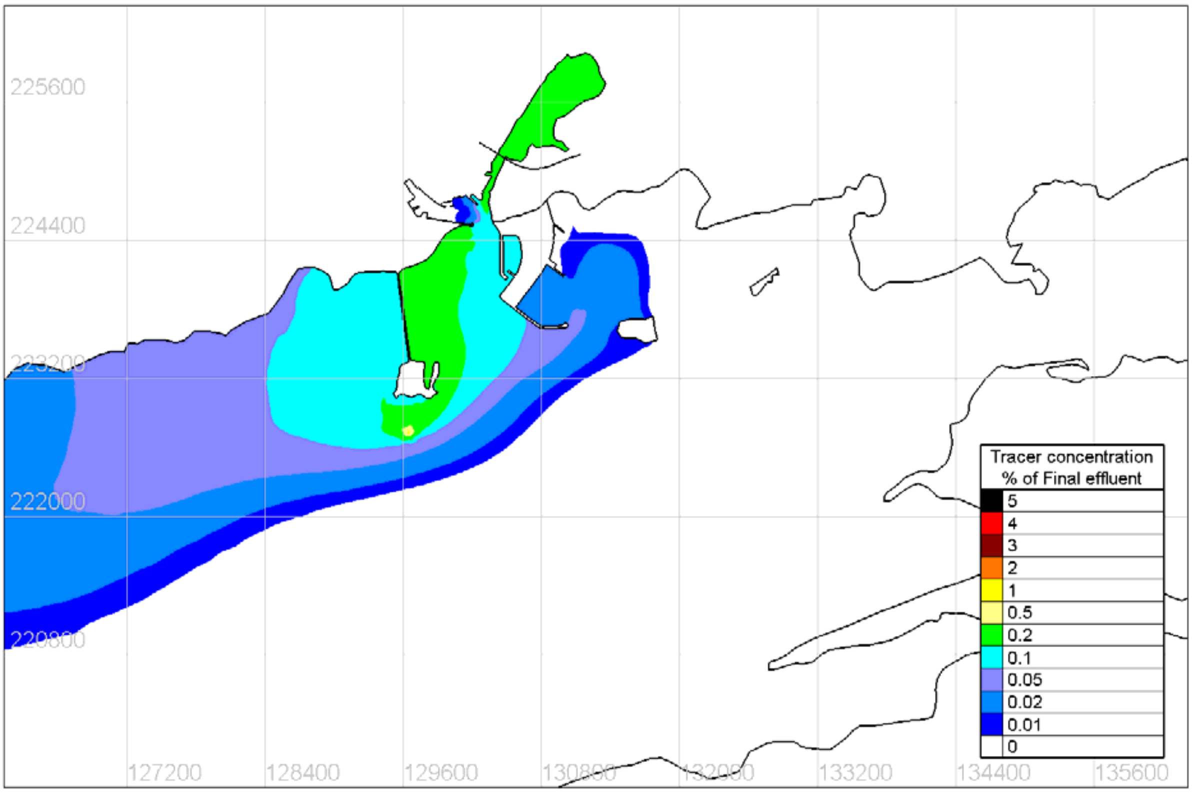


Figure 4.8.40 Tidal mean tracer concentration under S 15m/s wind conditions – Proposed Case

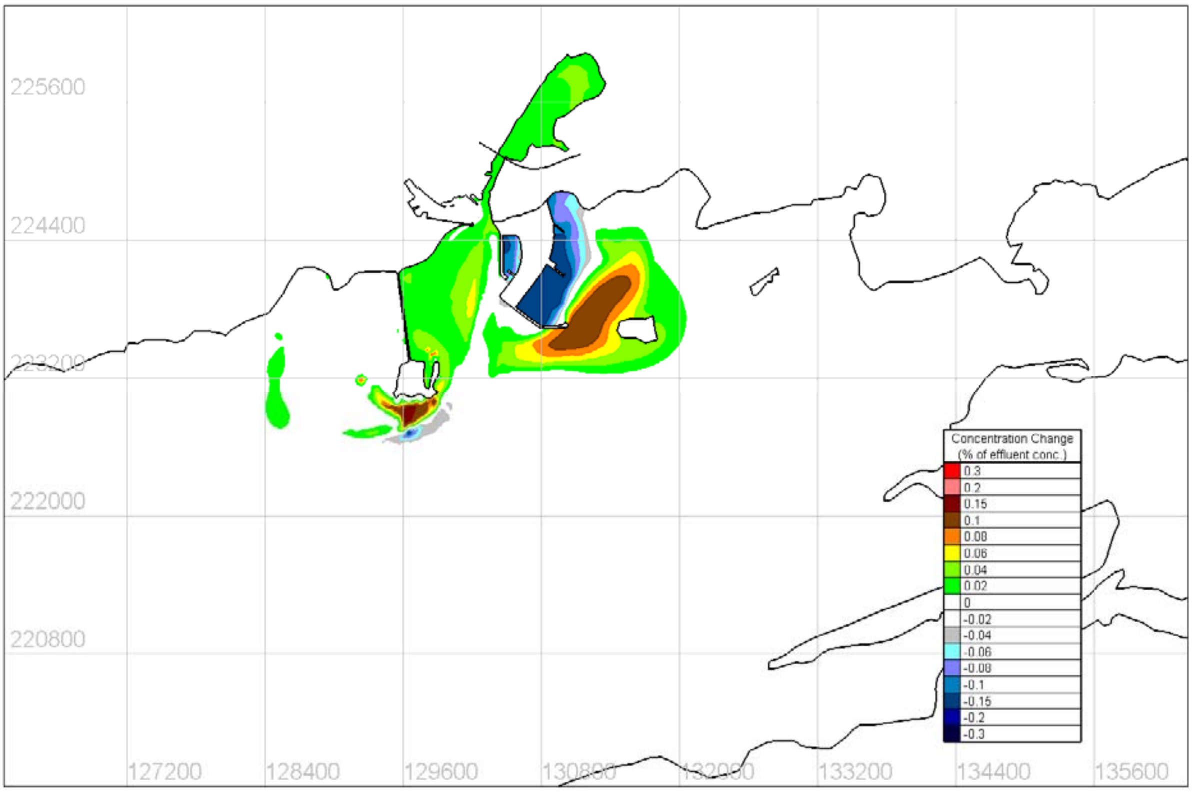


Figure 4.8.41 Predicted change in maximum surface tracer concentration – S 15m/s Wind Conditions

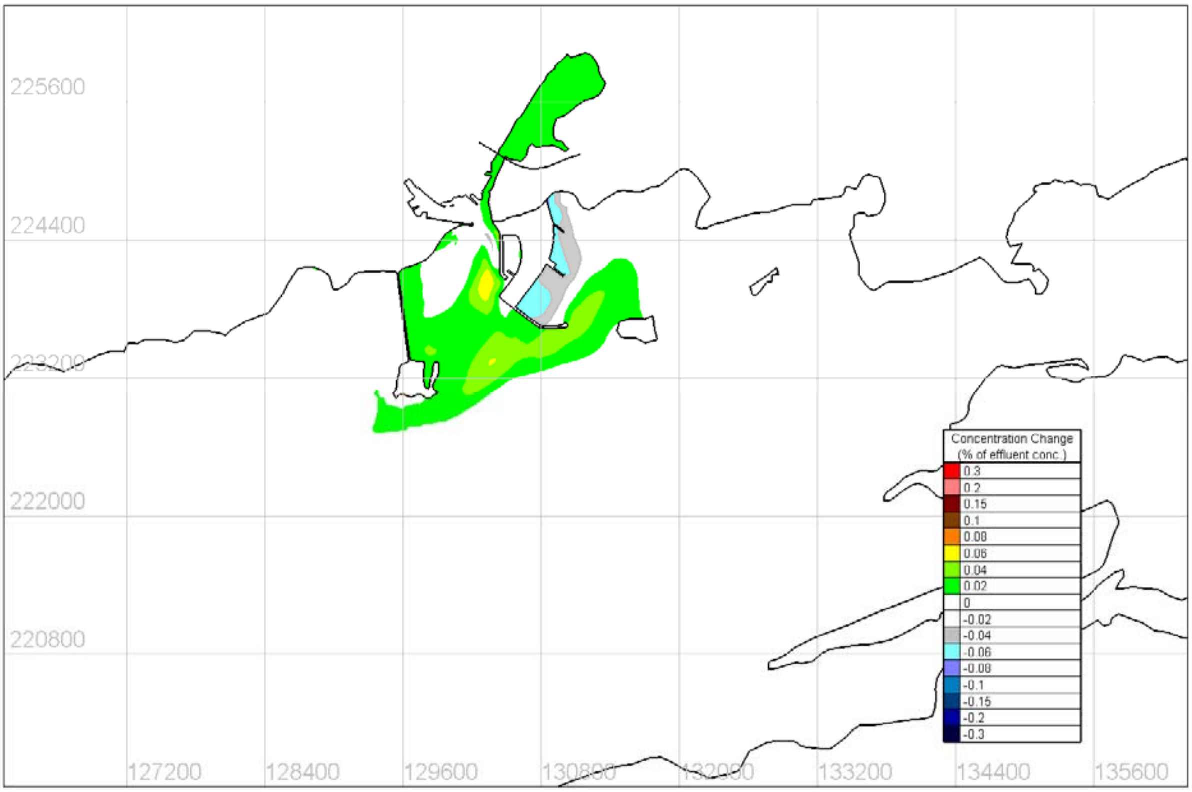


Figure 4.8.42 Predicted change in tidal mean tracer concentration – S 15m/s Wind Condition

4.8.5 Discussion Mutton Island Outfall

4.8.5.1 Conservative Tracer

Hydrodynamic Simulations of a conservative tracer were carried out for 7 different hydrodynamic / wind conditions for the Licensed Mutton Island Discharge. A comparison between the existing and proposed cases shows changes in the Plume pattern in the vicinity of Mutton Island and the Harbour development due directly to changes in the tidal circulation pattern caused by the harbour structure and navigational channels.

Under calmer wind conditions including the 5m/s wind simulations the model results show a slight increase in pollutant concentration of between 0.05% and 0.1% of the effluent concentration to the north of the outfall. The locations of increase are north of the outfall and east of Mutton Island, the Corrib entrance and Lough Atalia and along the Renmore Shoreline area to the East of the New Harbour. Areas of reduction in pollutant concentration are shown to the south of the outfall and in the immediate vicinity of the Harbour development, within the slacker water areas.

The largest predicted changes in concentration are immediately to the north of the outfall on the flooding tide where the plume trajectory under the proposed case takes a sharper more northerly route on the flooding tide. Corresponding reduction in concentrations are shown to the south of the outfall due to this northerly shift in the plume trajectory.

Under stronger wind conditions there are generally more similar plume paths and mixing at the outfall site and thus showing little change in pollutant concentrations. Under these stronger onshore wind conditions greater plume transport for both proposed and existing cases pushes the plume northwards into Lough Atalia and along Renmore Beach. However the relative change in pollutant concentration is small at generally less than 0.05 % between proposed and existing cases.

Immediately at the outfall site increases of up to 0.5% of effluent concentration for the proposed development case are predicted and generally less than 0.15% at the Corrib entrance and 0.1 to 0.15% to the east of the Harbour development. Within Lough Atalia the predicted maximum increase is less than 0.1% and the mean increase is typically less than 0.05%. Along the Renmore shoreline the maximum increase is less than 0.1%. Refer to Table 8.2 below as a guide for converting change in percentage values to mg/l (or cfu/100ml).

Pollutant	Mutton Island WWTP Final effluent concentration
Faecal Coliforms	**300,000 cfu/100ml**
BOD	**25 mg/l O_2**
Ammonia	**22.5mg/l as n**
Suspended Solids	**35mg/l**
Total Oxidised Nitrogen	**20mg/l**

Table 4.8.1 Final Effluent Quality for Mutton Island outfall

In terms of the above chemical parameters the predicted maximum percentage change resulting from the Harbour development is minor in terms of the respective concentrations and water quality standards and will not have a perceptible impact on the salmonid waters of the Corrib or on the water quality within Lough Atalia Lagoonal Water Body, prior to the application of a dilution factor at the diffused outfall.

Pollutant Chemical parameter	Effluent Concentration	Percentage Change			
		0.05%	0.1%	0.15%	0.5%
		Change in Concentration (mg/l)			
BOD	25 mg/l O_2	0.0125	0.025	0.0375	0.125
Ammonia	22.5mg/l as n	0.0113	0.0225	0.0338	0.1125
Suspended Solids	35mg/l	0.0175	0.035	0.0525	0.175
Total Oxidised Nitrogen	20mg/l	0.010	0.020	0.030	0.100

Table 4.8.2 Pollutant Concentration based on percentage change in effluent concentration

4.8.5.2 Faecal Coliforms

In respect to the bacteriological contaminants, such as faecal coliforms the conservative tracer simulations (i.e. do not include for die-off rates for faecal coliforms) show a potential impact to the Ballyloughaun beach area under the proposed development case. Typically the predicted maximum coliform numbers for the existing case under calm wind conditions are 300 cfu/100ml (i.e. 0.1% of 300,000 cfu/100ml final effluent) at Grattan Road Beach, 600 cfu / 100ml at Corrib entrance and 100cfu/ 100ml at Ballyloughaun Beach. The proposed case produces almost similar concentrations of 300 cfu at Grattan Rd Beach, 860 cfu/100ml at Corrib entrance (increase of 260 cfu/100ml) and 360 No/100ml at Ballyloughaun Beach (an increase of 260 cfu/100ml over the existing).

This predicted increase of 260 cfu/100ml faecal coliforms at Ballyloughaun Beach based on the conservative tracer simulation is significant in terms of Bathing Quality standards. Consideration of the simulation time series of faecal coliform concentration shows that the build-up at Ballyloughaun is over a number of days, which in reality is unlikely to occur given that T_{90} die-off rates are generally less than 12hours during summer periods and typically less than 24hours in winter periods.

To examine in more detail the potential impact from faecal coliforms specific dispersion model runs were carried out modelling a faecal coliform effluent concentration of 300,000 cfu/100ml with a low T90 die-off rate of 24hours (generally for bathing water studies higher die-off rates are used namely 90% die-off in 12hours as opposed to 24hours) and a dwf discharge rate of 0.3542 No./100ml.

Hydrodynamic simulation runs modelling calm wind conditions and an adverse 15m/s SSW wind were carried out for the existing and proposed cases. The simulation results in terms of predicted maximum concentrations and concentration change are presented in Figures 8.43 to 8.45 for the calm wind scenario and 8.46 to 8.48 for the SSW 15m/s wind.

These simulations with the T90 die-off rate of 24hours show significant reduction in coliform numbers over the conservative tracer simulation. The Simulation gives maximum predicted concentrations of 15, 130 and 1 cfu /100ml at Grattan Beach, Corrib entrance and Ballyloughaun Beach for the existing case under calm wind conditions and predicts maximum concentrations of 3, 451, and 43No./100ml under SSW 15m/s wind conditions. For the proposed case the simulation predicts maximum concentrations of 15, 227 and 10 cfu/100ml at Grattan Beach , at Corrib entrance and at Ballyloughaun Beach for Calm wind conditions and 3, 490and 36 cfu/100ml at the respective locations for SSW 15m/s wind condition.

If the Mutton Island outfall diffuser nearfield dilution is factored in, the above predicted concentrations would be significantly lower, pro rata for both the existing and proposed cases.

The magnitude of the predicted coliform concentrations at Grattan and Ballyloughaun beaches is small in terms of bathing waters standards (Blue Flag excellent quality class < 250 cfu/100ml at 95%ile) and therefore the small changes in water quality brought about by the proposed development will not impact on the water quality or bathing status of these waters or on the overall performance of the Mutton Island outfall.

4.8.5.2.1 Spring tide and Corrib low flow and Calm Wind Conditions – Faecal Coliforms

Figure 4.8.43 to 4.8.45 presents the maximum concentration plume and difference plots for calm wind conditions.

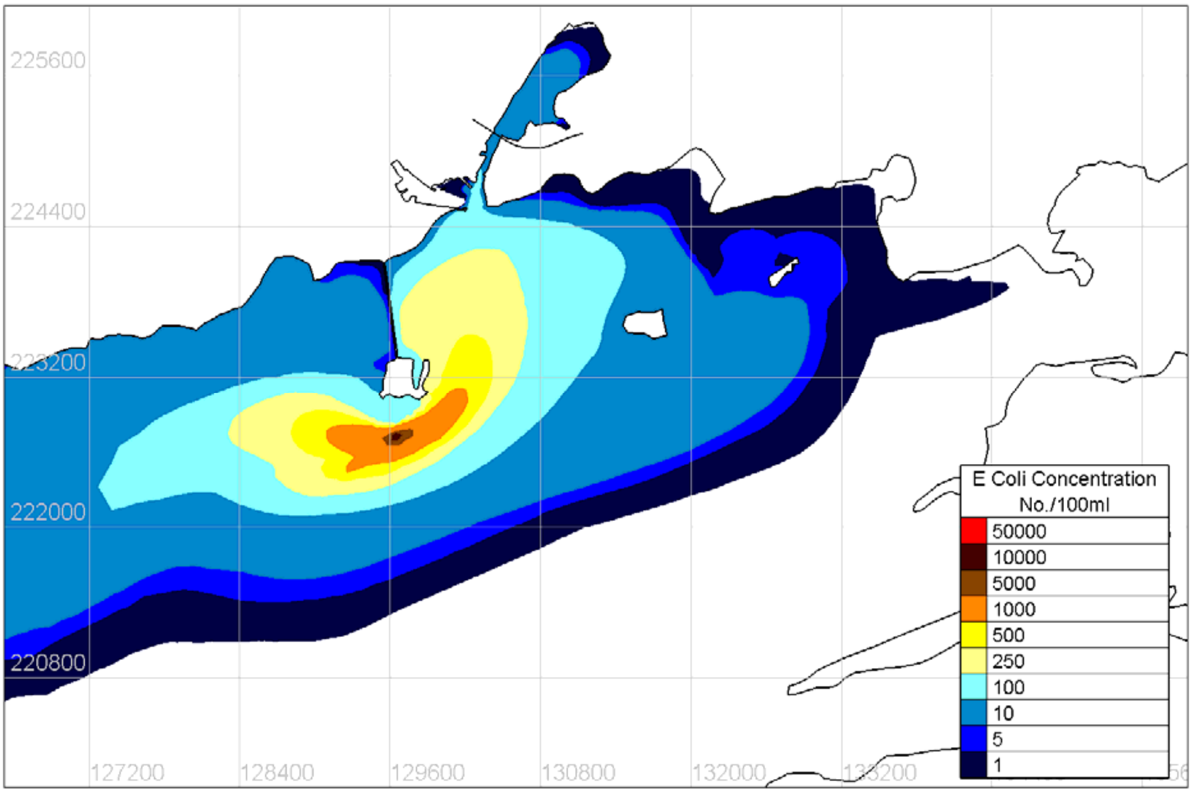


Figure 4.8.43Maximum faecal coliform surface concentration under Calm wind conditions– Existing

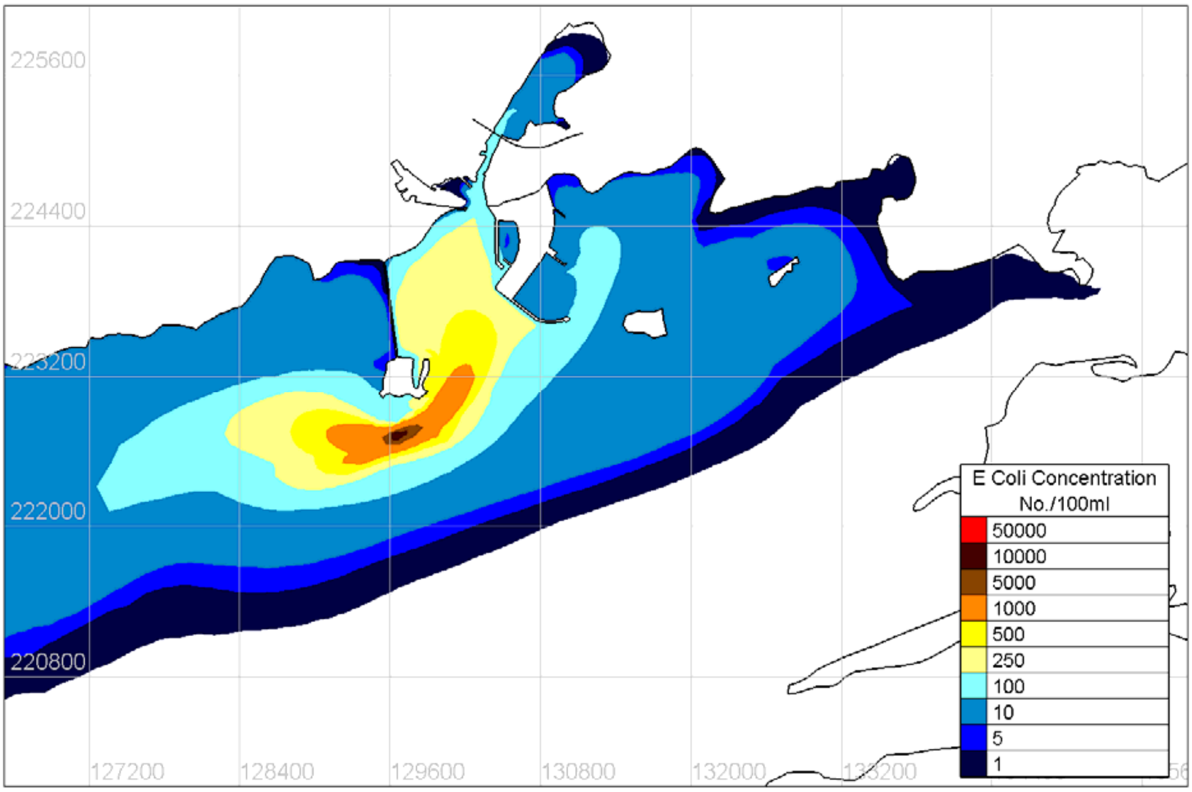


Figure 4.8.44 Maximum faecal coliform surface concentration under Calm wind conditions– Proposed

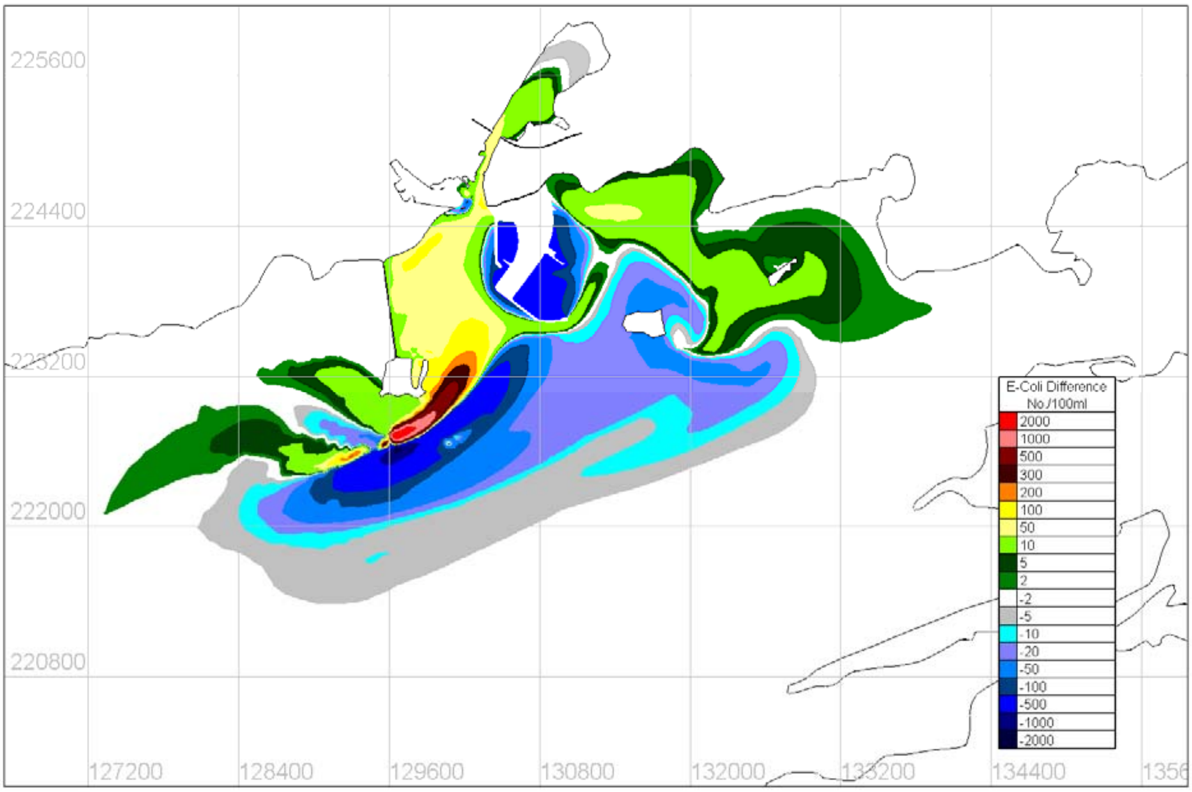


Figure 4.8.45 Predicted change in maximum faecal Coliform concentration – Calm Wind Conditions

4.8.5.2.2 Spring tide and Corrib low flow with SSW 15m/s Wind– Faecal Coliforms

Figure 4.8.46 to 4.8.48 presents the maximum concentration plume and difference plots for calm wind conditions.

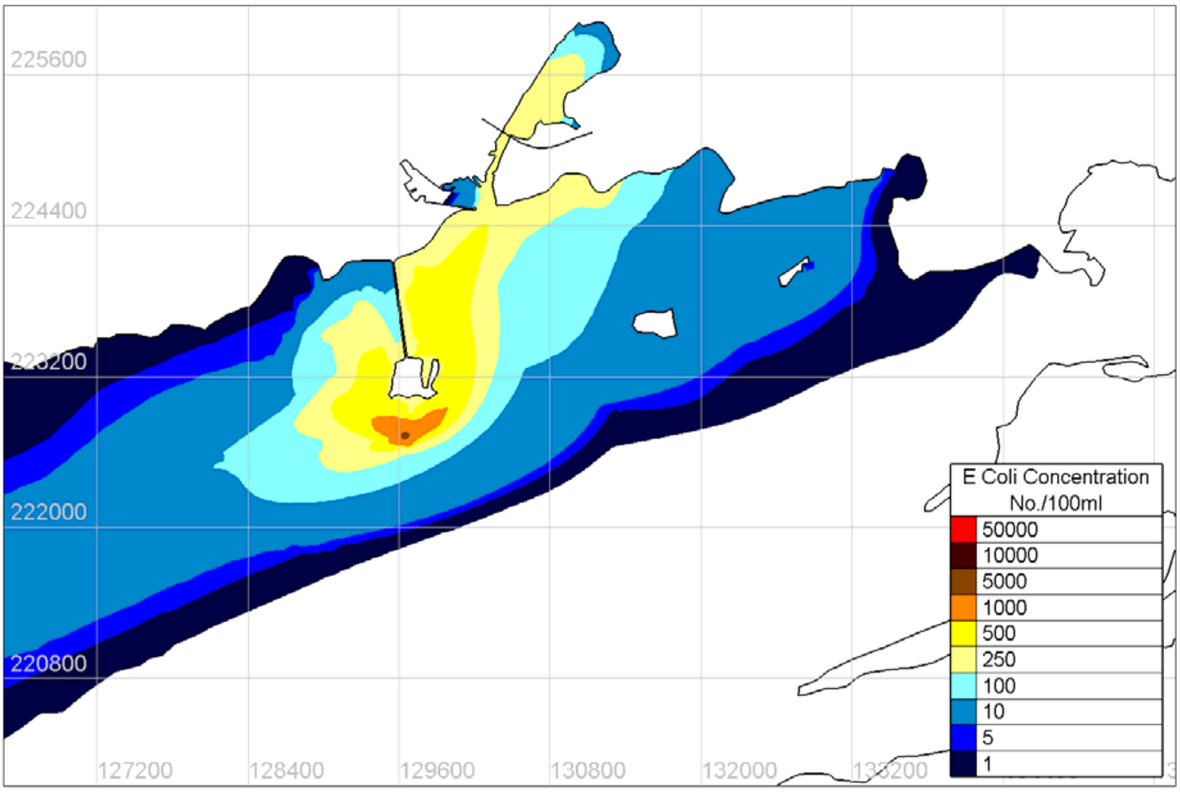


Figure 4.8.46 Maximum faecal coliform surface concentration of Tracer under SSW 15m/s wind conditions– Existing

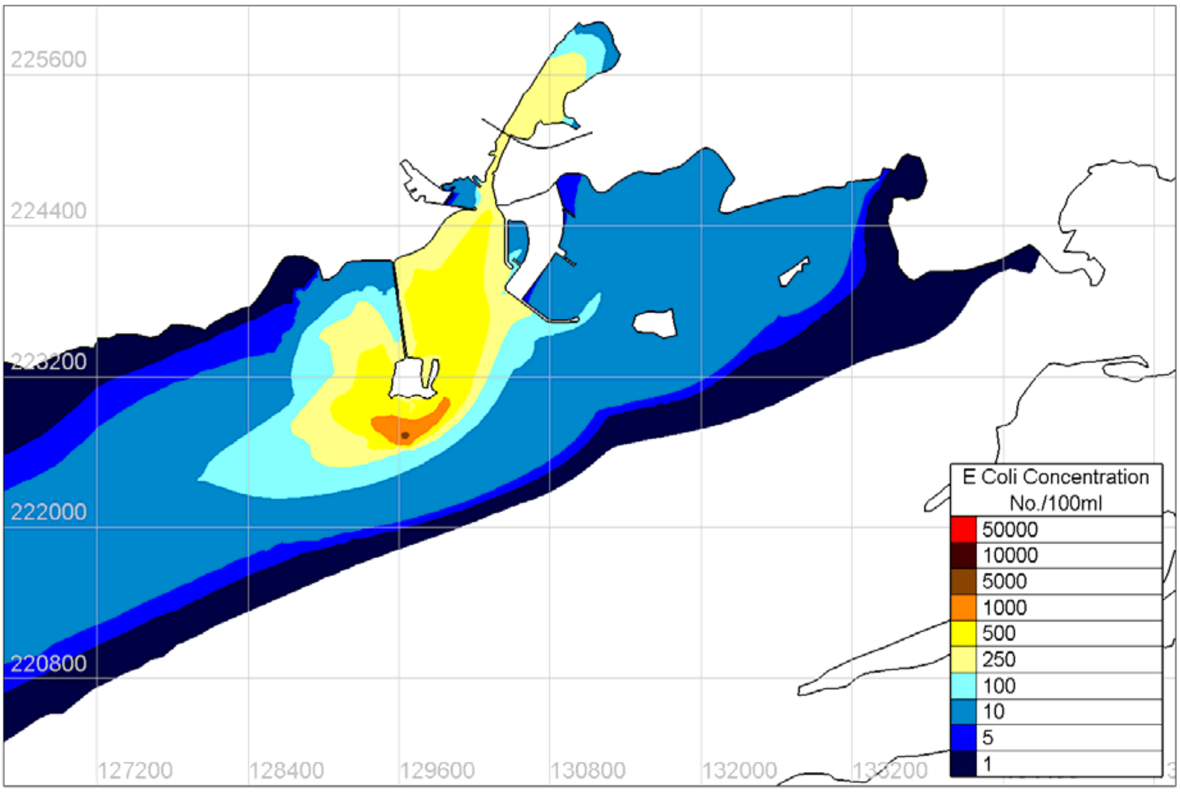


Figure 4.8.47 Maximum surface coliform concentration of Tracer under SSW 15m/s wind conditions– Proposed

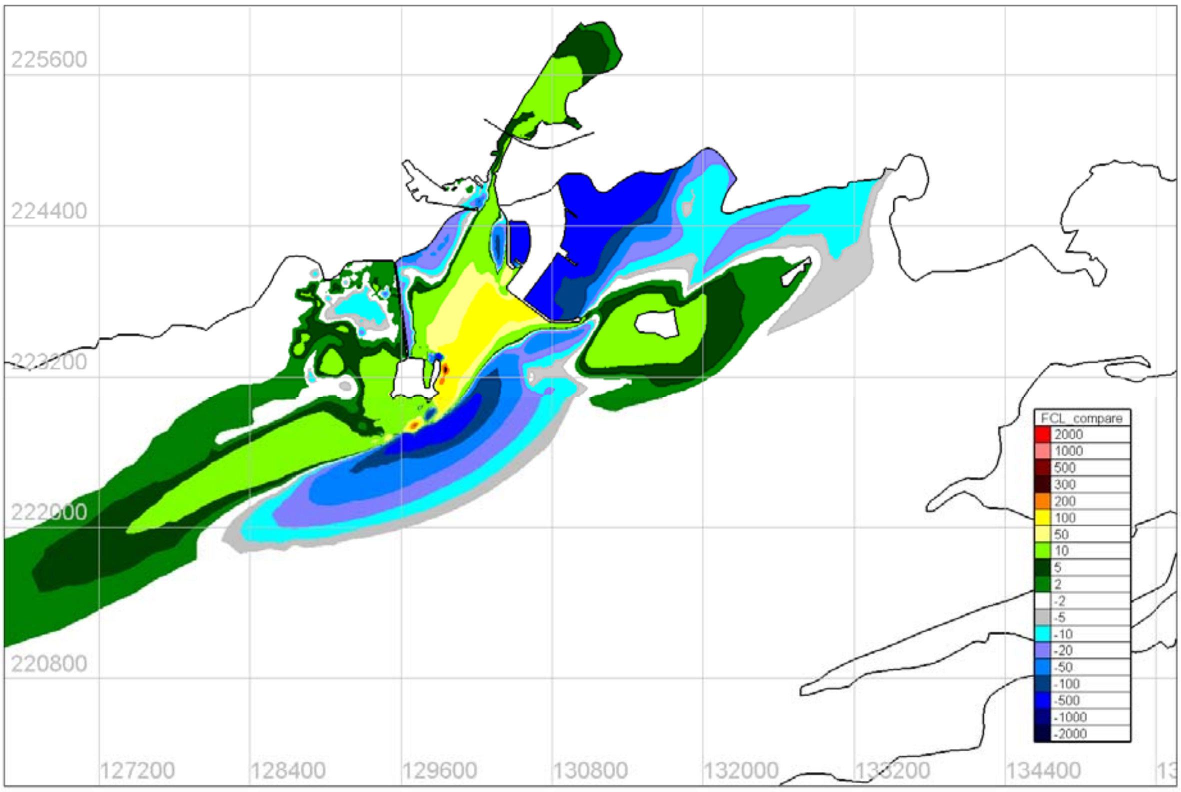


Figure 4.8.48 Predicted change in maximum surface tracer concentration – SSW Wind Conditions

4.8.6 Galway East Outfall Simulations

4.8.6.1 Spring tide and Corrib low flow and SW 15m/s Wind Condition

Figure 4.8.48 to 4.8.54 presents the concentration plume and difference plots for SW 15m/s wind conditions.

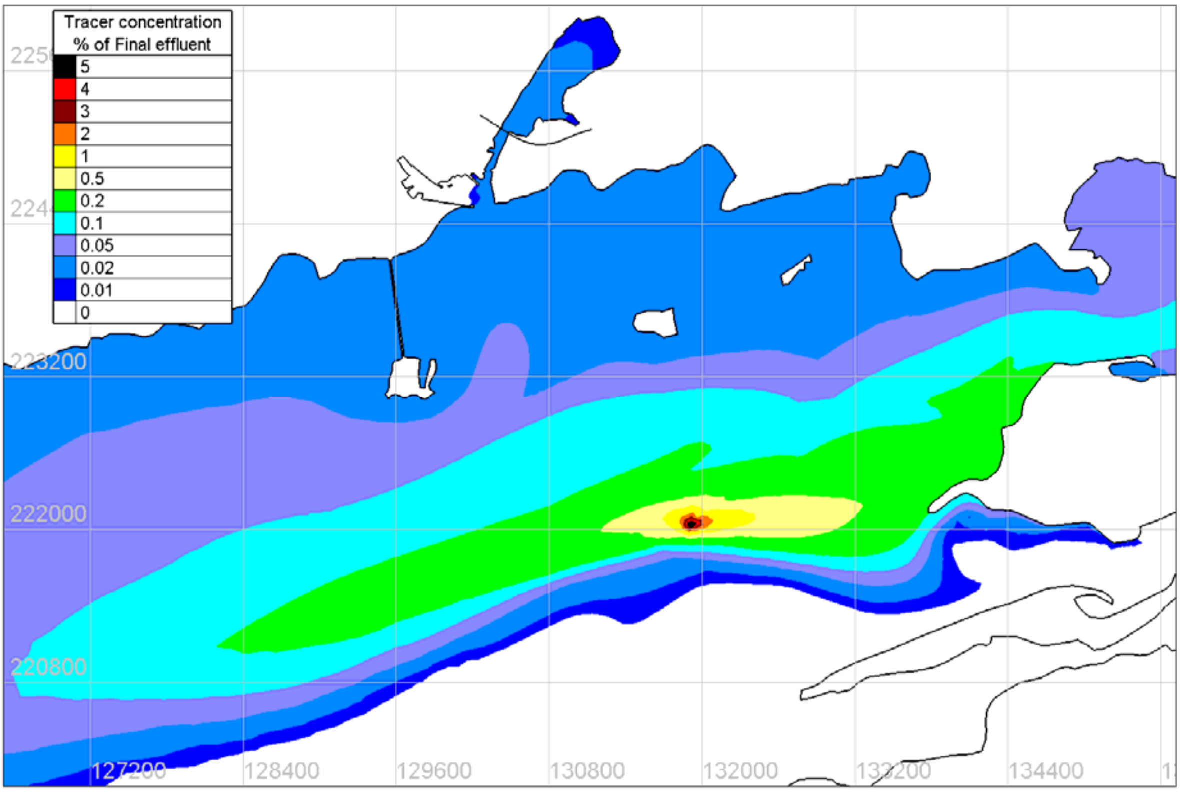


Figure 4.8.49 Maximum surface concentration of Tracer under SW 15m/s wind conditions– Existing

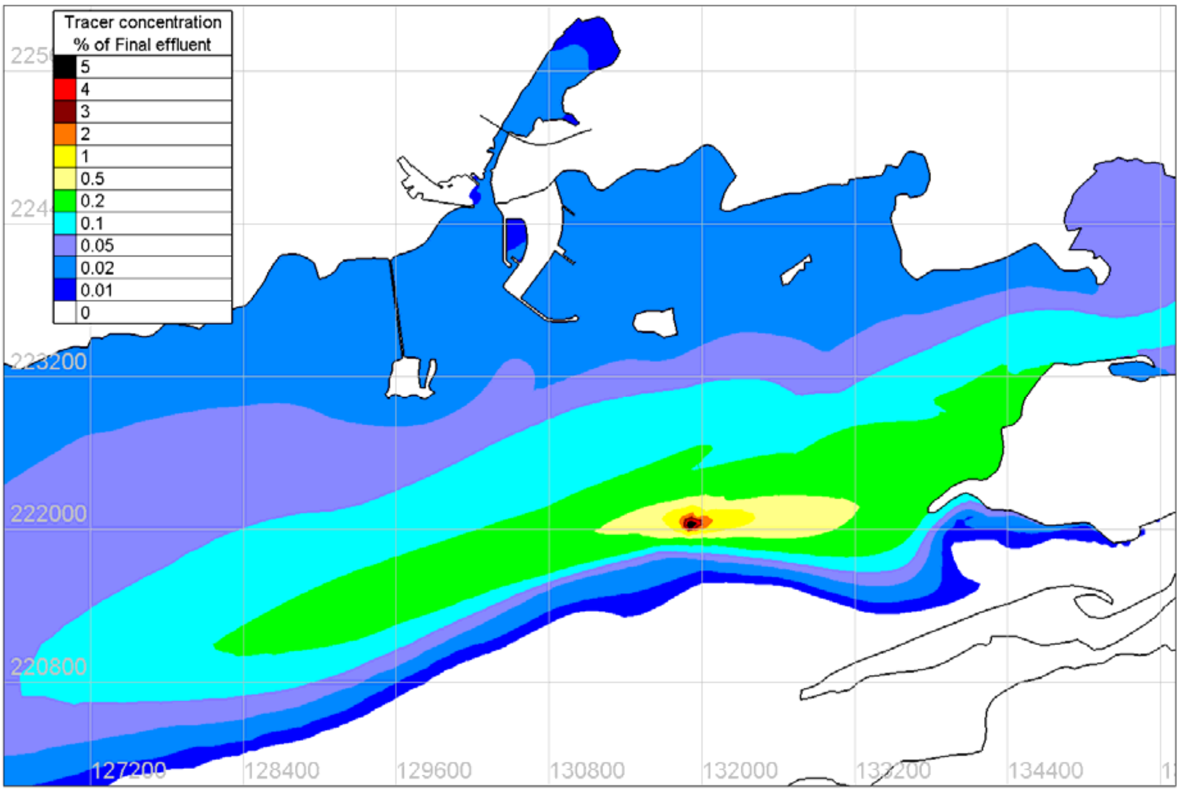


Figure 4.8.50 Maximum surface concentration of Tracer under SW 15m/s wind conditions– Proposed

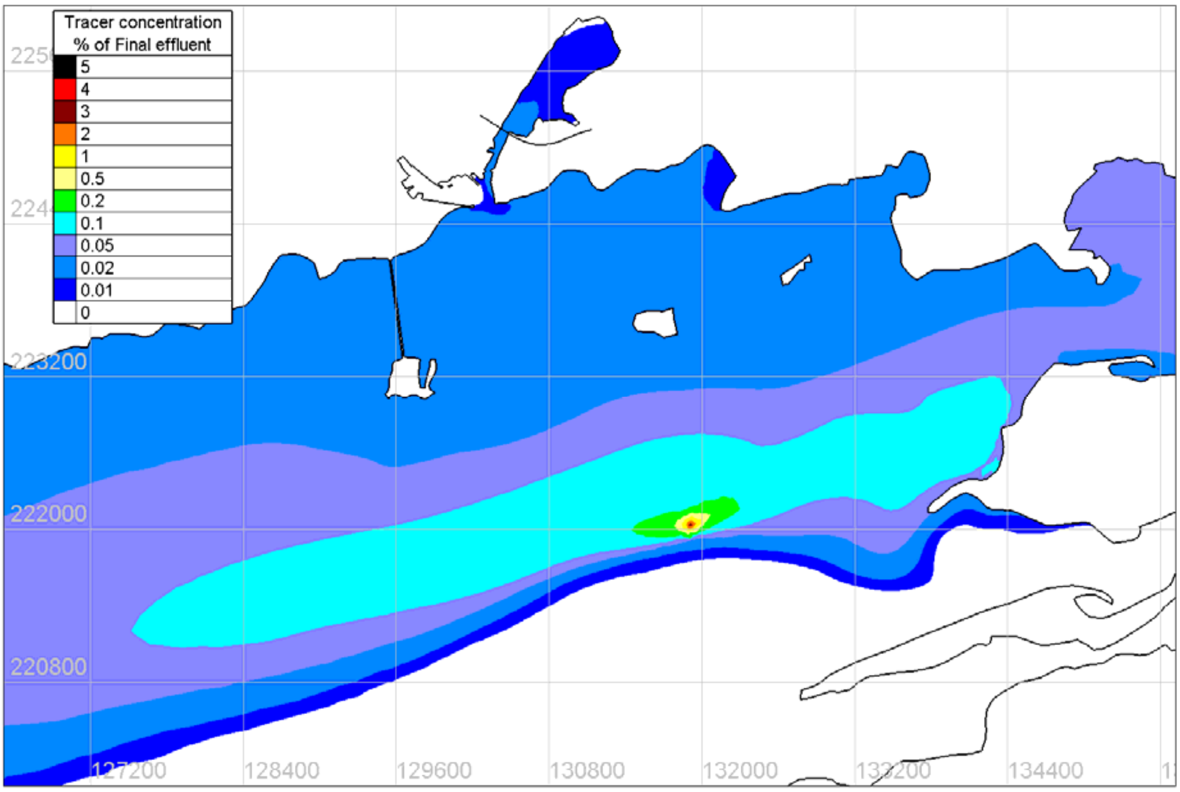


Figure 4.8.51 Tidal mean tracer concentration under SW 15m/s wind conditions – Existing Case

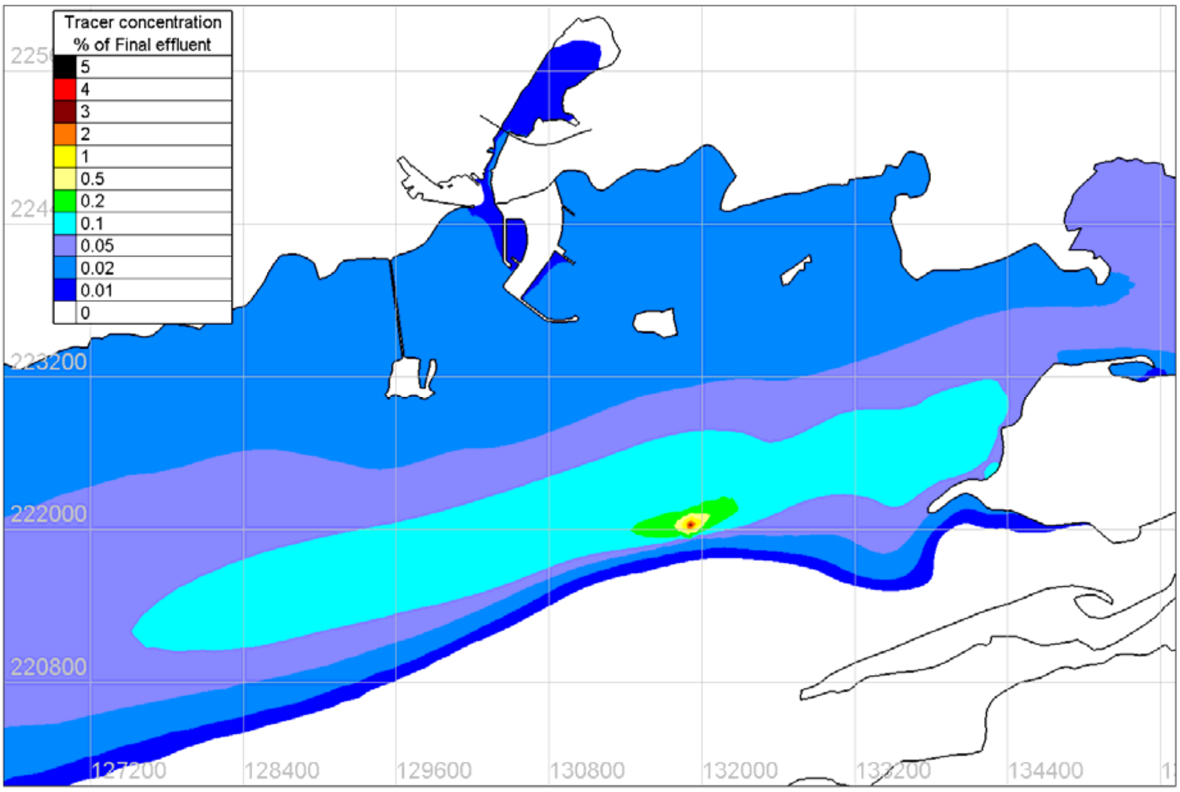


Figure 4.8.52 Tidal mean tracer concentration under SW 15m/s wind conditions – Proposed Case

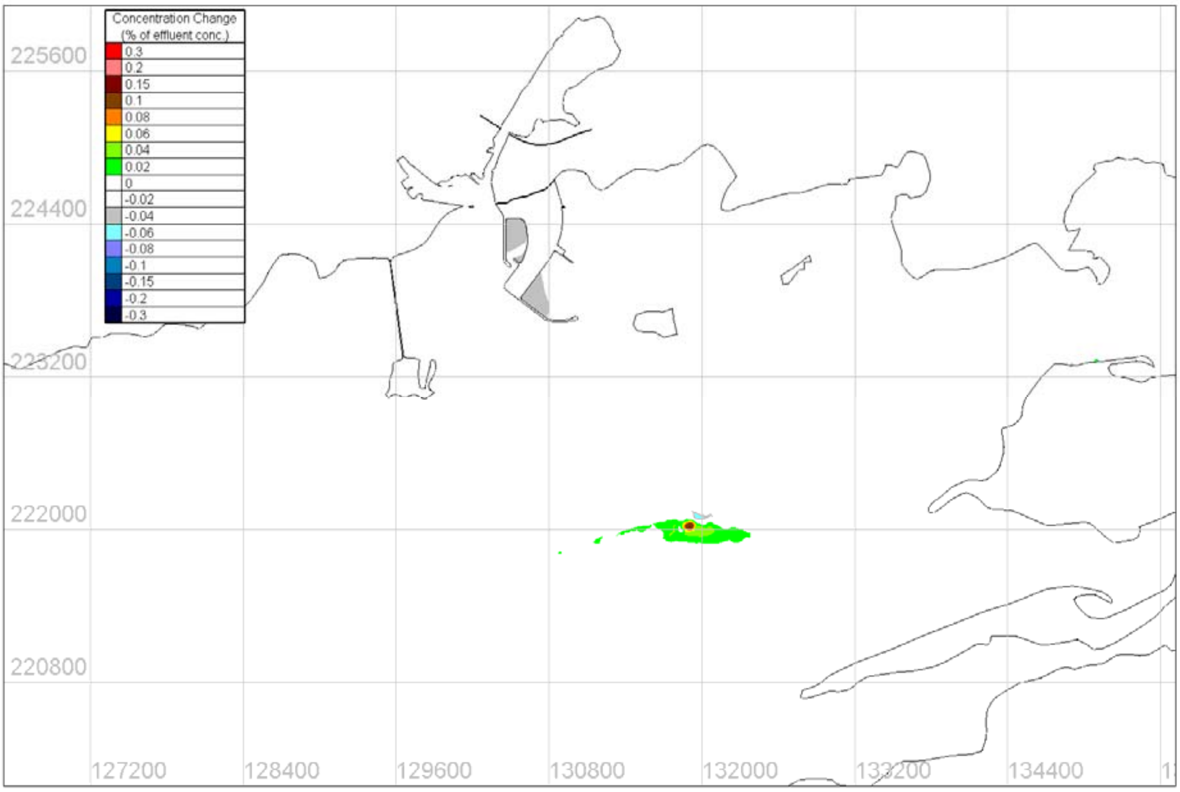


Figure 4.8.53 Predicted change in maximum surface tracer concentration – SW 15m/s Wind Conditions

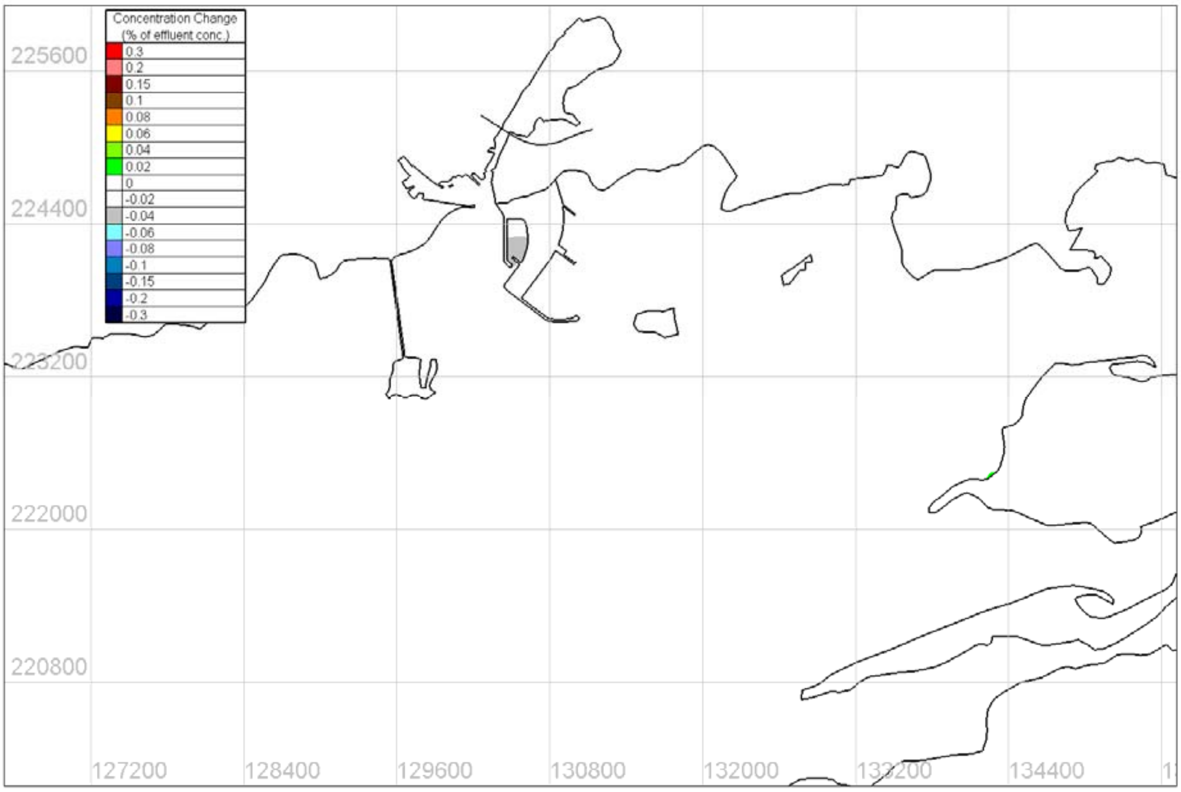


Figure 4.8.54 Predicted change in tidal mean tracer concentration – SW 15m/s Wind Condition

4.8.6.2 Spring tide and Corrib low flow and southerly 15m/s Wind Condition

Figure 4.8.55 to 4.8.60 presents the concentration plume and difference plots for South 15m/s wind conditions.

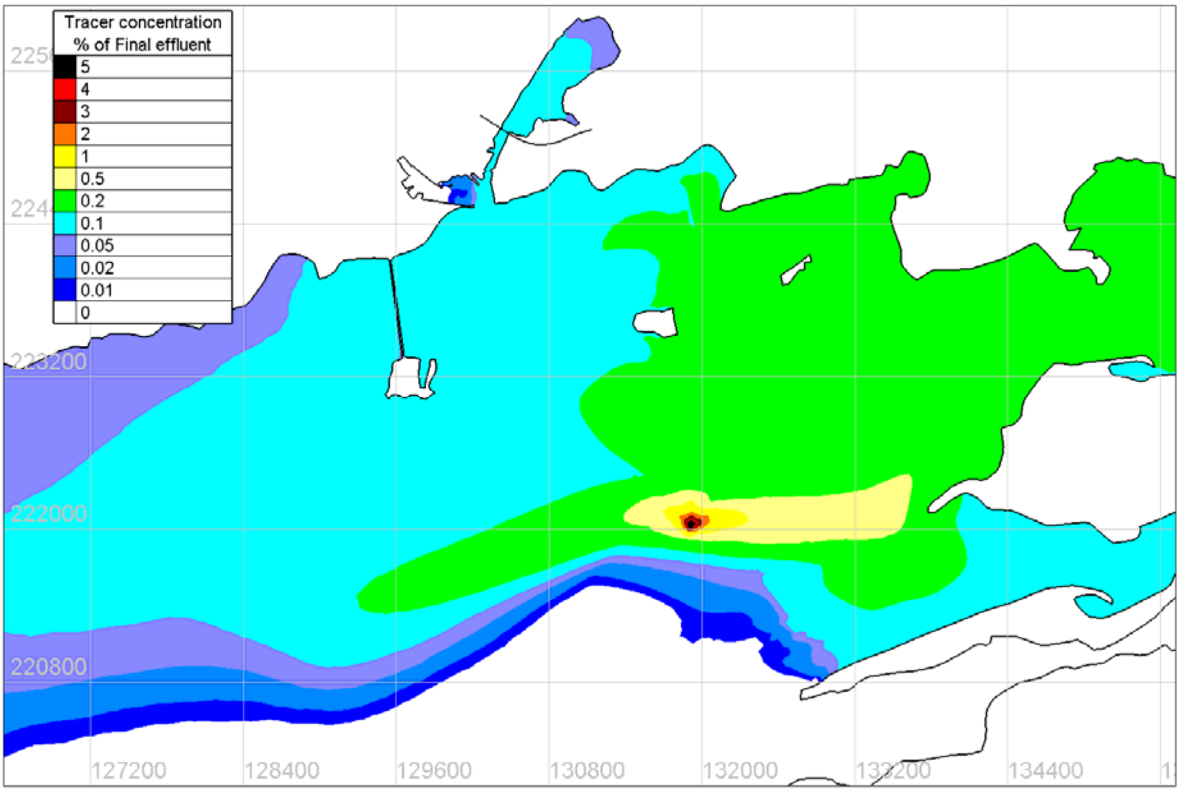


Figure 4.8.55 Maximum surface concentration of Tracer under S 15m/s wind conditions– Existing

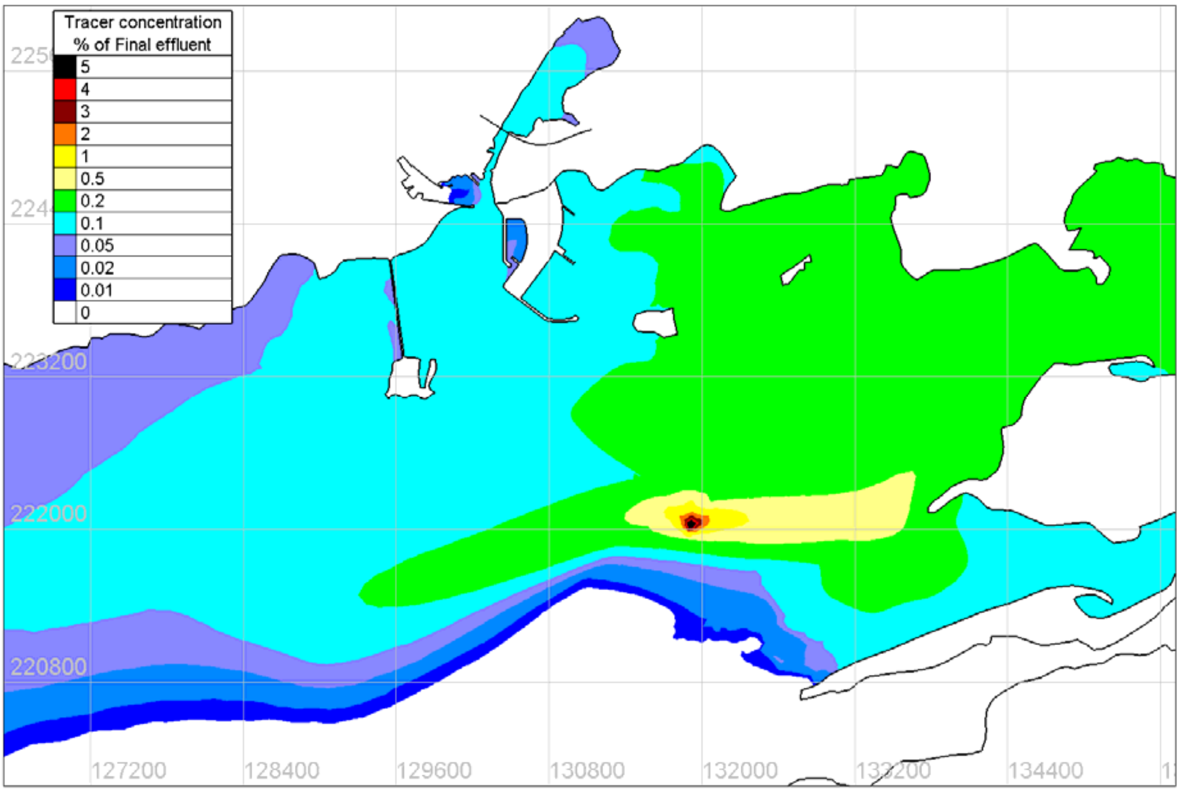


Figure 4.8.56 Maximum surface concentration of Tracer under S 15m/s wind conditions– Proposed

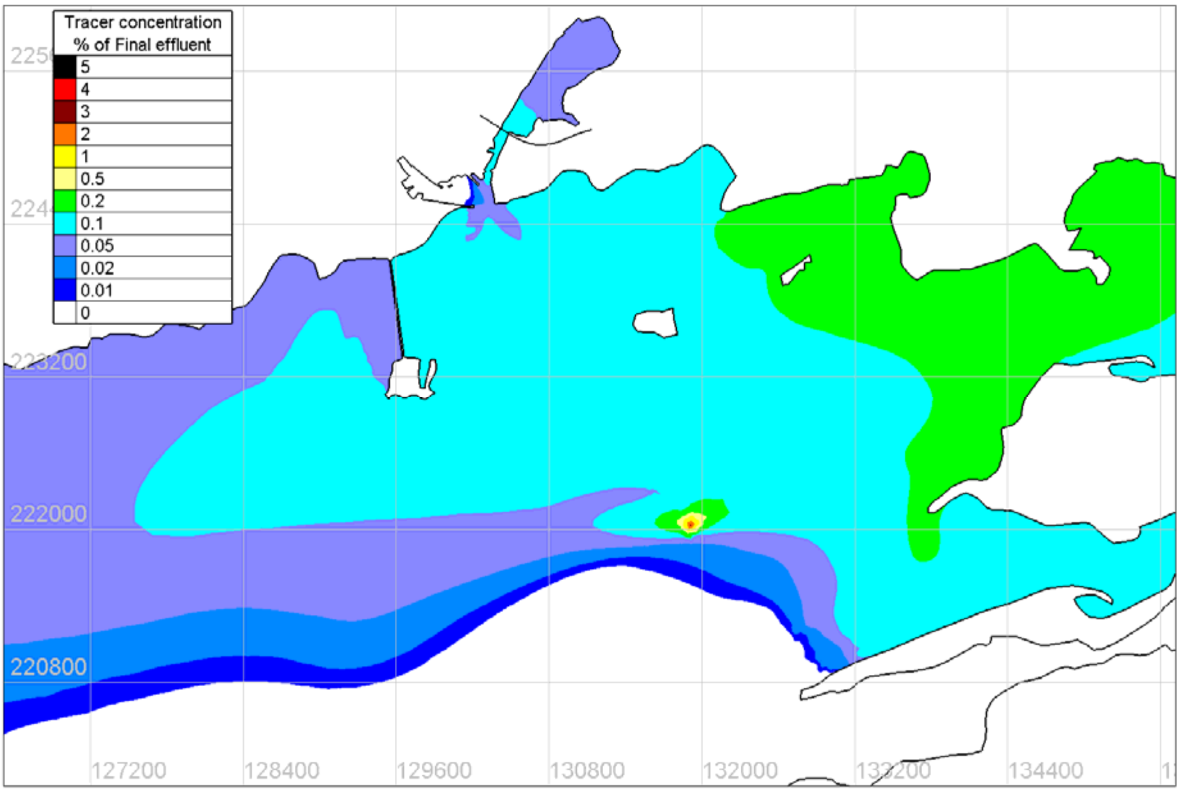


Figure 4.8.57 Tidal mean tracer concentration under S 15m/s wind conditions – Existing Case

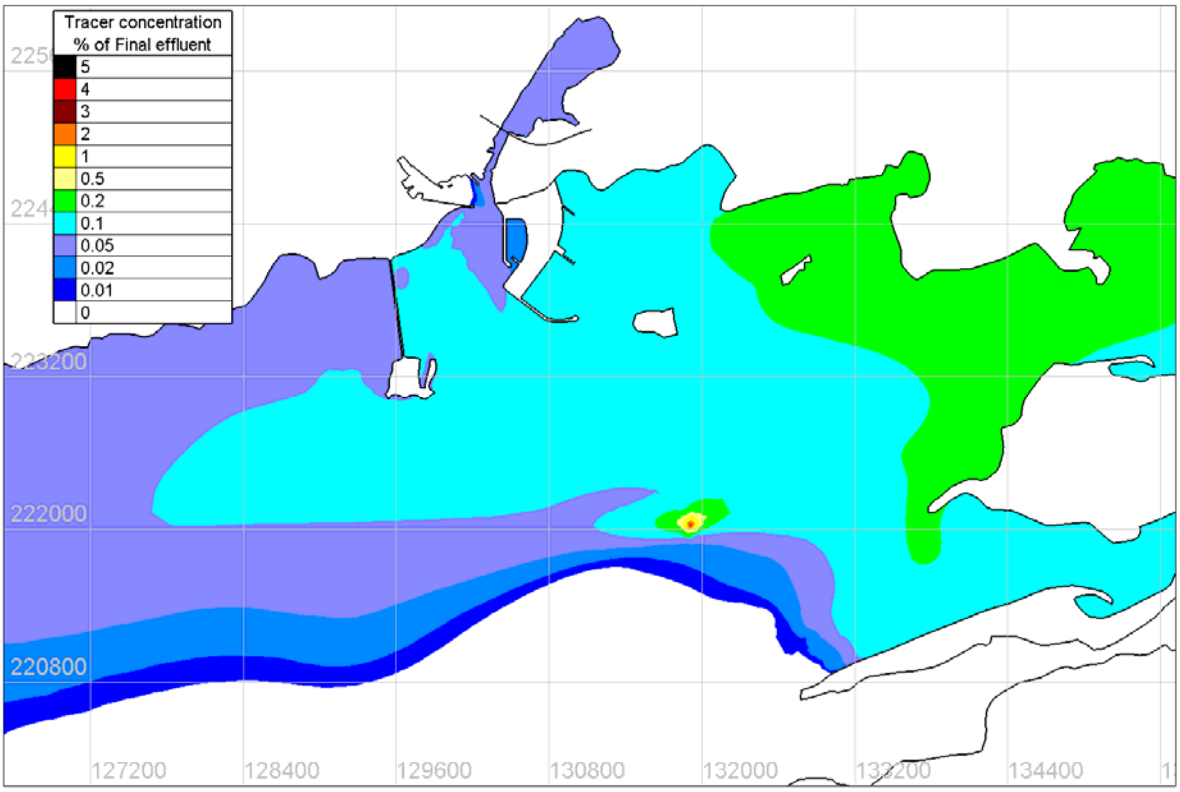


Figure 4.8.58 Tidal mean tracer concentration under S 15m/s wind conditions – Proposed Case

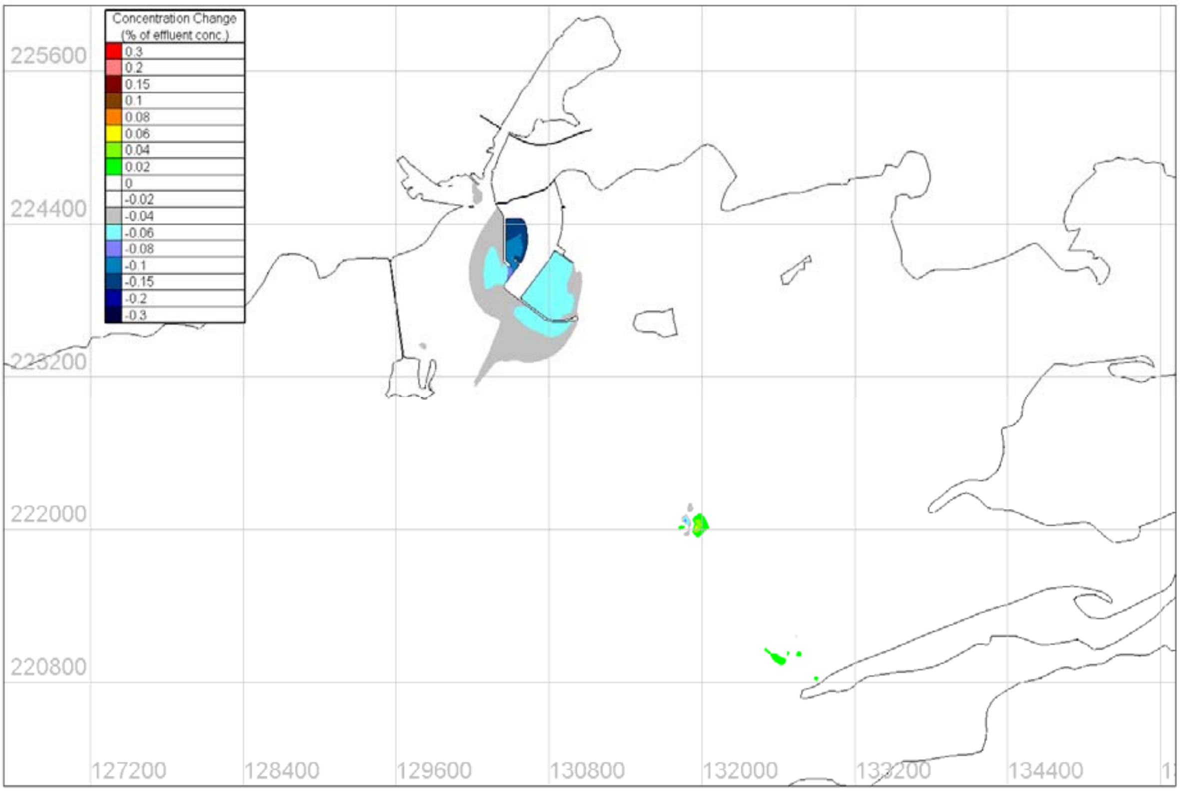


Figure 4.8.59 Predicted change in maximum surface tracer concentration – S 15m/s Wind Conditions

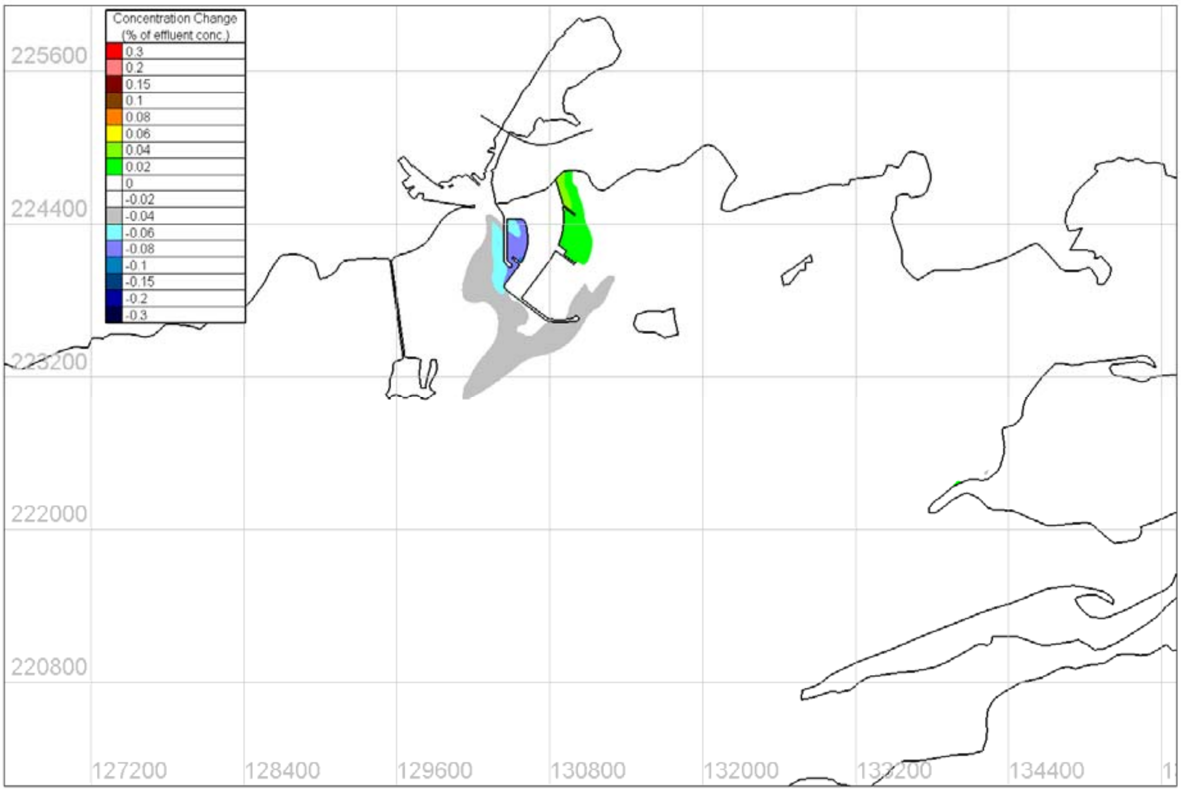


Figure 4.8.60 Predicted change in tidal mean tracer concentration – S 15m/s Wind Condition

4.8.6.3 Spring tide and Corrib low flow and SE 15m/s Wind Condition

Figure 4.8.61 to 4.8.66 presents the concentration plume and difference plots for for SW 15m/s wind conditions.

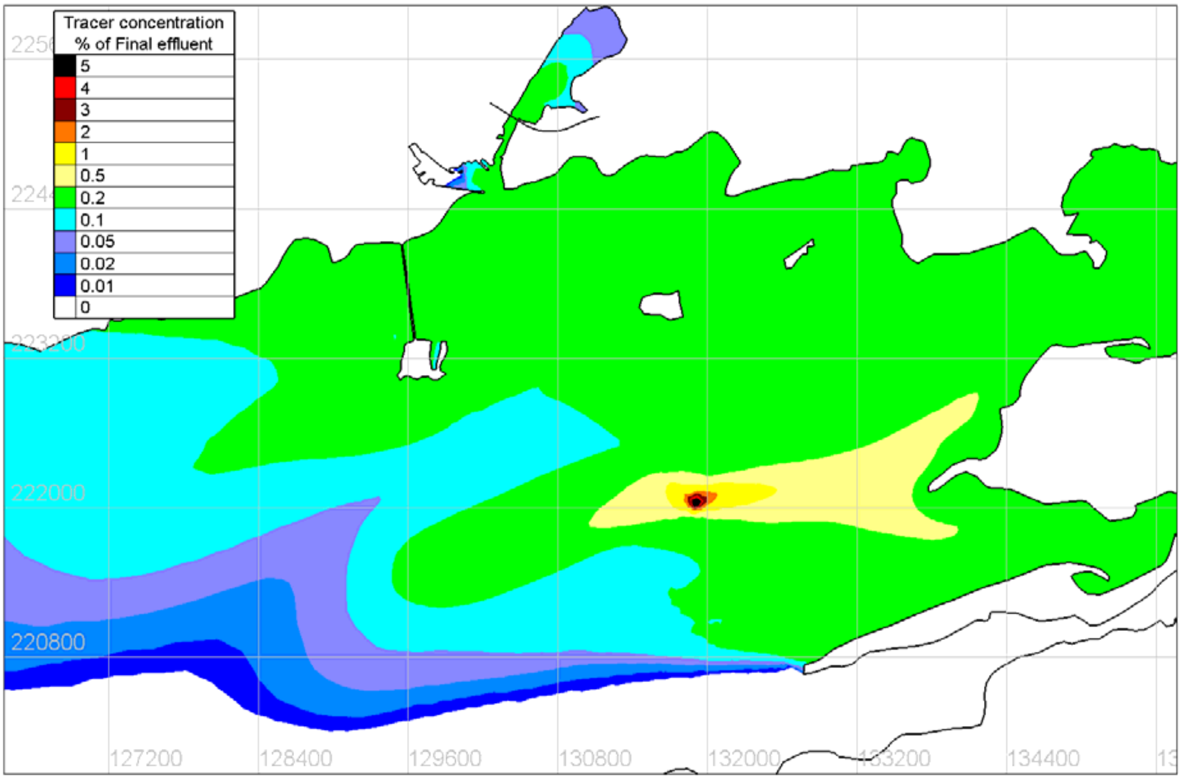


Figure 4.8.61 Maximum surface concentration of Tracer under SE 15m/s wind conditions– Existing

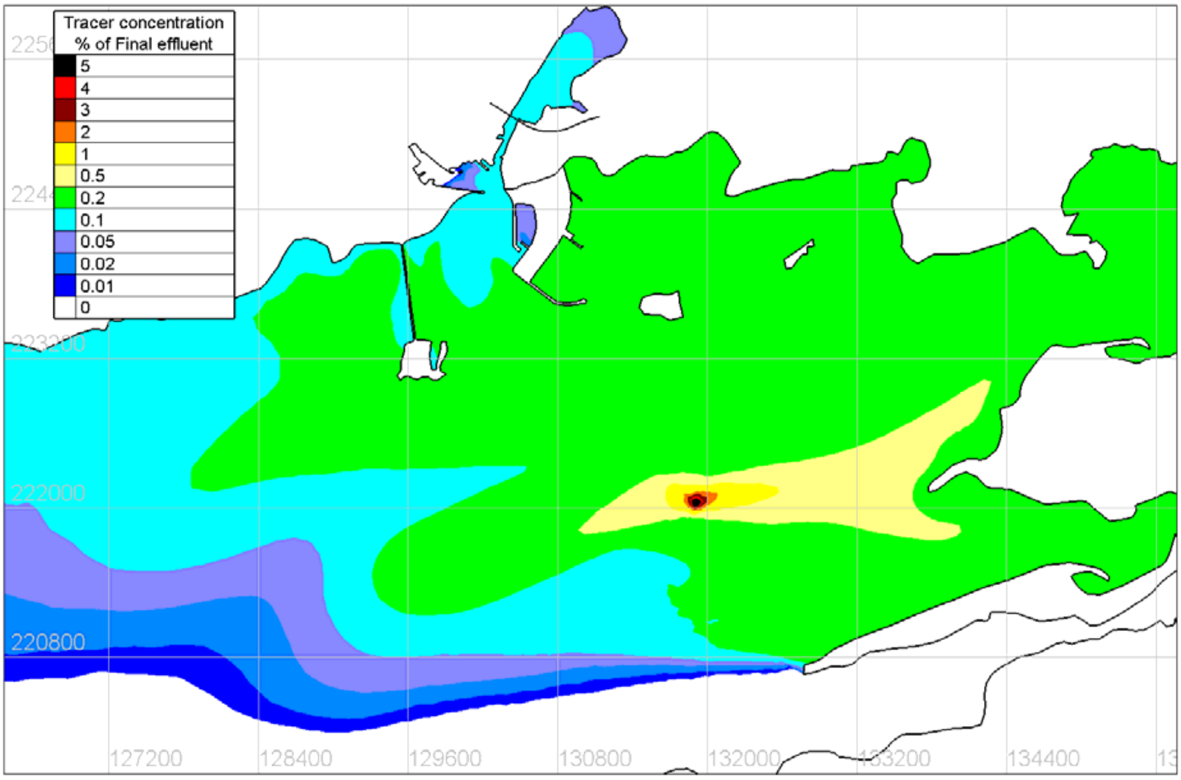


Figure 4.8.62 Maximum surface concentration of Tracer under SE 15m/s wind conditions– Proposed

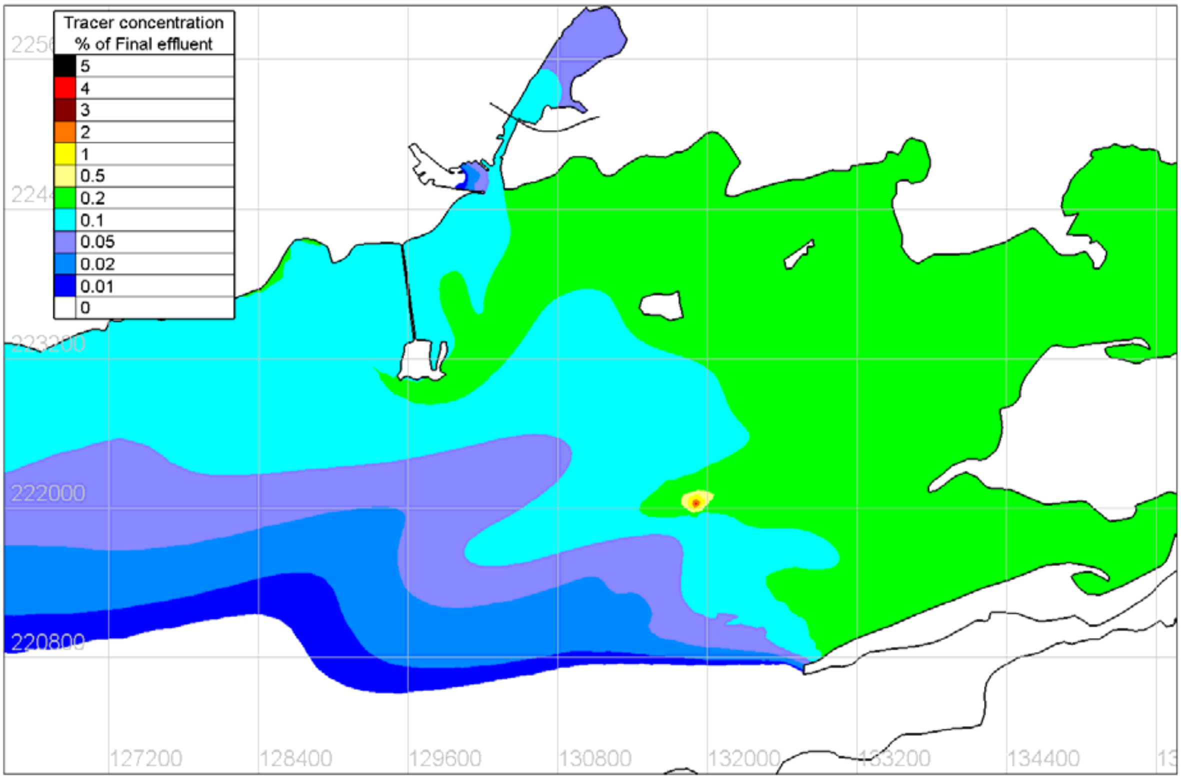


Figure 4.8.63 Tidal mean tracer concentration under SE 15m/s wind conditions – Existing Case

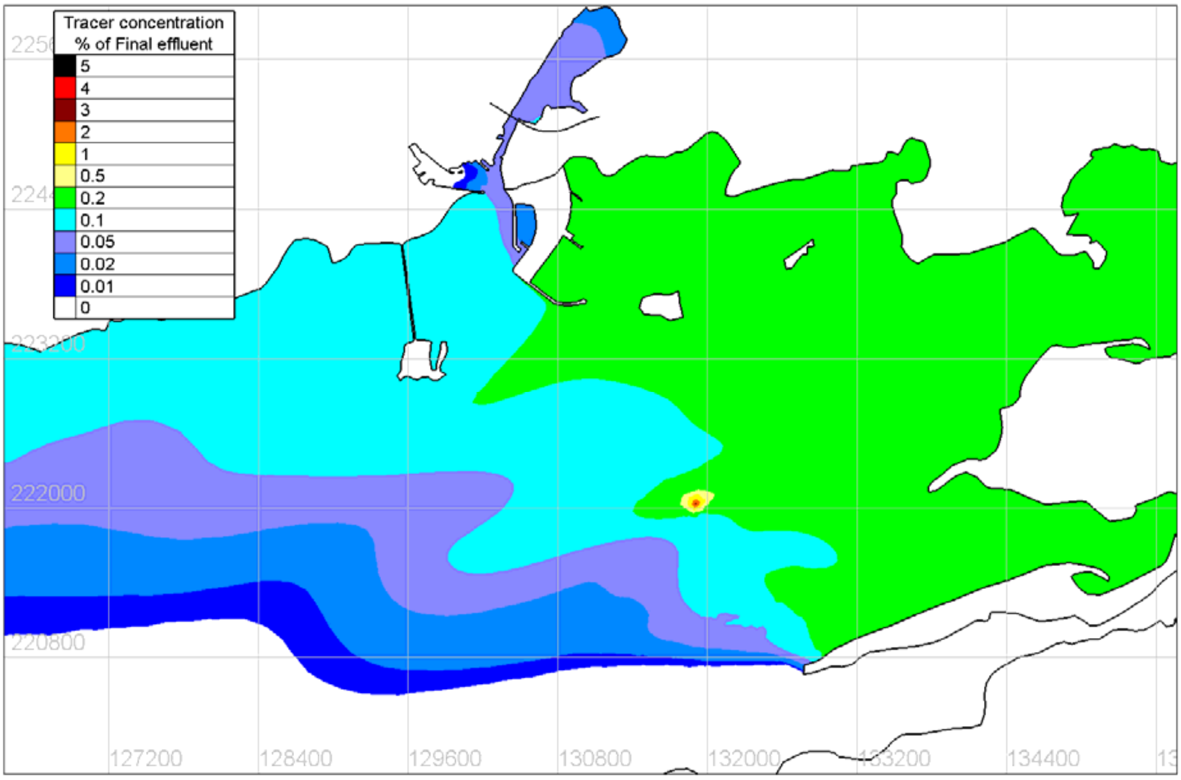


Figure 4.8.64 Tidal mean tracer concentration under SE 15m/s wind conditions – Proposed Case

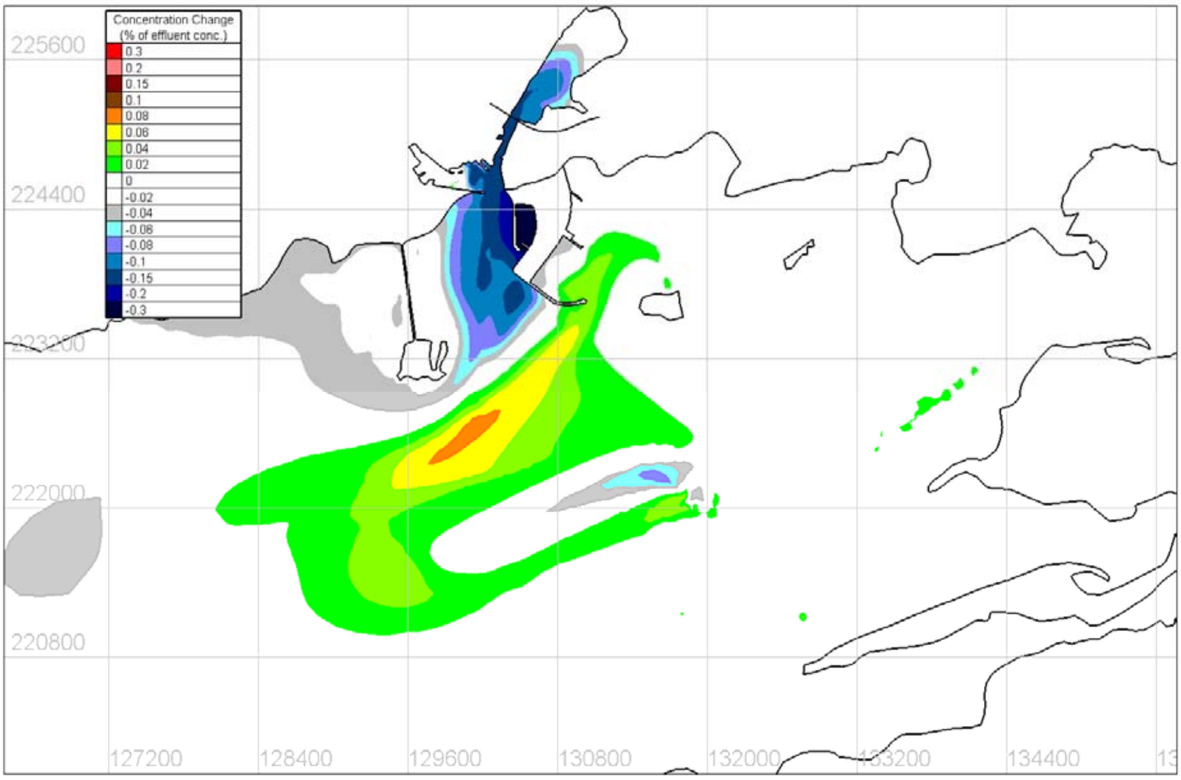


Figure 4.8.65 Predicted change in maximum surface tracer concentration – SE 15m/s Wind Conditions

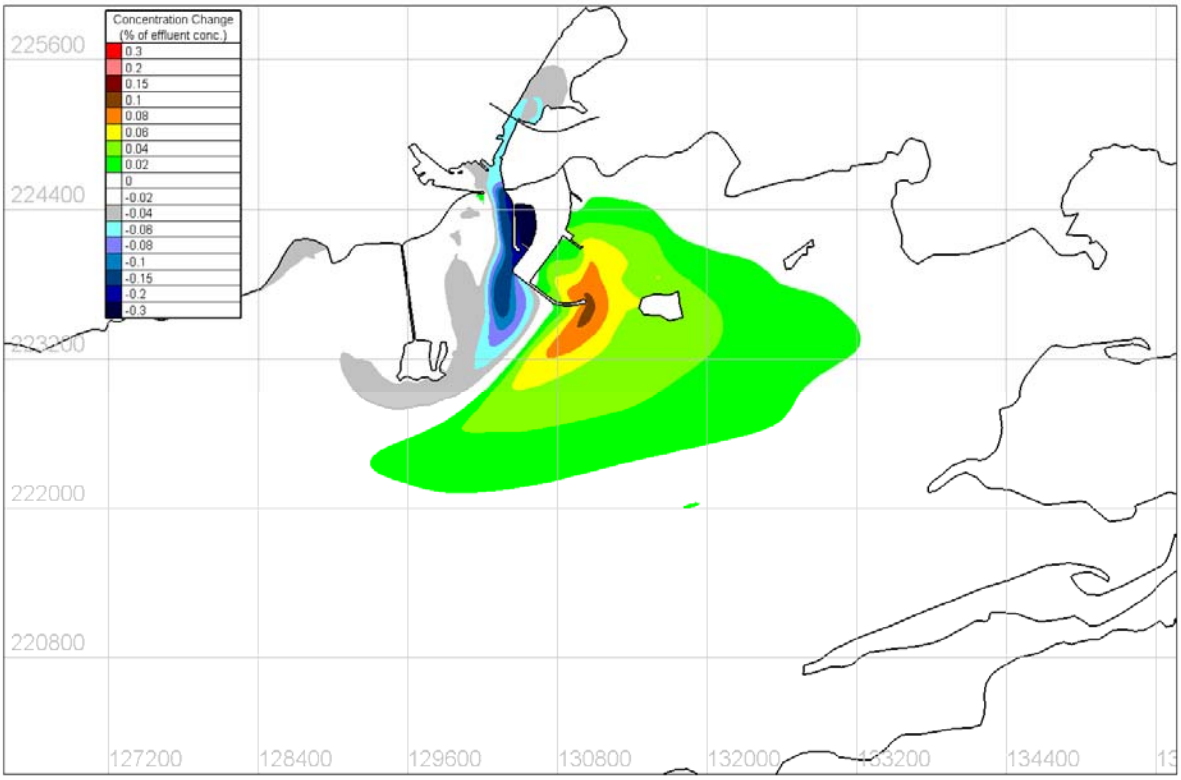


Figure 4.8.66 Predicted change in tidal mean tracer concentration – SE 15m/s Wind Condition

4.8.7 Discussion – Galway East Outfall

The previous 2D simulations presented in the EIS showed the Galway EAST trajectory to travel generally SW to NE from the outfall discharge with little ability to directly interact with the Mutton Island outfall discharge (located 2.4km to the northwest) and the northern shoreline area.

The 3-D Simulations presented in Figures 4.8.49 to 4.8.66 modelling adverse SW, S and SE wind conditions transport the Galway East Plume northwards towards the Harbour development area and the sensitive receptors of the Bathing Waters. The predicted plume concentration are a well mixed plume having concentration of 0.25 to 0.3% of the effluent concentration. The simulations also show that a number of tidal cycles are required to reach the northern shoreline area. Therefore faecal coliforms will be considerably lower (in excess of 10 fold lower) than the 0.25 to 0.3% as modelled without the diffuser dilution to be proposed.

The Impact of the Harbour Development on the Galway East plume concentrations is minor under south and southwest winds, with the greatest effect occurring for the southeast wind. The difference Plots in Figures 4.8.65 and 4.8.66 show a reduction (improvement) over the existing case to the west and north of the Harbour including the Corrib entrance and Lough Atalia and an increase of 0.04 to 0.08% to the east of the harbour in the vicinity of the Commercial Port and Hare Island. No Impact is predicted to the Ballyloughaun Beach or Grattan Road Beach.

Pollutant	Galway East Outfall WWTP Final effluent concentration
Faecal Coliforms	20,000 cfu/100ml
BOD	25 mg/l O_2
Ammonia	3mg/l as n
Suspended Solids	35mg/l
Total Oxidised Nitrogen	20mg/l

Table 4.8.3 Final Effluent Quality for Galway East Outfall

Pollutant Chemical parameter	Effluent Concentration	Percentage Change			
		0.05%	**0.1%**	**0.15%**	**0.5%**
Faecal Coliforms	**20,000 cfu/100ml**	**10**	**20**	**30**	**100**
BOD	**25 mg/l O_2**	**0.0125**	**0.025**	**0.0375**	**0.125**
Ammonia	**3mg/l as n**	**0.0015**	**0.0030**	**0.0045**	**0.0150**
Suspended Solids	**35mg/l**	**0.0175**	**0.035**	**0.0525**	**0.175**
Total Oxidised Nitrogen	**20mg/l**	**0.01**	**0.02**	**0.03**	**0.1**

Table 4.8.4 Pollutant Concentration based on percentage change in effluent concentration for Galway East Outfall Discharge

The simulation results clearly show that the potential impact by the Proposed Harbour Development on the Galway East Outfall plume concentrations is minor to negligible and will not affect the future performance of this outfall.

4.8.8 Conclusions

The 3-D hydrodynamic dispersion analysis confirms the conclusions reached in the EIS report that the Harbour Development will not significantly (noticeably) affect the performance of the Mutton Island outfall in respect to dilutions and mixing within the receiving waters of Inner Galway Bay. Changes in plume pattern are predicted as a result of the Development, however these changes will not impact the overall Water Quality Status of the receiving waters or impact on the status of sensitive locations such as the Corrib Salmonid Water, Bathing Waters at Grattan Beach, Ballyloughaun Beach and the Corrib entrance at Nimmo's Pier including the Claddagh basin, existing Docks and Lough Atalia.

The dispersion simulations confirm that the plume characteristics for the proposed Galway East outfall will not be impacted and that the combined effect with the Mutton Island outfall on the receiving waters along the Galway City Shoreline area including the Corrib entrance, Salthill beaches and Ballyloughaun Beach will be imperceptible even under adverse southerly wind conditions (SE to SW).

If the outfall diffuser nearfield dilution at both outfalls is factored in, then the above predicted concentrations would be significantly lower, pro rata for both the existing and proposed cases.

4.9 MAPPING

Mapping of Maximus Wave Heights

Query:

In section 8.4.6.7 of the EIS reference is made to maximum wave heights within the Bay. The applicant is requested to present the maximum wave heights in the form of a map.

Response:

We present maps at Figures 4.9.1, 4.9.2 and 4.9.3 as follows:-

Figure 4.9.1 shows existing maximum wave heights within the Bay taking account of the additional swan modeling and the effects of wind, current and roughness as requested in this R.F.I.

Figure 4.9.2 shows the corresponding wave heights for the proposed case.

Figure 4.9.3 is a representation of Plot 4.5.41 which is the difference plot of the maximum predicted wave heights existing and proposed wave climate for all on-shore directions (West to East South-East).

This shows all of the landward locations which will have the benefit of reduced maximum wave because of the sheltering effect of the proposal as well as the seaward areas which will show greater maximum wave because of wave reflection, increased depth, realigned currents.

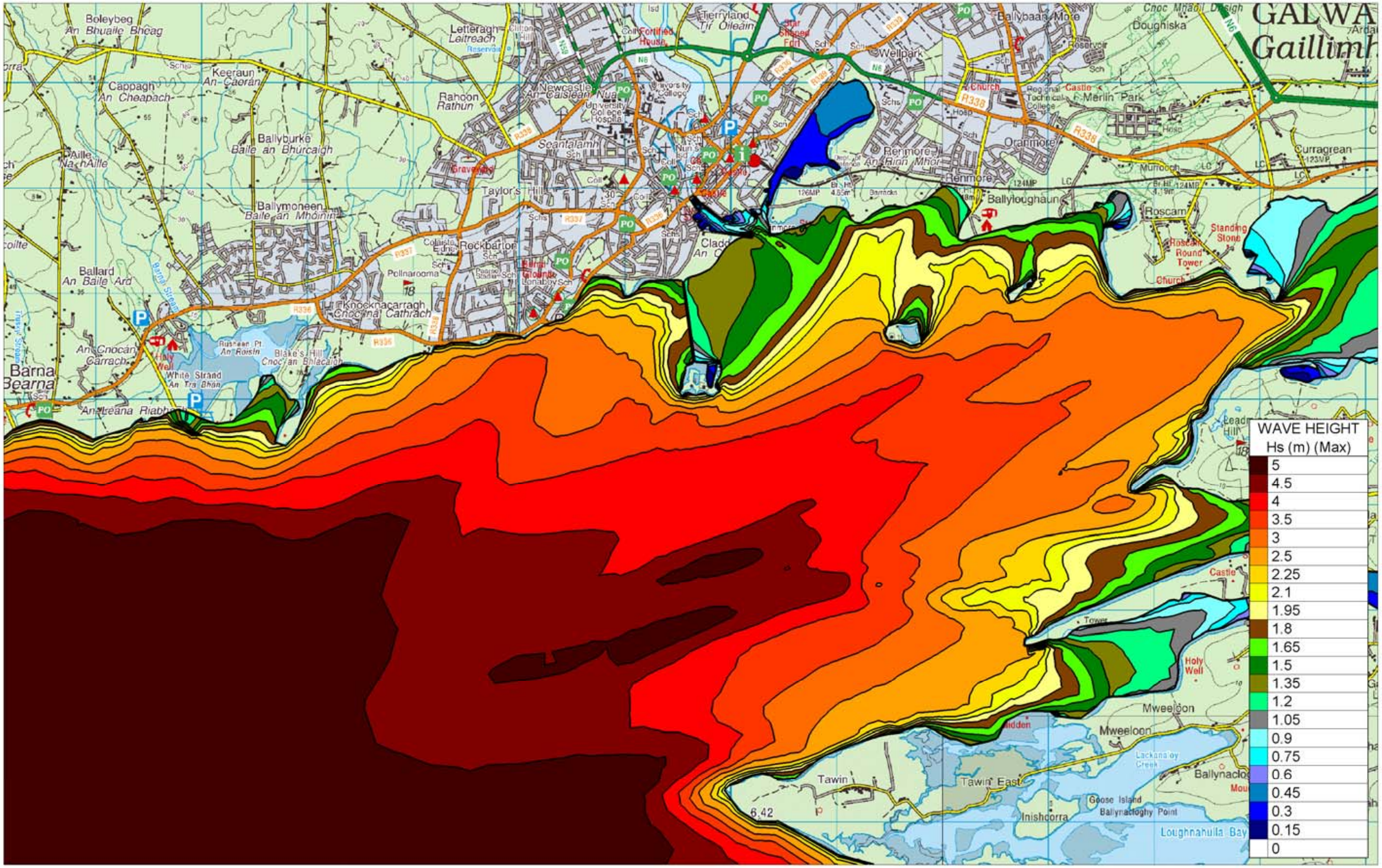
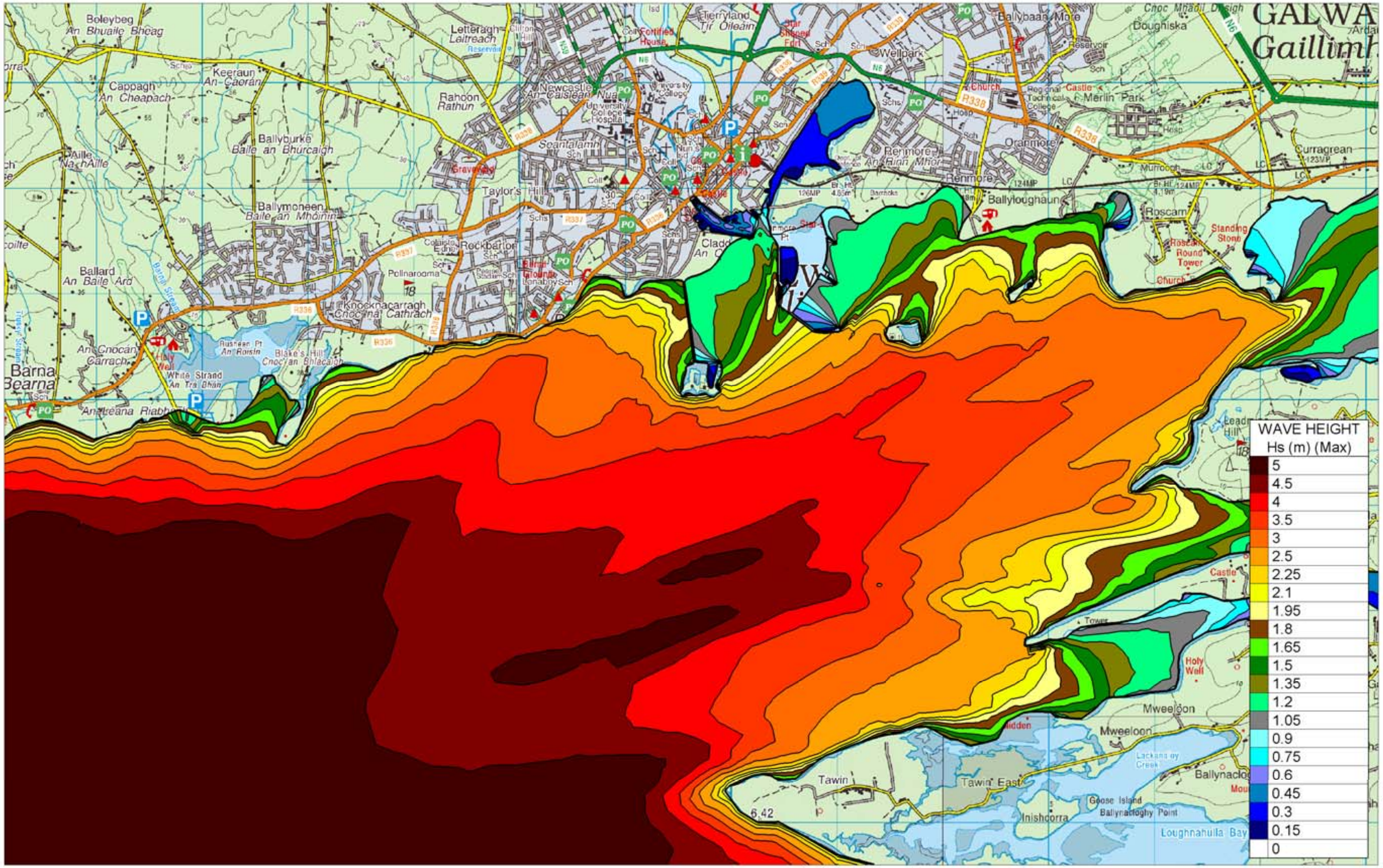


Figure 4.9.1 Shows maximum wave heights within the bay, existing case



4.9.2 Shows maximum wave heights within the Bay, Proposed Case

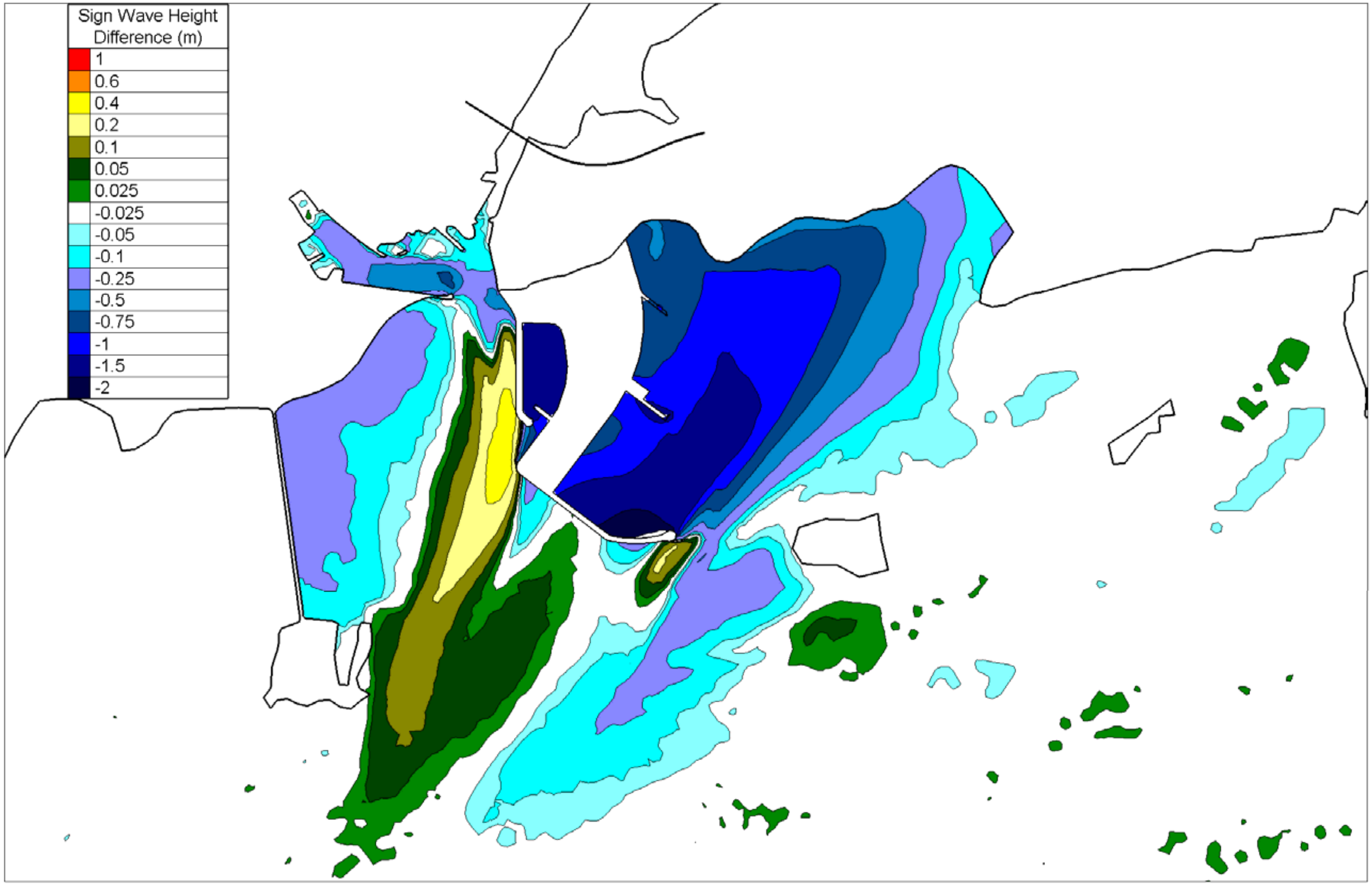


Figure 4.9.3 Difference plot of maximum predicted Wave heights existing and Proposed Wave climate for all onshore directions (West to ESE)

Also shown at Figure 4.5.4.

4.10 MAPPING OF AREAS OF POTENTIAL FLOOD RISK

Query:

Likewise section 8.4.7.3 of the EIS makes reference to the specific locations for potential flood risk. These are merely mentioned in the form of street names in the text. The applicant is requested to present this information in the form of a map.

Response:

We present a map at Figure 4.10.1 to address the above.

The map shows the 4.2m contour and 4.7m contour.

The 4.2m contour corresponds with the 200 year tide of 4.146 with additional freeboard allowance.

The 4.7m contour corresponds with the 200 year tide plus 500mm climate change, total 4.646m.O.D. Malin with additional freeboard allowance.

Highest astronomical tide is presently 2.84 m.O.D.

Recent storm events reached 3.6 (3.59 February 2014)

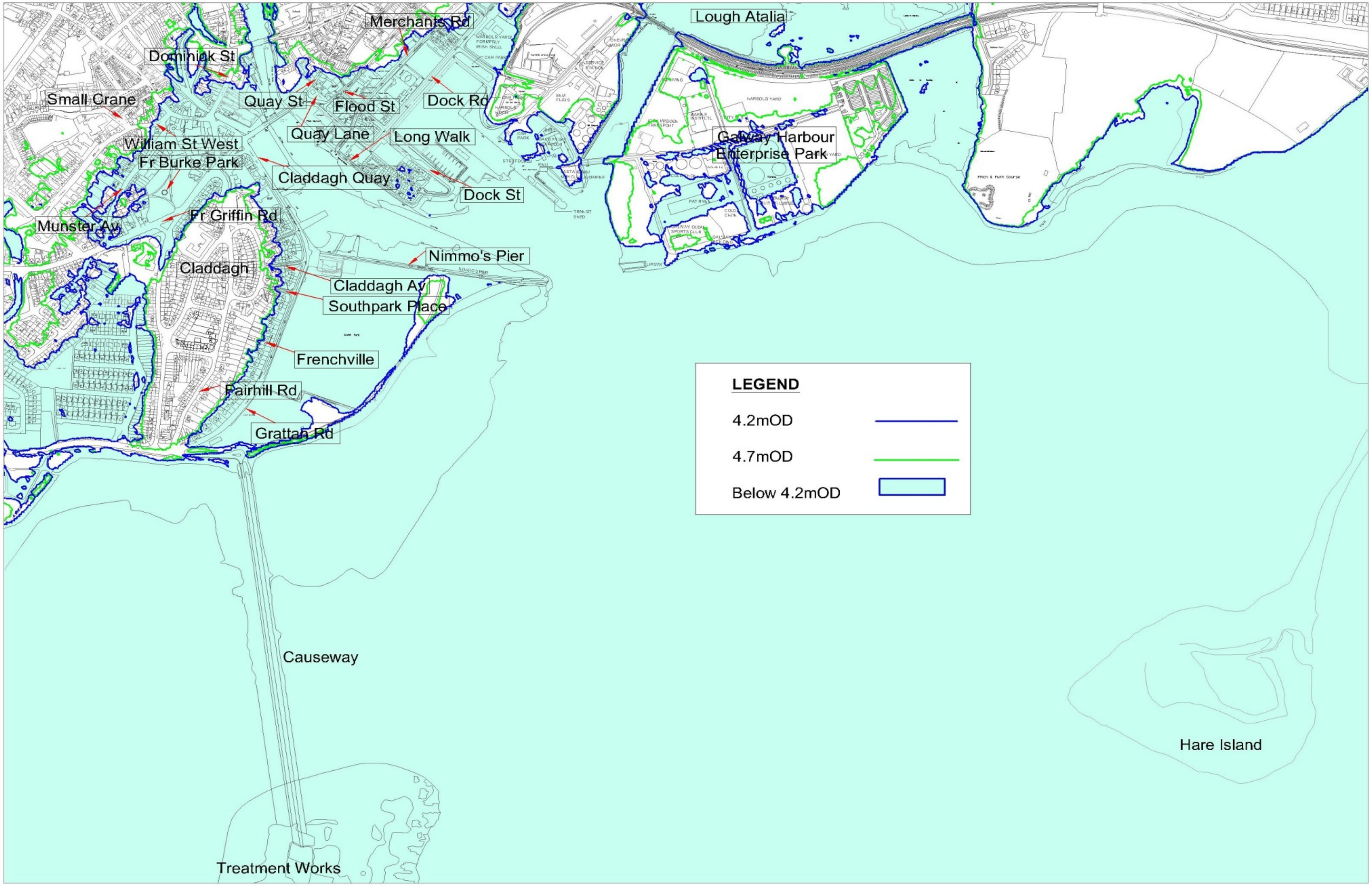


Figure 4.10.1 Map showing Locations of Potential Flood Risk, Showing Location Names

5 ECOLOGY ISSUES: ANNEX I HABITATS

5.1 INFORMATION IN NIS

Query:

As a standalone document, the Natura impact statement (NIS) lacks some detail required, much of which is included in the environmental impact statement (EIS). This is particularly notable in the case of Annex I habitats. For example:

Response:

Taking into consideration this point, information from the EIS document as submitted for planning has been incorporated into the NIS Addendum/Errata document, with particular regard to Annex I habitats. The incorporated information includes detailed data and assessment information with regard to coastal lagoon habitats at Lough Atalia and Renmore. In addition more detailed botanical surveys of stony bank and salt marsh habitats were completed by Dr. Micheline Sheehy-Skeffington. This information has also been included within the NIS Addendum / Errata document and considered during the assessment process.

5.1.1 Information in Ch. 7 of EIS on Potential for Interaction of Habitats to be Incorporated into NIS

Query:

Chapter 7 of the EIS details the evidence that there is no potential for interaction of habitats within the Galway Bay complex with designated habitats in other sites. This information should be incorporated more fully in the NIS.

Response:

Information with regard to the zone of potential influence of the proposed development which was originally only included within Chapter 7 of the EIS has now been included as part of the NIS Addendum / Errata document in Section 2.2.1. Additional information on in-combination effects as presented in the EIS have also been included where relevant.

5.1.2 Information in Ch. 8, Appendix 4.2 and Appendix 4.4 of EIS to be Incorporated into NIS

Query:

The EIS details mitigation measures to offset potential disturbance to Annex I habitats that should be explained in greater detail in the NIS because they are necessary to make an informed assessment of the potential operational effects of the proposed development on Annex I habitats. These include potential impacts from altering the local hydrography, management of invasive species, oil spill contingency plans and management plans for catastrophic events. Relevant sections within the EIS include Chapter 8, Appendix 4.2 and Appendix 4.3.

Response:

5.1.2.1 Local Hydrology

5.1.2.1.1 <u>Morphology of Outer Harbour Area</u>

Location of existing and proposed river silt / sand deposits / erosions are presented. Less river sediment will be deposited to the East of the development. River sediment results show it to be the lesser element of sediment supply in the Outer Harbour.

Flushing effect of peak river flows for existing and proposed cases are examined.

Peak river flow will more effectively maintain the proposed channel than it does the present channel. Present build up of sediment in the existing channel is more indicative of littoral drift supply of sediment.

Analysis of the historic channel dredge requirements show a low littoral drift supply which was reduced by the causeway construction.

South and South West storm wave erosion plots for fine sand are presented. These show small areas of minor scour and accretion adjacent to the new channel, to the old Port.

The main change in the outer harbour area will be a reduction in scouring on the Renmore shoreline. The vicinity of Hare Island shows little change.

The outer harbour area general morphology will remain stable and largely comparable to present. There will be no changes to the West of the causeway. Benthos will not be subject to increased morphological pressures of any consequence.

The bulk of the deposition of spilt capital dredge materials falls within the zone of influence previously indicated.

These deposits will not impact on the benthos to any detrimental extent as the order of turbidity outside the zone of influence will correspond to that caused by storm events at present.

Future maintenance dredge requirement should be a similar period to existing (12 years) and less than twice the existing requirement.

5.1.2.1.2 River Sediment Load

Suspended solids load in Corrib waters is generally below the limit of quantitation, now 2 mg/l.

River supply estimated at 5,000 to 10,000T/A.

At least 50% of that will not settle in the harbour waters.

5.1.2.1.3 Wind Waves

Impact of river current on wave heights, with tidal flow due to refraction

Additional modelling was undertaken by Swan Model (previously was by Artemis) to address the above.

The results show an increase in wave height in the area of the new channel to the old Port i.e. along the marina wall.

Other increases shown by the Swan Model are the same for the existing and proposed cases.

The conflict of wind wave and current which occurs at present, upstream of Nimmos Pier, due to S to SE storm winds will be eliminated by the shelter which will be provided by the proposed case.

5.1.2.1.4 Increase in wave heights if current effects are included

The study was extended to include Atlantic storm wave (swell) with the local storm wind waves combined with currents in Section 3) above to test the impact of current on the worst combined wave case.

A combined plot for all on-shore wind directions at 4.4.41 shows that the new channel to the old Port, the area between Mutton Island and the main breakwater, and at the nose of the proposed breakwater are the locations of increased waves.

A minor increase is apparent to the West of the head of Nimmos Pier, otherwise South park and from the Corrib entrance to the Claddagh all show maximum predicted wave height reduction between existing and proposed cases.

5.1.2.1.5 Wind wave "breaking" / Increase in Water Level Further Inland

Plots of where wind wave breaking could arise have been prepared for existing and proposed cases 4.5.1 and 4.5.2.

A flood simulation was run with the (wave breaking) radiation terms included and showed no discernible change in upstream flood levels within the Claddagh Basin area.

5.1.2.1.6 Flow Resistance / Sea Bed Roughness / Test Other Roughness Factors

The roughness coefficient was tested at 1 and 100. The initial was at 10.

The roughness coefficient shows to only be of consequence in the Corrib upstream of the entrance primarily at low water levels.

At high water levels this was less critical.

The model showed no discernible difference due to roughness in the comparison of existing and proposed cases.

5.1.2.1.7 Flow Resistance

Impact of Wind Waves on Roughness

Wind waves can modify sea bed roughness by rippling of the sand bed. This is not significant in the area as demonstrated at 6) above.

5.1.2.1.8 Outfall Dispersion Studies

Mutton Island and Proposed East Galway Sewage Treatment Outfalls

SSW wind driven surface current, towards the Corrib entrance possible pollutional impact were studied.

Studies of both outfalls were undertaken individually and then in combination.

Models were run assuming no dilution of effluent from sea bed diffuser outfall to surface current.

Plots are presented on this basis for various wind conditions. The predicted change due to the proposal are deemed to be minor for the Mutton Island outfall chemical parameters. A faecal colliform analysis was undertaken which shows a less than 10% increase in SSW wind conditions at the Corrib entrance. Calm conditions would show a lower concentration existing case but a greater increase caused by the proposal.

When dilution and die off of coliform are included, the issue is not considered significant relative to bathing water standards.

The Galway East outfall pattern is not noticeably impacted by the proposal. Model and tracer is not noticeable at the Corrib entrance. The combination impact is not therefore of significance.

5.1.2.1.9 Maximum Wave Height Map from Within the Bay

This is provided for existing and proposed cases and the difference plot is presented to facilitate ease of assessment.

5.1.2.1.10 Flood Risk Map With Street Names

This is provided showing the 4.2m and 4.7m existing land contours noting the 200 year tide as 4.146m and with 500mm global warming is 4.646.

5.1.2.2 Management of Invasive Species

Invasive species, either algae or invertebrates, can be brought into Irish coastal seas in a number of ways: larvae in ballast or bilge water can be released into the water column, if the vessel pumps this liquid within a short distance of the shoreline. This can be prevented if vessels are required to pump bilges *etc* in off shore water. A Harbour bye law will be added to the existing bye laws to require that "vessels are required to exchange ballast waters outside of the 12 mile limit".

The other way that invasive species can enter Irish territorial waters is if adults are present on the vessel's hull. It is possible that these adults could release larvae in Irish coastal waters and that these then could settle as adults on suitable substrates. This is a universal issue and there in no method to prevent this happening. However, the area around and within the existing Galway Docks site and been the subject of many surveys carried out by AQUAFACT staff as early as 1975 when they were active researchers in NUI, Galway. No non-native invertebrate species have been recorded within the area to date.

Another way that non-native species can be brought into Irish territorial waters is via import of shellfish spat from waters outside the State: a non-native species, *Didemnum vexillum* (an ascidian or sea squirt) was recorded in 2007 at Parknahallagh near Ballindereen, County Galway. It is believed that aquaculture stock transmissions of oysters were the main means of its spread. It was recorded there again in 2014 and was found to have extended its range since 2007. It was first recorded in Ireland in 2005 in Malahide marina. *D. vexillum* was the subject of species alerts issued by the National Biodiversity Data Centre (NBDC) in 2007, and by the all-Ireland forum on invasive species under the aegis of The Department of Arts, Heritage and the Gaeltacht.

5.1.2.3 Environmental Management Framework

A copy of the Environmental Management Framework [Appendix 4.2 of the EIS] is now included in the NIS Addendum at Appendix 3.7.

5.1.2.4 Oil Spill Contingency Plan

A copy of the Oil Spill Contingency Plan [Appendix 4.3 of the EIS] is now included in the NIS Addendum at Appendix No. 3.5.

5.1.2.5 Management Plan for Catastrophic Events

A copy of the Galfire Plan [Appendix 4.4 of the EIS] is now included in the NIS Addendum at Appendix No. 3.6.

5.2 .

5.2.1 Spatial Pattern of Habitat Quality

Query:

Detailed multivariate faunal analyses and sediment profile imagery (SPI) surveys of subtidal sediments are reported in Chapter 7 of the EIS, but the methodologies used for the assessment of sensitivity of these habitats to potential operational impacts could be improved. Many of the references quoted are very old. What is clear is that the macrofaunal communities of Inner Galway Bay are viable in composition because they are subject to frequent natural disturbance and occur on a mosaic of sediment types. Habitat quality, as a measure of conservation status (and sensitivity) should be determined using a multimetric index of the type developed for Water Framework Directive (WFD) monitoring. In Ireland, the index routinely used is the Infaunal Quality Index (IQI). This would enable the ecological status of the communities of the proposed development area to be empirically compared at different times and locations, despite the variable multivariate structure of the fauna. This may pertain particularly to the operational effects of proposed maintenance dredging. O'Reilly et at (2006) demonstrated, using a combination of SPI and faunal analyses, that habitat quality in the dredged channel approaching Galway Docks is lower than in the surrounding area. *The spatial pattern of habitat quality (conservation status) should be assessed in the area to determine if the same pattern exists in the baseline data presented,* and the potential impacts of maintenance dredging on Annex I habitats should be discussed. The applicant is requested to address the above points in a more comprehensive manner.

(a) The spatial pattern of habitat quality (conservation status) should be assessed in the area to determine if the same pattern exists in the baseline data presented.

Response:

The marine part of the Water Frame Work Directive (WFD) uses a number of meristics used in combination to evaluate the status of the sea in any area. These include an evaluation of water quality, phytoplankton and zooplankton, macrophytes and the benthos. As the benthic environment acts as a long term reservoir of organic enrichment (and any anthropogenically derived compound), assessments of benthic data need to viewed in a longer time frame and not as a temporally short reflection of coastal processes. An Infaunal Quality Index (IQI) has been developed as part of the WFD and this uses three main data inputs – the number of taxa present in a 0.1m^2 grab sample, a combined assessment of the sensitivity of each of the taxa present in the sample (AZTI/AMBI) and a statistical evaluation of the numbers of taxa and numbers of specimens called Simpson's Evenness value.

Figures 1 and 2 show the results of the analyses using the IQI on the 2004 and 2010 benthic faunal data. Only one station in the 2004 data set returned a "bad" status (at the northern end of the shipping channel close to the mouth of the River Corrib) while the remainder of the sites returned either a moderate (1 station), good (1 station) or high (18 stations) IQI status. Examination of the 2010 data show that 1 site was scored at "moderate status (again at the northern end of the shipping channel closest to the mouth of the River Corrib), 3 at "good" and the remaining 8 were rated at "high". O'Reilly *et al.,* (2006) also noted that benthic communities in the shipping channel were also locally disturbed in the same area.

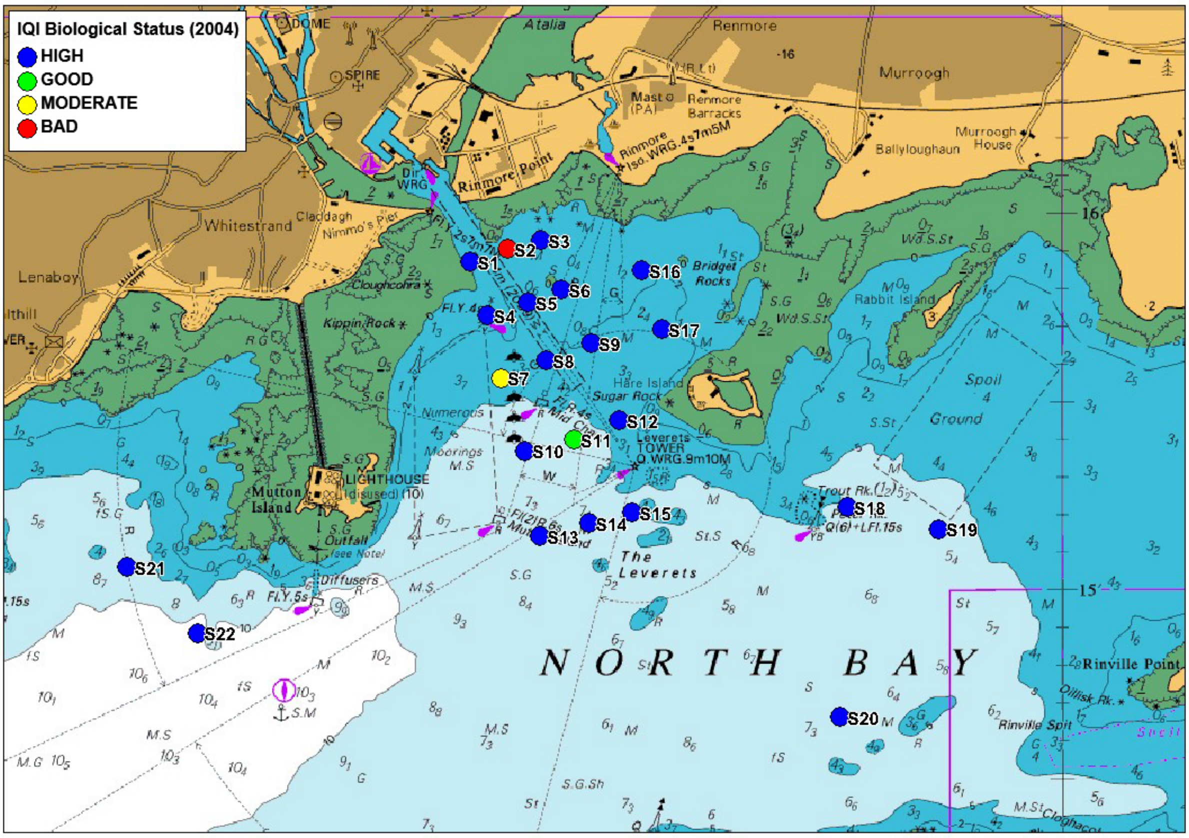


Figure 1. IQI Biological Status for 22 stations sampled in 2004.

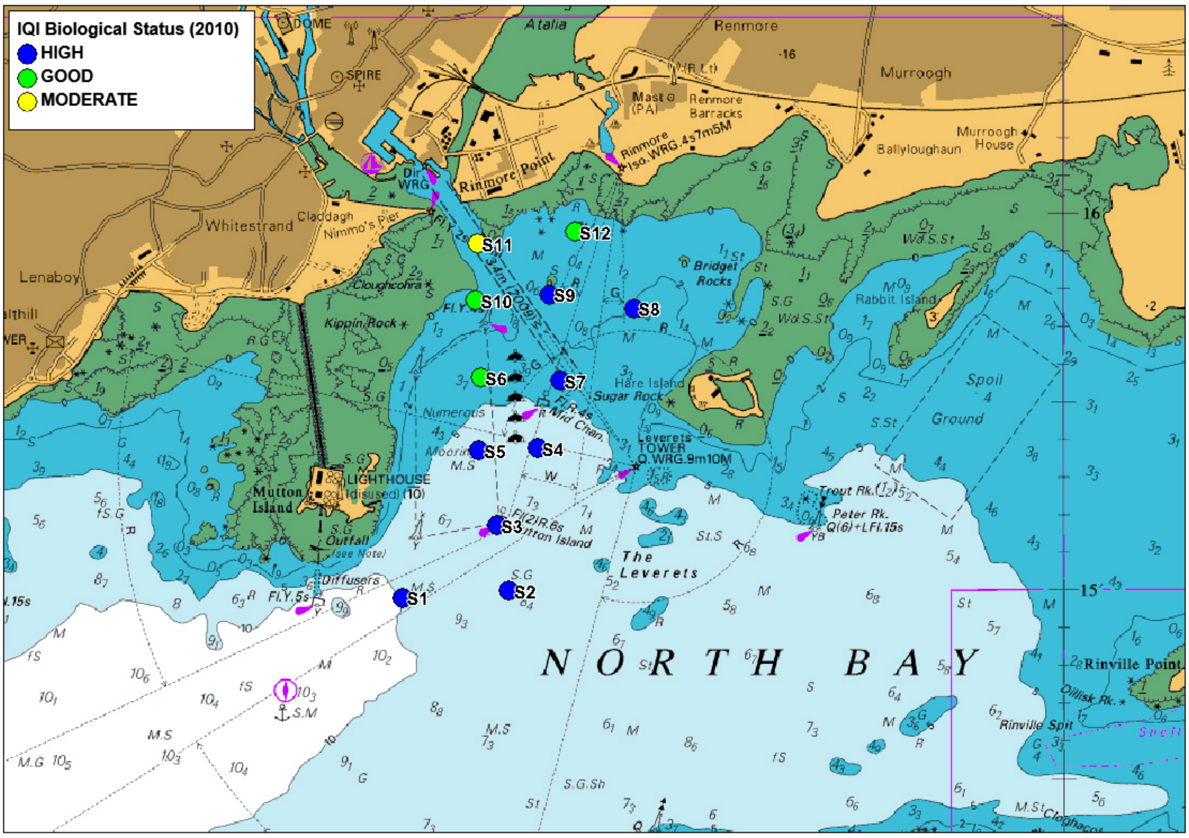


Figure 2. IQI Biological Status for 12 stations sampled in 2010.

The 22 sampling stations where the SPI camera was deployed in 2004 are shown in Figure 3 below and the BHQ values for these are shown in Table 1 below. Locations 1 – 9 lie within the foot print of the Galway Harbour Extension. Table 1 below presents the results (as means) of the analyses of the images and the column on the extreme right of this table presents the Benthic Habitat Quality (Nilsson and Rosenberg, 2000) values. These range from 1.3 at Station 5 to 6.7 at Station 8.

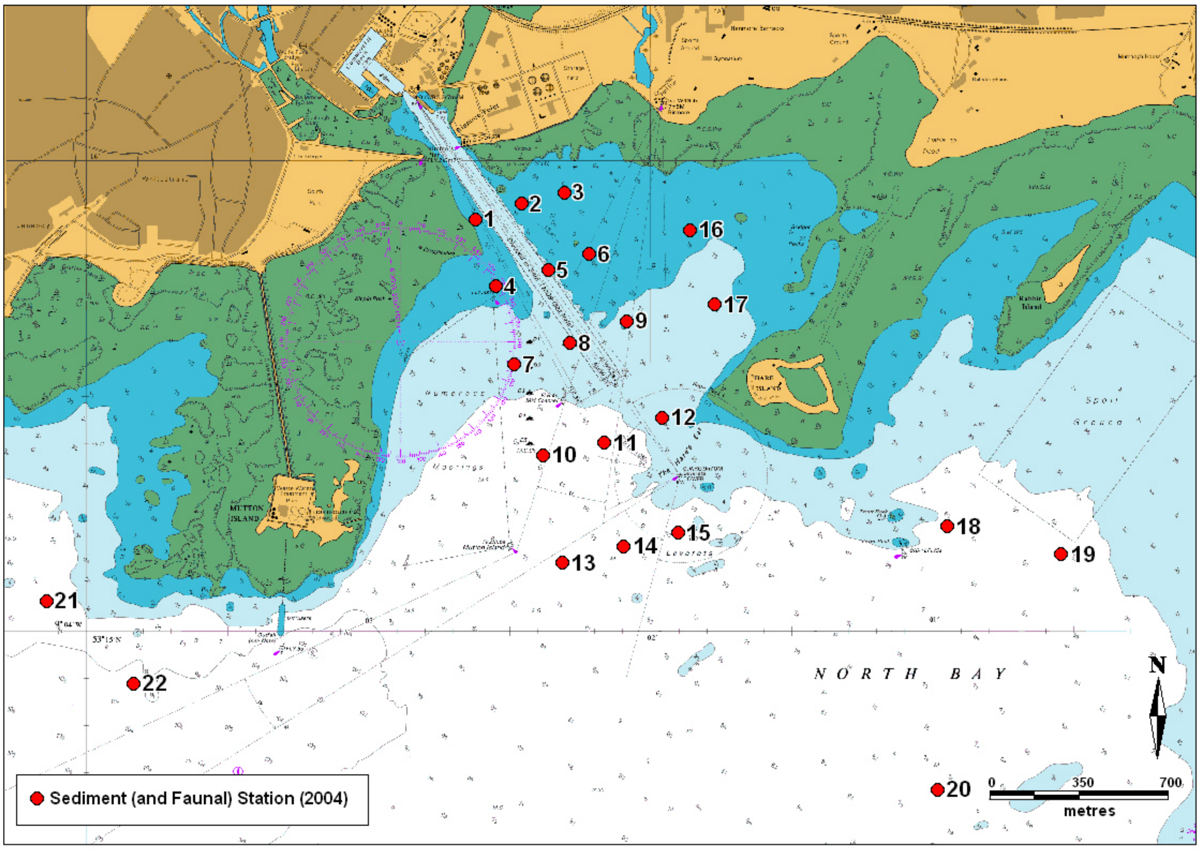


Figure 3. Station location map showing the 22 sites where the SPI camera was deployed in 2004.

Mean values for SPI analyses							
Station	**Major Mode (phi)**	**Mean Penetration (cm)**	**S.B.R. (cm)**	**Mean Redox (cm)**	**S.S.[1]**	**OSI[2]**	**BHQ[3]**
1	3 – 2	6.245	0.97	4.88	II	2	5
2	2 – 1	3.65	1.07	2	II	-1	4
3	2 – 1	4.05	1.32	>4.05	II	4.3	6
4	3 – 2	13.61	0.77	4.45	I	-0.3	2.3
5	2	5.97	9.42	1.57	I-II	-2	1.3
6	2 – 1	3.14	0.89	2.8	II	-0.5	2.5
7	4-3/3-2	>21 (op)	-	2	I	-1	2
8	2 – 1	14.16	1.23	4.37	II	4.3	6.7
9	3-2/2-1	12.23	1.02	5.07	II	2	5
10	4/4-3	17.96	1.9	2.5	I	-1	2.5
11	3 - 2	>21 (op)	-	1.5	I	-2	4.7
12	3 – 2	20.72	0.60	3.6	II	5	4
13	3 – 2	16.71	0.84	3.88	II-III	3.7	4
14	3 – 2	18.5	1.09	1.01	II	6	6
15	3 – 2	11.73	0.91	4.17	II	1.3	3
16	2-3/3-2	8.67	0.70	4.85	II	4	5
17	2-1/3-2	10.07	0.69	4.875	II	4.3	5.3
18	3 – 2	12.63	3.65	2	Azoic - II	-0.6	2
19	3 – 2	18.09	1.46	4.9	I-II	-1.3	2
20	1-0/3-2	16.04	0.68	3.45	I on III	1	2
21	2 - 1	2.62	2.09	>2.62	II	0	3
22	3 - 2	17.13	0.92	3.24	I-II	1.3	3

Table 1. Results for SPI analyses at 22 stations in Inner Galway Bay.

Rosenberg *et* al (2004) ascribe the following status to ranges of the Benthic Habitat Quality index (BHQ) scores in waters of less than 20 m:

15 - > 8 = High
8 - > 6 = Good
6 - > 4 = Moderate
4 - > 2 = Poor
2 - 0 = Bad.

From the above Table 1, it can be seen that 5 stations are rated as Bad, 9 as Poor, 7 as Moderate and 1 as Good. Overall, the BHQs recorded in the table indicate that this part of the bay has an over a low index. This reflects the long term effects of organic enrichment from untreated sewage historically in the city, the historic dredging and disposal of spoil from the approach channel, the seasonal high variability of salinity in the area and the effect of storms on re-suspending sediments there also.

With regard to the spatial pattern of habitat quality described by O'Reilly *et al.*(2006), of the 12 stations surveyed by them, data from only three sites (*i.e.* 4, 5 and 12) are comparable to the stations surveyed for the EIS and these are Stations 2, 5 and 18. O'Reilly *et al*. (2006) score these as being of poor habitat quality. Examination of the results shown in Table 1 above for the equivalent locations *i.e.* 2, 5 and 18 also scored these Stations as being of poor habitat quality.

(b) The potential impacts of maintenance dredging on Annex I habitats should be discussed.

Response

Of the Annex I marine subtidal habitats listed in the Conservation Objectives for Galway Bay cSAC issued by the National Parks and Wildlife only "large shallow inlets and bays ", "reefs" and "lagoons" occur near (not within) where maintenance dredging may be required. (N.B. "lagoons" are regarded as a Priority Habitat in the EU Habitats Directive).

With regard to the need for maintenance dredging, as there will be at most only the same amount of sediment coming in from the river/sea, the rate will be at most the same as it is at present. In fact with the Mutton Island causeway in place, the expected increase in current velocities anticipated due to the new structure and the decommissioning of the sewerage pipes in the Corrib River and off South Park, the sediment loadings will be somewhat less than in previous years. This in turn suggests a slower build-up of material within the proposed development area over time than is the case at present.

Information from the Harbour Master indicates that maintenance dredging occurs *ca* every 10 years *i.e.* when the channel has filled in to *ca* +50 cm over the last dredging episode. As suspended sediment loadings will be lower and current velocities will be higher, it is predicted that maintenance dredging will be required on a longer time scale than the current 10 years. The habitat where dredging will be required is defined by NPWS as "transitional water", a habitat that is not a qualifying interest for Galway Bay cSAC.

Simulations of sediments suspended during dredging operations were undertaken as part of the mathematical modelling studies (see Chapter 8 of the EIS). 4 points in the model domain were examined to provide predictions on the spatial extent of the sediment plume and concentration of suspended solids generated by dredging activities. The model results indicate that sediments fall out of suspension within short distancesof where they are mobilised and only very small amounts will be carried to areas where Annex I habitats occur. Predicted impacts on "shallow bay and inlets" and "reef" habitats from maintenance dredging in future years are therefore considered to be insignificant.

Output from one of the points in the model domain mentioned above which is closest to the mouth of Lough Atalia (a "lagoon" habitat) showed the potential for sediments suspended during dredging to enter the lagoon. In order to prevent this and to protect the ecological status of this priority habitat, dredging in this general area will only be carried out on an ebbing tide ensuring that suspended sediments are carried away from Lough Atalia.

As it is planned to dispose of the maintenance dredge material in a location sufficiently distant from any NATURA site, this aspect of the maintenance dredging will not affect Galway Bay cSAC.

5.3 METHODOLOGY FOR CALCULATION OF BENTHIC HABITAT QUALITY INDEX

Query:

Appendix 7.4 of the EIS does not detail the methodology used to calculate the Benthic Habitat Quality (BHQ) index. This index has also been adapted for the purposes of the WFD, including an adjustment for the decreased expected occurrence of high BHQ values in shallow water, by Rosenberg et al (2004). The SPI data should be analysed using this methodology to support the macrofaunal data in assessing the conservation status of the Annex I habitats. The applicant is requested to address this.

(a) Appendix 7.4 of the EIS does not detail the methodology used to calculate the Benthic Habitat Quality (BHQ) index.

Response:

The concept of establishing an index to classify benthic habitat quality was initiated by Pearson and Rosenberg in their seminal 1978 paper. In 1982, Rhoads and Germano developed the Pearson-Rosenberg model for use in the interpretation of sediment profile images and used infaunal successional stage and the depth of the apparent REDOX discontinuity to generate a value they termed the Organism Sediment Index (OSI). Nilsson and Rosenberg (1997) and Nilsson and Rosenberg (2000) refined the OSI by suggesting an objective way of defining the successional stage and therefore a more scientific calculation of the quality of the benthic habitat. This they termed the Benthic Habitat Quality and it was this method that was used to calculate the BHQ.

(b) The SPI data should be analysed using this methodology to support the macrofaunal data in assessing the conservation status of the Annex I habitats.

Of the 22 stations sampled in the 2004 SPI/grab survey (see Figure 3 above), only Stations 18 – 22 fall within the Annex I habitat “shallow waters and bays”. Output from the mathematical modelling study has shown that the areas around this set of stations will not be affected by sediments suspended during dredging operations or by any significant changes in current velocities or directions. There may be some changes in salinity at these sites as the plume of the Corrib will be restricted by the Galway Harbour Extension. This could cause both decreases in salinity due to greater volumes of river water passing over some stations *e.g.* Stations 21 and 22 or increases in salinity due to the fact the Corrib water may not access the sites *e.g.* Stations 18 and 19. This will depend of river flow rate and the tidal cycle. However, as the salinity of the overlying water will vary with the stage of the tide, it is unlikely that the pore water salinity will permanently change. It is therefore predicted that the conservation status of this Annex habitat will not be affected by the proposed development.

The habitat that is present where all other benthic sampling was undertaken in the same survey for the Galway Harbour Extension EIS falls under the habitat type described as “transitional waters” in the EU Habitats Directive and as shown in the NPW Conservation Objectives document for the Galway Bay cSAC. This habitat is not listed as an Annex I habitat for Galway Bay cSAC in that same document and therefore, as there are no conservation objectives for this habitat, its conservation status is not relevant.

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O'Reilly, R., Kennedy, R., Patterson, A. and Keegan,B.2006. Ground truth sediment profile imagery with traditional benthic survey data along an established disturbance gradient. Journal of Marine Systems, Vol. 62 :189 – 203.

Pearson, T. and Rosenberg., R. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanography and Marine Biology Annual Review.16 – 229 – 321.

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Rosenberg, R., Blomqvist, M., Nilsson, H., Cederwall, H. and Dimming, A. 2004. Marine quality assessment by use of benthic species-abundance distributions: a proposed new protocol within the European Union Water Framework Directive. Marine Pollution Bulletin, 49: 728 – 739.

5.4 ANALYSIS OF BARRIER TO RENMORE LOUGH

Query:

The information provided in relation to terrestrial and coastal habitats is not sufficient to describe the structure, sensitivity, functioning and correspondence with Annex I habitats of these communities. This is of particular concern in the receiving environment to the east of the proposed development where saltmarsh and stony banks occur. The stony banks that form part of the barrier to Renmore Lough require particular study. Relevant habitats include perennial vegetation of stony banks (1220) Atlantic salt meadows (1330) and Mediterranean salt meadows (1410). The NIS states that the potential impacts on these habitats are "unlikely but must be considered to be Indeterminate". More information should be provided describing these habitats with particular reference to their structure and sensitivity to the potential impacts of the proposed development.

5.5 POTENTIAL IMPACTS ON BARRIER TO RENMORE LOUGH

Query:

The applicant's study of coastal lagoons (1150) predates the storms of 2013-2014. A site visit by NPWS to these sites in 2014 has shown that the extent of stony banks has increased inland and into Renmore Lough. Further information is now required on the potential impacts of the proposed development on the stability of the barrier to Renmore Lough in light of these changes.

Response:

Dr. Michelene Sheehy-Skeffington, an acknowledged expert on salt marshes and stony bank habitats in Ireland was commissioned to undertake a site visit and to complete an assessment of the habitat. A visit was made to the seaward edge of L. Atalia to establish the changes in habitat brought about by the winter storms. The upper strandline, shingle area and habitat immediately north of this ridge were walked. The site was visited on 22nd July, 2014.

The shingle bank, formerly ca 1m in height, has been completely altered. Most of the shingle has been moved inland, forming a spit immediately to the south of Renmore Lough (site number 1 Fig. NIS(A) 5.1 below). More was spread along the inner edge of the grassy bank that used to form the inner (northern) edge of the shingle. It is likely that there were two sources of shingle –1) that present on the shore line and 2) material thrown up from the sea floor to the south of Renmore Lough.The shingle has been moved to such an extent that the seaward edge now forms part of the strandline and vegetation comprises species tolerant of tidal submergence such as spear-leaved orache *Atriplex prostrata,* sea rocket *Cakile maritima,* sea mayweed *Tripleurospermum maritimum,* sea radish *Raphanus raphanistrum maritimum*. On the higher ground, the vegetation and its soil was broken up, but still formed a band of grassy vegetation with creeping bent grass *Agrostis stolonifera,* perennial ryegrass *Lolium perenne,* red fescue *Festuca rubra,* false oatgrass *Arrenatherum elatius* forming the grass layer and a mixture of ruderal (weed) species such as colt's foot *Tussilago farfara,* nettle *Urtica dioica,* ragwort *Senecio jacobaea,* perennial sow-thistle *Sonchus arvensis* and smooth sow-thistle *Sonchus oleraceus*, along with calcareous coastal grassland species such as ribwort plantain *Plantago lanceolata,* field medick *Medicago lupulina,* bird's foot trefoil *Lotus corniculatus* and kidney vetch *Anthyllis vulneraria.*

The shingle, between sections of grassland, supports sea radish, spear-leaved orache and curled dock *Rumex crispus*.

Notable on the strandline and shingle was the rare *Lactuca tatarica*, once abundant on the shingle, but which had disappeared in recent years. This is the only known site for this alien species in Ireland (Reynolds 2002). The disturbance of the storms has exposed the seed-bank and this and the rare native black mustard*, Brassica nigra*, have appeared, the latter occurring sporadically on the inner edge of the shingle. This is the first time the black mustard has been recorded not only here, but in all of east county Galway (see map Fig NIS(A) 5.2 below; Preston *et al*., 2001), though it has been recorded on Inishbofin and on Inishmore, Aran Islands in the past (Webb and Scannell 1983). Another rare coastal transient species that used to be common on this shingle bar is henbane *Hyoscyamus niger*. It has disappeared since the 1980s, but the recent storm-induced re-working of the shingle and exposure of dormant seed banks may yet bring about a return of the species. This illustrates the conservation interest of such naturally disturbed habitats as shingle. But, since the former shingle ridge has largely now been flattened, it is unlikely that many species not tolerant to tidal inundation will remain, as the shingle is either at the strand-line, or adjacent to grassland that is likely to eventually colonise it. The effects of the construction are likely to only serve to stabilise the structure of the bar, though storm surges may wash over it, thus preventing the establishment of scrub with bramble sycamore and ash –all noted on this ridge. The complex of shingle and strandline vegetation comprise EU Habitats Directive Annex I habitats 1210 Annual vegetation of drift lines and 1220 Perennial vegetation of stony banks.

The southwest edge of the shingle merges into an eroded salt marsh. It is not clear to what extent it was intact before the storms, but it probably has been fragmentary for some time. Upper marsh species are present such as red fescue *Festuca rubra,* sea milkwort *Glaux maritima,* sea arrow-grass *Triglochin maritimum,* salt marsh rush *Juncus gerardii,* scurvey grass *Cochlearia officinalis* and sea aster *Aster tripolium.*

Most of the vegetation landward of the shingle bar comprises marsh and wet grassland. A small, probably brackish, pond has abundant reedmace *Typha latifolia* (area 2 on map Fig NIS(A) 5.1) and areas possibly intermittently flooded support extensive creeping bent grass *Agrostis stolonifera* with a fringe of sea rush *Juncus maritimus.* The edge of the inlet south of the railway line is bordered by some sea rush and salt marsh rush as well as sea club-rush *Bolboschoenus maritimus* and all three species indicate that this is largely a lagoonal type salt marsh. The drier –more elevated– parts of this area support bracken *Pteridium aquilinum* and some hawthorn *Crataegus monogyna* bushes. Some reed *Phragmites australis*, also occurs nearer the railway line.

In summary, the shingle now forms a low area of cobbles below High Water Spring Tide (HWST) with strand-line species and the bank behind this is mixed shingle and grassland on soil. This bank would only be breached by a storm surge, but if the wave force is attenuated by the proposed construction, it is less likely to be structurally altered to the extent it was in January 2014. A storm surge may flood the grassland behind the shingle, via the inlet from Lough Atalia or over the shingle, but the sea-water would drain off, such that the lagoonal salt marsh and grassland will not become very saline and the vegetation, already a mosaic of species tolerant of brackish or saline water (lagoonal marsh) is unlikely to alter to a great extent.

With the predicted greater stability as a result of the proposed construction, less storms will reach the shingle and salt marsh area. As shingle is of its nature a naturally unstable habitat, it is likely that the increased stability will alter the vegetation in the area of shingle above the HWST. This includes the shingle moved inland during the January 2014 storms. Shingle that becomes stable eventually becomes colonised with a heath grassland and/or grassland community, with a reduction of the adventive ruderals that benefit from the regular disturbance of the cobbles.

The salt marsh per se is only extensive north of the railway line. This is as mapped in Figure 5.1 below. Most of this salt marsh comprises upper marsh species, notably the relatively large sea rush that defines the physiognomy of much of the vegetation on the eastern side of L. Atalia. It overlies a deep peat that has fragments of reed suggesting it was a freshwater marsh in the past. Other species present are red fescue and salt marsh rush. This comprises EU Habitats Directive Annex I 1410 Mediterranean salt meadows (*Juncetalia maritimi*).

The only lower marsh present is in depressions, notably at points along the track north of the railway line, but this is very fragmentary. Species such as common salt marsh grass *Puccinellia maritima,* sea plantain, scurvy grass and sea aster are more abundant in these lower, more frequently-inundated areas. This is too fragmentary to be noted as a significant amount of Habitats Directive Annex I 1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*).

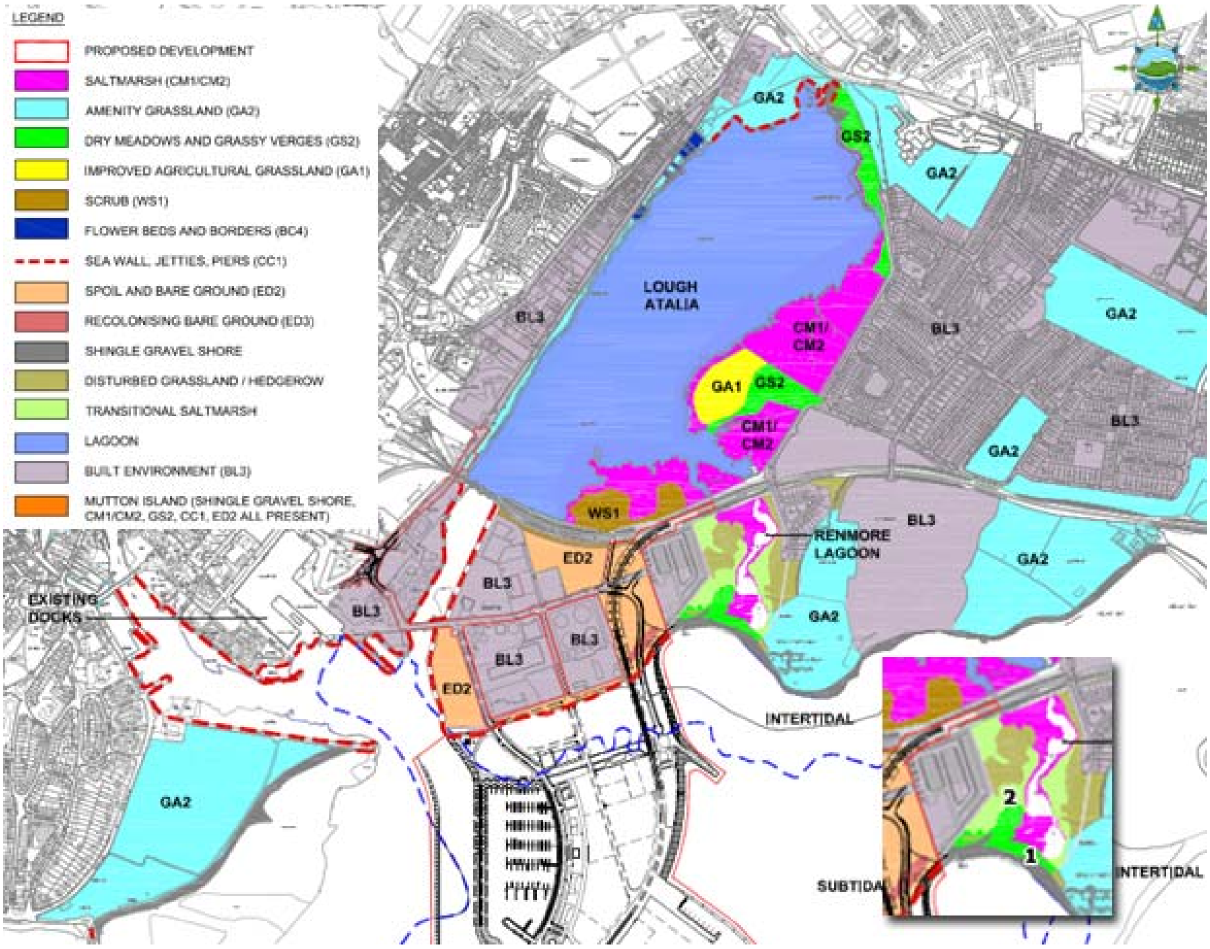

Figure NIS(A) 5.1 Terrestrial habitats present in the vicinity of the proposed harbour extension (copied from Original report Fig 2.8).

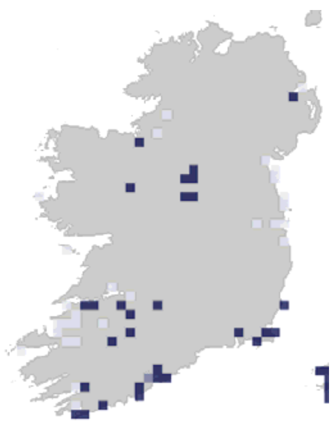

Figure NIS(A) 5.2 Fig. 2. BSBI map of 10 x 10km squares where *Brassica nigra* was recorded in *Atlas 2000* (Preston et al 2001). Lighter squares represent pre-1970 records. Note its complete absence from mainland County Galway and from inner Galway Bay specifically.

5.6 CLASSIFICATION OF IMPACTS

Query:

The first paragraph of Section 3.7 of the NIS states that an impact classified as "indeterminate" must be considered as "likely significant" when assessed with relevance to Article 6.3 of the Habitats Directive. In other words, "indeterminate" is not an acceptable classification for any potential impact. Despite this, the text of the NIS repeatedly classifies potential impacts as "indeterminate". The applicant is requested to re-evaluate the NIS with regard to these "indeterminate" classifications. You are requested to consider whether or not replacing them with "likely significant", as stated in Section 3.7, is appropriate so that the application can be fully assessed with relevance to Article 6.3. This applies to all text and tables in the NIS.

Response:

As part of the assessment process, occasions arose for certain habitats or species, or impacts thereon, where it was not possible to rule out the potential for impact. While in some instances it was not considered likely that the impact would be significant, it was not possible to fully assign a level of significance to the residual impact. In these circumstances, the level of impact was considered indeterminate. It is acknowledged however that under the precautionary principle that where the potential for impact remains, this is required to be considered as likely significant.

All of the text and tables within the NIS were reviewed and an assessment of the level of impact was further scrutinized where possible. All tables have been updated to reflect this process and are presented within the NIS Addendum / Errata document, most notably Tables 3.15 – 3.28.

6 ECOLOGY ISSUES – MARINE MAMMALS

6.1 POTENTIAL IMPACT ON HARBOUR SEAL

Query:

The potential adverse impacts on harbour seal are described in the NIS and EIS. Given the nature of the proposed development and the importance of the development location for harbour seal, more information is required to assess the potential effects on this Annex II species. A robust and comprehensive desktop analysis is required to address harbour seal aquatic habitat use in the area and the observed impacts of similar developments and associated coastal/maritime activities on harbour seal populations in other locations. This should be done with the assistance of a suitably qualified seal ecologist and be based on international scientific research as well as information currently available from Ireland. The purpose of this analysis would be to better inform and better determine appropriate final conclusions in the relevant impact statements regarding the likelihood and significance of any adverse effect on the conservation objectives of the site arising from the proposed development.

The following response was compiled with the assistance of Kelp Marine Research, by Dr. Fleur Visser and Machiel Oudejans, M.Sc. A copy of their final report, including full bibliography and references, is presented as Appendix RFI 2.2.

Response:

Aquatic Habitat use of the Harbour Seal (Phoca vitulina)

6.1.1 Introduction

Harbour seals are one of the most widespread pinniped species, distributed from temperate to polar regions throughout the coastal waters of the Northern Hemisphere (Thompson & Härkönen 2008). In Ireland, the harbour seal inhabits bays, rivers, estuaries and intertidal areas, primarily along the western Atlantic coast (Cronin et al. 2004, Ó Cadhla et al. 2007, Duck & Morris 2013a, b). Adult males are up to 1.9 m long and weigh 70-150 kg. Females reach 1.7 m in length and 60-110 kg in weight. At birth, pups are 65-100 cm long and weigh 8-12 kg (Burns 2002).

Harbour seals require both terrestrial and marine habitat. The terrestrial habitat use includes periods of resting, breeding/nursing and moulting behaviour, while access to sea is required for obtaining food and for nursing and mating. The terrestrial localities, generally referred to as haul-out sites, are often used by the same individuals over consecutive years (Thompson et al. 1998, Cronin et al. 2009). However, shifts in preferred haul-out sites have been known to occur within an SAC (Cordes et al. 2011).

The high site-fidelity for both foraging and resting behaviours classifies harbour seals as central-place foragers (Orians & Pearson 1979) and offers the opportunity for the identification of key habitat and the development of Special Areas of Conservation for this species (Thompson et al. 1997, Cunningham et al. 2008). The dependence on terrestrial habitat for resting, moulting and rearing pups has provided opportunities to conduct large-scale population assessments, identifying population growth and decline in different regions worldwide (Lonergan et al. 2007).

In Ireland, national harbour seal censuses were conducted in 2003 (Cronin et al. 2004) and in 2011-2012 (Duck & Morris 2013a, b). These recorded an 18% increase in the overall number of harbour seals between 2003 and 2012, from a total of 2955 to 3489 individuals (Cronin et al. 2004, Duck & Morris 2013b). These estimates could not be corrected for the proportion of animals at sea at the time of the survey and hence likely underestimate the total number of individuals (e.g. due to age- and sex related differences in haul-out behaviour; Thompson et al. 1989, Härkönen et al. 1999).

Harbour Seal in the Galway Bay cSAC

The harbour seal is a resident species of the Galway Bay cSAC and the species has been incorporated in the conservations objective target statement of the SAC (NPWS 2013). The inner Galway Bay is home to a significant population of harbour seals within Irish coastal waters (Duck & Morris 2013a, b). The area includes a number of haul-out, breeding and moulting sites for the species (NPWS 2013). Between 2003 and 2011, the number of harbour seals in the inner Galway Bay increased from 200 to 248 individuals (Duck & Morris 2013a, b). On a larger regional scale, harbour seals increased from 467 individuals in 2003, to 886 in 2011/12 in County Galway, an increase of 75% (Duck & Morris 2013b). Opposed to the terrestrial habitat use, relatively little is known about the aquatic habitat use of harbour seals in the Galway Bay cSAC.

During fish predation surveys 50 harbour seals were recorded foraging on sprat (Galway Harbour Company 2014). In addition, available water depth, habitat type, prey presence and proximity to haul-out sites suggest the Galway Bay cSAC likely functions as a foraging area for harbour seals.

6.1.2 Diving Behaviour

The diving and foraging behaviour of harbour seals have been studied using a variety of electronic recorders, including time-depth (TDR) and satellite dive recorders. By combining dive profiles, stomach temperature, telemetry and swim speed recordings, these studies have allowed the allocation of function to different dive types (e.g. Lesage et al. 1999). No studies using TDR or other recorders of diving behaviour have been conducted with harbour seals in the Galway Bay cSAC. Hence, no specific or detailed data is available on the diving behaviour of the harbour seal in the area.

Dive types

Harbour seal dives typically fall into one of two broad categories: deep foraging dives referred to as "square" or "U-shaped” dives, and "V-shaped" dives, which are often more shallow (Schreer et al. 2001). The remaining dives are a variation of these two shapes. The U-shaped dive is the most common dive type exhibited by the harbour seal (Baechler et al. 2001, Eguchi et al. 2005, Wilson et al. 2014).

U-shaped or square-shaped dives are typically considered foraging dives based on the increased proportion of time spent at depth (Wilson et al. 2014). These dives are often longer in duration and have a greater mean depth than V-shaped dives (Lesage et al 1999, Schreer et al. 2001, Eguchi et al. 2005). However, male harbour seals conducted U-shaped dives while travelling within their home range (Baechler et al. 2001) and as part of mating behaviour (Hanggi & Schusterman 1994), indicating this dive type is not solely linked to foraging. V-shaped dives consist of more shallow dives, which are generally shorter in duration than U shaped dives, and are associated with travelling, predator avoidance and exploration behaviour (Lesage et al. 1999, Schreer et al. 2001). The reduction in drag during V-shaped dives enables more efficient travelling, while potentially increasing the chances to encounter prey (Williams & Kooyman 1985). Harbour seals in St Lawrence conducted both U- and V-shaped dives during foraging behaviour, which may suggest that dive types represent different foraging strategies (Lesage et al. 1999). Wiggles in the dive profile have been observed in both U- and V-shaped dives and likely refer to patchy prey distribution (Wilson et al. 2014). Harbour seals typically conduct consecutive foraging dives within a dive bout, with only a small percentage of foraging dives conducted outside of these bouts (Wilson et al. 2014).

The proportion of U- and V-shaped dives changes with age, season and age-class. Adult males conduct more U-shaped dives than females (Baechler et al. 2001). The proportion of U-shaped by male harbour seals declined from 63 to 45% between premating and mating periods, indicating a behavioural change and alteration of aquatic habitat use in this period (Baechler et al. 2001). Subsequently, the proportion of V-shaped dives significantly increased during the mating season. Adult females altered their diving behaviour during periods of lactation: U-shaped dives increased significantly from early to late lactation, whereas the number of V-shaped dives decreased (Baechler et al. 2001). During the breeding season, both male and female harbour seals shifted towards more V-shaped dives (Wilson et al. 2014). Suckling pups showed an increase in U-shaped dives, and subsequent decline in V-shape dives between the early and late lactation period (Baechler et al. 2001). Weaned pups showed an increase of U-shaped dives over the first month post weaning, while the proportion of V-shaped dives significantly decreased (Baechler et al. 2001).

Diurnal patterns

Several studies reported diurnal dive patterns of harbour seals. In St Lawrence, harbour seals conducted U-shape dives with an average depth of 20 m during daylight whereas dives occurred in shallower waters (~8 m) at twilight and during the night (Lesage et al. 1999). A greater percentage of V-shaped dives was exhibited at night during the breeding season in San Juan Islands, along the US Pacific coast (Wilson et al. 2014). Harbour seals in Prince William Sound spent more time in-water and diving at night between September and April (80%) compared to 50% in July (Frost et al. 2001). Similar night time diving behaviour was reported for individuals in the Moray Firth, which was thought to reflect the diurnal behaviour of vertically migrating prey, which becomes more accessible at night (Thompson et al. 1989).

Time-in-water

Harbour seals generally haul out on sandbanks and rocky shorelines that become available during low tide (Schneider & Payne 1983, Pauli & Terhune 1987, Cronin et al. 2009). Some populations also use high tide haul-out sites (London et al. 2012). In general, seals spend most of their time in the water: 61%-93% in Moray Firth, Scotland (Thompson et al. 1998), 76%-93% in the Dutch Wadden Sea (Ries et al. 1997) and 68%-75% in Monterey Bay, US (Frost et al. 2001). Males and females spend a similar percentage of time in the water (Thompson et al. 1998). In the water, harbour seals spend most of their time foraging (e.g. 76% of the time in Moray Firth; Thompson et al. 1998). Multi day foraging trips are common, and appear to be conducted by both male, female and juvenile seals (Thompson et al. 1998, Lowry et al. 2001, Sharples et al. 2012, Wilson et al. 2014).

Time-in-water shows fluctuations on both daily and seasonal scales. In Ireland, harbour seals spent the most time at sea during the winter months and remained the most time ashore post-moulting in October (Cronin et al. 2009). This pattern is consistently reported in other studies (Frost et al. 2001). Terrestrial habitat use increases during the breeding and moulting season when harbour seals spend approximately 60% of their time on the haul-out site and 40% in the water (Yochem et al. 1987, Thompson et al. 1989). Frost et al. (2010) suggested that prey may become more abundant in near shore waters in summer, resulting in seals spending less time in the water. Subsequently, a deeper mean dive depth was recorded during winter months compared to summer months, which suggests that prey becomes less accessible in shallow waters during this period (Frost et al. 2001). Harbour seals in Prince William Sound spent the least time in the water diving in the morning (0300-

0900), which increased throughout the day and was highest at night (2100-0300; Frost et al. 2001).

Diving depth
Harbour seals prefer water depths ranging from 4 to 100 m depth (Bjørge et al. 1995, Lesage et al. 1999, Lesage et al 1999, Frost et al. 2001, Bailey et al. 2014). For example harbour seals in Prince William Sound have nearby access to waters >200 m deep, while the majority of their foraging dives are confined to waters 20-100m deep (Frost et al. 2001). The at-sea distribution of harbour seals in the Moray Firth was related to water depth and seabed slope (Bailey et al. 2014). Here, harbour seals showed a preference for foraging in water depth between 10 and 50 m, and tended not to use waters less than 10 m deep (Tollit et al. 1998). In contrast, in the St. Lawrence estuary in eastern Canada, fifty-four percent of the total dives of harbour seals were found to be in water less than 4 m deep (Lesage et al. 1999).

Diving and foraging strategies of harbour seals are tailored to their local habitat and hence differ within a heterogeneous marine landscape. Regional patterns in dive depth were identified as part of a large-scale study of harbour seal behaviour around Britain. Based on a large dataset including data from all main harbour seal haul-out sites, Sharples and colleagues (2012) found large regional variation in dive patterns coinciding with habitat type and available water depth surrounding the haul-out sites. Typically, individuals inhabiting the more shallow waters along the British east coast conducted longer distance foraging trips than seals inhabiting the deeper waters north and west coast of Scotland (Sharples et al. 2012). In addition, regional patterns showed a relation between maximum depth during foraging and accessible habitat (Sharples et al. 2012).

6.1.3 Foraging behaviour

Sensory detection of prey
Harbour seals use their whiskers to detect water movement and accurately follow hydrodynamic trails generated by fish, which enables long distance prey location (Dehnhardt et al. 1998, 2001). Seals maximally reduce the whiskers' basic noise by means of an undulating the surface structure of the hair. This optimizes its signal to noise ratio and enhances its sensory performance (Miersch et al. 2011). In theory, a hydrodynamic trail of a fish (e.g. herring), might be detectable for a seal up to 180 m away (Dehnhard et al. 2001). Using its extraordinarily well-developed vibrissae, seals are capable of foraging at night and in murky waters, besides using vision to search and catch prey during daytime. As all other pinnipeds (and cetaceans), the harbour seal is considered to be functionally colour blind (Peich et al. 2001). The sensitivity of the eyes however, is high, and seals are probably able to orient visually even at great depth (Levenson & Schusterman 1999).

Diet
Harbour seals are opportunistic and catholic feeders (Harkonen 1987, Pierce & Santos 2003, Andersen et al. 2004, Kavanagh et al. 2010). Within the northeast Atlantic, they feed mainly on teleost fish species (Kavanagh et al. 2010). In the Moray Firth, harbour seals mainly foraged in waters between 10 and 50 m deep (Tollit et al. 1998). Mid-water dives recorded during foraging trips were thought to be encounters with pelagic prey (Tollit et al. 1998).

A relatively small number of species dominates the diet of harbour seals, but seasonal shifts in diet are seen in many areas, associated with seasonal fluctuations in prey availability (Brown and Mate 1983, Tollit et al. 1998). The diet of harbour seals in the Moray Firth consists primarily of bottom associated prey species (Tollit & Thompson 1996), including sand eel, lesser octopus, whiting, cod and flounder. Similar diets were recorded during in Scotland (Pierce et al. 1991), Sweden (Harkonen 1987) and Iceland. Sand-eels consisted of the main prey during the summer months both in Scottish and Baltic coastal waters, gadoids contributed to the diet in winter, while cephalopods were mostly recorded in summer, coinciding with seasonal prey availability in coastal waters (Tollit and Thompson 1996, Tollit et al. 1998). Harbour seals along the Irish west coast hunt on a wide variety of prey, with a few dominant prey species (sole, sand eel and Trisopterus species) representing the majority (47%) of the diet biomass (Kavanagh et al. 2010). Harbour seals in Puget Sound, US, inhabiting rocky-reef sites, foraged on bottom dwelling species (Lance et al. 2012). A large part of their diet consisted of vertically migrating schooling fish including herring, Pacific hake and salmon (Lance et al. 2012).

Foraging strategy

The foraging behaviour of a harbour seal varies with season, species and locality. They are opportunistic predators, changing their foraging tactics depending on the behaviour and distribution of the prey species (Middlemas et al. 2006, Thomas et al. 2011), which correlate with habitat and sediment type (Payne et al. 1989). Seasonal differences in diet composition as well as inter-annual variations found within haul-out sites, further stipulate the ecological flexibility of the harbour seal diet. This opportunistic character is illustrated by a rare observation of a foraging event within the Galway Bay cSAC, whereby numerous harbour seals were feeding on a large shoal of sprat (Galway Harbour Company 2014).

In general, optimal foraging conditions are influenced by i) local bathymetry, ii) the ability to maximise foraging time, iii) and the availability of prey. Analysis of foraging behaviour using time depth recorders (TDRs) showed that harbour seals generally forage at or near the seabed (e.g. Harkonen 1987, Bjorge et al. 1995). Telemetric studies identified that the species forages within 50 km of haul-out sites, and primarily within 10-20 km (Tollit et al. 1998, Thompson et al. 1998, Cunningham et al. 2008, Wilson et al. 2014). In many areas, harbour seals exhibit two foraging strategies (Thompson et al. 1998, Grigg et al. 2009). In one strategy, harbour seals make short, daily trips to and from foraging areas near the haul-out site; in the alternative strategy, harbour seals make longer foraging trips to more distant foraging areas, often lasting for a number of days and followed by extended haul-out period. Grigg and colleagues (2009) reported a spatial overlap between harbour seal distribution at sea and distribution of prey within San-Francisco Bay. This overlap was found to be more accurate within 10 km and declined with increasing distance from the haul-out site. Furthermore, Grigg and colleagues (2009) revealed that harbour seals often return to the same foraging area, showing that they are able to identify foraging areas over long time scales. Similar preferences for and repeated usage of foraging areas were recorded in the Moray Firth (Thompson et al. 1994, Cordes et al. 2011, Bailey et al. 2014).

Recordings of foraging trip durations in the Moray Firth showed that over 70% of the harbour seals made foraging trips longer than 24 h. Similar trip duration was observed in south-west Scotland (25 h) and in north-west Scotland (35 h; Cunningham et al. 2009) and for individual seals along the Irish west coast (Cronin et al. 2009). In the Moray Firth, a positive relation was found between the length and the body mass of an individual and the duration and length of the foraging trip: larger males conducted the longest foraging trips (Thompson et al. 1998). No such correlation was found between forage trip distance and body mass during a study along the Scottish west coast (Cunningham et al 2008). Foraging behaviour of adult females changes during the breeding season (Thompson et al. 1994). During pre-pupping period, adult females conducted regular foraging trips. During the pupping period, long distance foraging trips ceased, and females remained within 2 km from the haul-out site, indicating a reduction in home range during this period. 10-24 days after the pupping period, long distance foraging trips resumed (Thompson et al. 1994).

Sex- and age-class specific foraging behaviour
Studies on harbour seals in the Moray Firth found a correlation between body mass, dive duration and dive depth, indicating larger adult seals conducted deeper and longer dives (Tollit et al. 1998). This likely results in a reduction in intraspecific competition for food resources in inshore areas. Here, both foraging range and foraging-trip duration were observed to be relatively short for the body size of females compared to males (Thompson et al. 1998). Thompson et al. (1998) furthermore suggested that harbour seals would forage as far as possible within the energy and time budget, which is constrained by their body-size. A positive relationship between body mass and dive duration of long dives was also reported for harbour seals in Monterey, California (Eguchi et al. 2005). In contrast, no body mass relationship was apparent for harbour seals along the Scottish west coast (Cunningham et al. 2008). The authors argued that food availability requirements for all individuals, regardless of sex or size, were accessible within easy range of the haul-out cluster throughout the year. Similarly, no body mass-dive correlation, or sex-related differences in at-sea movements were recorded in harbour seals inhabiting Prince William Sound (Lowry et al. 2001). In Prince William Sound, where the bathymetry is highly variable and a large range of water depths is available to seals within a few kilometres from their haul-out site, harbour seals prefer water depths between 20-100 m (Lowry et al. 2001). Interestingly, the horizontal foraging ranges of seals were found to be fairly similar to those for harbour seals in other areas (Lowry et al. 2001).

Pup foraging
Harbour seal pups are exceptional among phocids due to their ability to swim and enter the water soon after birth (Bowen et al. 1999). Pups perform dives associated with foraging before weaning (Jorgensen et al. 2001), and may accompany their mother at sea during foraging trips (Bowen et al. 1999). As a result, harbour seal pup development contains a large aquatic component. Studies using stomach temperature telemetry identified that pups primarily nurse in water (Schreer et al. 2010) and ingest approximately two-third (68%) of the milk when in water (Sauve et al. 2014). Accordingly, female harbour seals undertook foraging trips beyond the first week of lactation (Thompson et al. 1994).

6.1.4 Movement patterns

Range
Harbour seals are capable of travelling long distances, covering several hundreds of kilometres during foraging trips (Lowry et al. 2001). Several studies have investigated foraging behaviour and movements of harbour seals using VHF radio-telemetry (e.g. Allen 1988, Thompson et al. 1989, Thompson & Miller 1990, Bjørge, et al. 1995). Individual harbour seals foraged within 50 km of haul-out sites, with the majority of individuals remaining within 10-20 km from the haul-out site. More accurate satellite telemetry studies in recent years confirmed these small-scale movement patterns within coastal waters (Cunningham et al. 2008), while simultaneously identified offshore trips formed a larger component of the harbour seal movement patterns than previously described (Sharples et al. 2012, Peterson et al. 2012).

Several studies identified individual harbour seals to conduct multi-day foraging trips that covered several hundreds of kilometres from the haul-out location (Lowry et al. 2001, Cunningham et al. 2008, Cronin et al. 2009). Analysis of behavioural data of 118 tagged harbour seals in seven core regions around Britain showed a high variability between individual at-sea movements (Sharples et al. 2012). The results furthermore revealed that the observed variations in trip duration and distance travelled could not be explained by differences in size, sex and body condition of the tagged individuals, but concluded that foraging variability was best supported by habitat and environmental constrains at a regional level. In addition to the haul-out fidelity and adjacent movement in coastal waters, the study identified a more pronounced offshore component in the movement pattern of the harbour seal than previously identified, and wide-ranging movements into offshore waters were observed in all colonies along the British coasts (Sharples et al. 2012). Similarly, a high number of tagged adult males in Paddila Bay, near Vancouver Island, Canada, conducted long distance movements >100 km (Peterson et al. 2012). Preferential use of certain habitats or response to spatio-temporal changes in prey density may explain such movements (Peterson et al. 2012).

Age- and sex-specific variation in movement patterns

Individual variation in movement patterns was evident in most studies. In the Moray Firth, adult male seals conducted longer foraging trips and covered larger distances than females (Thompson et al. 1998). In contrast, Lowry et al. (2001) found that juvenile harbour seals in Prince William Sound (PWS) travelled larger distances, moved between more spread out haul-out locations, and ranged further offshore during foraging trips than adult seals. The average distance from haul-out sites of the smaller juvenile harbour seals in PWS was almost twice as far as for adults. Juvenile dispersal, emigration and establishment of new haul out sites are possible reasons for long-range movements of harbour seals (Burns 2002).

Home range

Thompson and colleagues (1998) reported that the mean foraging range, and hence the home range for adult males was larger than that for females. In contrast, females in Prince William Sound exhibited larger home ranges than males, and home range size variations showed large variations over the year (Lowry et al. 2001). Furthermore, juveniles were found to maintain a greater home range, and travelling longer distances between haul-out sites than adult seals in Prince William Sound (Lowry et al. 2001). Seasonal variation in home range size is linked to behavioural patterns during breeding and moulting. Female home range declined with the onset of pupping when females remained within 2 km from the haul-out site (Thompson et al. 1994). In Prince William Sound, both male and female harbour seals showed a similar decline in home range during the breeding season, however, male home range size showed more variation (Lowry et al. 2001).

Site fidelity

Intensive short-term studies have shown that harbour seals display high levels of site-fidelity over periods of months to years (Härkönen & Heide-Jørgensen 1990, Thompson et al. 1997). Observations in many regions have shown that harbour seal pupping sites are used consistently in successive years (Lonergan et al. 2007). Satellite derived telemetry data collected during two years revealed that harbour seals in southeast Scotland spent 39% of time within 10 km of haul-out sites between November and June (Sharples et al. 2009). Along the southwest coast of Scotland, individual seals used on average 13 haul-out locations (range 6-29, Cunningham et al. 2008). The number of sites was positively correlated with the duration of tag deployment, suggesting individuals do visit more haul out locations over time. The seals used different haul-out sites in the autumn/winter (October to February) compared to spring/summer (March to July) (Cunningham et al 2008). The distances between these seasonal haul-out sites ranged between 40 and 130 km. In addition, almost half of the identified haul-out sites were not used for return trips and described as transient sites, while only a small number of haul-out sites showed a high level of individuals returning back (Cunningham et al. 2008). Cordes and colleagues (2011) described changes in the long-term pattern of haul-out use in the Special Area of Conservation in the Moray Firth, Scotland, showing considerable inter-annual variability in both abundance and the relative importance of areas within the SAC, and nearby areas (Cordes et al. 2011). Over a 20 year period, the harbour seal distribution shifted from the SAC to a nearby estuary, resulting in a drastic decline in mother pup pairs within the SAC. The foraging areas used by females remained broadly the same during both periods, hence the redistribution was thought to be caused by a decline in the quality of the haul-out, rather than a change in foraging behaviour (Cordes et al. 2011).

6.1.5 Mating behaviour

The mating structure of the harbour seal is described as a lek-system in which males aggregate and display to attract females (Bradbury 1981). During the mating period, male seals use multiple tactics to acquire access to females (e.g. Hayes et al. 2004, Boness et al. 2006).

Mating behaviour of the harbour seal occurs mainly in the water (Van Parijs et al. 1997). The mating season has been described to start directly after the suckling period, at end of lactation (Thompson et al. 1994, Van Parijs et al. 1997). At the start of the mating period, males spend more time in the water and the size of the home range decreases, in order to increase their chances of encountering females (Boness et al. 2006, Cunningham et al. 2008). Male seals change their diving behaviour and show an increase in short shallow dives (Van Parijs, et al. 1997). These shorter dives form part of an underwater display behaviour, during which males produce simple stereotyped broadband roar vocalizations for the purpose of attracting females and competing with other males (Van Parijs et al. 1997, Bjørgesæter et al. 2004, Boness et al. 2006). Various acoustic vocalisation behaviours have been identified including single male display, and aggregations of multiple males (Hayes et al. 2004). This display behaviour may occur near haul-out sites, in foraging areas, and on transit between both sites (Van Parijs et al. 2000a, Hayes et al. 2004). Male seals established different acoustic and display based territories, through which females freely travelled (Hayes et al. 2004). Acoustic evidence indicated that areas were occupied by single males (Van Parijs et al. 2000b). Site-fidelity to territories was found to last at least 2-4 years (Van Parijs et al. 2000b, Hayes et al. 2004). Female harbour seals choose males based on the display and vocal display (Hanggi and Schusterman 1994, Boness et al. 2006).

6.1.6 Anthropogenic Impacts

The type and the severity of a behavioural response as a result from an anthropogenic disturbance are variable and dependent on multiple abiotic (e.g. type of disturbance, the frequency of occurrence, time of day), and biotic factors (e.g. behavioural state, group size, habituation; Bejder et al. 2009). Biological disturbance due to anthropogenic noise has been receiving more and more scientific attention over the past decade. Leading in this field is the information on cetaceans, as they are known to rely heavily on sound and feature on most agreements of species protection. Pinnipeds have been somewhat less studied, possibly because they forage by sight and sense rather than sound (Schusterman et al. 2000). Currently however, there remains a large uncertainty about the extent to which predicted noise levels may impact individual seals (Thompson et al. 2013), illustrated by the preliminary nature of the noise exposure criteria developed by Southall et al. (2007). Nevertheless, it is recognized that acoustic disturbance is an important issue in pinniped conservation, because of the relatively high sensitivity of these animals to low frequency sounds, which constitute most anthropogenic noise. For example, disturbance of foraging behaviour is predicted to lead to increased competition for food, greater energetic cost of foraging, or reduced foraging opportunities, which likely will cause a reduction in an individual seal's overall energy balance followed by a decline in reproductive success and consequences and population-level (Thompson et al. 2013).

Direct effects

Both pinnipeds and cetaceans have been documented with mild to severe and lethal trauma after vessel collision (Moore et al. 2013). Distinctions can be made between blunt and sharp trauma, which are caused by rotating and non-rotating parts of the vessel, respectively (Moore et al. 2013). Different factors can affect the severity of the impact, such as vessel size and velocity, the angle at which collision takes place, and the anatomy of the body part that is hit (Laist et al. 2001, Vanderlaan & Taggart 2007, Moore et al. 2013). The likelihood of such collisions is thus far unclear, as frequency studies have only been conducted for species with very high incidences of collisions, such as right whales (Kraus et al. 2005). It has been stated that the number of collisions generally does not pose a threat to a species on population level (Weinrich et al. 2010), but quantitative reports on this matter have yet to be written.

Seals can taste the water, when opening the mouth, and their eyes are continuously exposed to whatever dissolved irritants there may be in the water. Such chemical pollution, irritating or even harmful to the seals could potentially be present during construction.

Direct disturbance and/or injury due to sound and intensified motorised vessel/plant/construction activities

Few studies have investigated the effect of disturbance on harbour seal behaviour. A controlled behavioural response study was conducted to investigate the anthropogenic impact on harbour seal haul-out behaviour (Anderson et al. 2012). The study, conducted within a seal reserve in Denmark during the breeding season, recorded the flight initiation for two stimuli: an approaching vessel and a pedestrian. The results showed that harbour seal decision-making strongly influenced by the fleeing of neighbouring seals and seals became alert at greater distances with increasing group size. Furthermore, harbour seals responded to boat disturbance at significant greater distances than to an approaching pedestrian. Seals were alerted by approaching vessels at distances ranging between 560 to 850 m, and a flight response was initiated at distances ranging between 510 to 830 m (Anderson et al. 2012). For pedestrian approaches distances were shorter and ranged between 200 to 425, and 165 to 260m respectively. These patterns of response were consistent during pre-during and post breeding periods.

Johnson and Acevedo-Gutierrez (2007) observed that harbour seals were less affected when powerboats and kayaks passed by, but did flee when powerboats were approaching within 400 m. This difference may relate to an approaching vessel possibly blocking the direction of the seal's escape route (Anderson et al. 2012). During the breeding period, harbour seals may be very reluctant to flee completely from the haul-out site on approaching boats, and harbour seals returned significantly sooner to the haul-out site than for non-breeding period (Anderson et al. 2012). This reluctance to leave has been reported in other harbour seal populations (Henry & Hammill 2001). Interestingly, seals did not return until sunset irrespective of disturbance type when disturbances occurred outside the breeding season (Anderson et al. 2012). In addition, indirect effects, such as disturbed birds may cause an increased alert response by seals at a larger distance.

Grigg and colleagues (2012) identified that anthropogenic activity had a relative low influence on the aquatic distribution of seals in San Francisco Bay. Harbour seal distribution was primarily determined high prey abundance and distance from the haul-out site. In fact, seals were found closer than expected to human activity, which included fishing activity, other (boat) activity and outflow locations. Harbour seals in Hood Canal, Washington, altered their haul-out pattern to coincide with peaks in anthropogenic activity. During periods of high human interactions in the summer, harbour seals were less likely to haul-out during the day, but instead hauled out more during night-time (London et al. 2012). In autumn and winter, when interaction rate was low, this shift was reversed.

Harbour seals may interact with fisheries, especially in coastal waters (Cosgrove et al. 2013). Cronin and colleagues (2014) conducted a review of fisheries interactions between harbour seal and fisheries in Irish waters. Grey seal interactions were found to be significant in inshore waters (<12 nautical miles from shore), and especially with static-net (or passive) fisheries (e.g. gill/tangle nets), which have increased following the driftnet ban in 2006. While little direct evidence is available, Cronin et al. (2014) assumed given the inshore distribution of the harbour seal, interactions are likely to be comparable between grey and harbour seals in Irish waters.

In Ireland, the use of pingers, or seal scarers, at salmon farms was effective, but only in the short term. Seals soon became habituated to the devices, which then were perceived to act as attractants (Cronin et al. 2014). Acoustic Deterrent Devices (ADD) were effectively used to reduce seal movements up Scottish rivers in which interactions between salmon rod and seals occurred (Graham et al. 2009). However multiple studies have reported the short effectiveness of acoustic deterrent devices with seals (Jacobs & Terhune 2002, Götz & Janik, 2013). In these cases, animals may tolerate or habituate to high noise levels (i.e. as the result of food motivation) and consecutively may suffer hearing damage, further reducing the responsiveness to ADDs (Götz & Janik, 2013). An additional side-effect of ADDs is that they may have an ecological effect on other marine species, in particular the harbour porpoise. New methods are currently developed that use selectively inflicted startle responses in harbour seals by using a frequency range that is sensitive to harbour seal, but less sensitive for non-target species including the harbour porpoise (Götz & Janik, 2014). The use of ADDs and pingers have the potential to be used as a conservation measure. During construction of offshore windpark in Denmark, seal scarers were used to keep seals and harbour porpoise away from the construction site, in order to prevent them from severe noise impact (see further below: Edrén et al. 2004). Likewise, Tougaard et al. (2006) found acoustic deterring devices (Aquamark 100, Lofitek seal scarer) to be efficient in order to deter seals and harbour porpoise out to safe distances, during piling, and anchoring of vessels during wind farm construction.

Industrial development

Long-term displacement of seals was recorded in Broadhaven Bay, Ireland during an offshore construction of a pipeline (Anderwald et al. 2013). The impact of the industrial construction resulted in a negative correlation between vessel number and seal abundance. Based on analysis of the vessel type, the authors stated that the observed decline was more likely caused by increased levels of underwater noise, than by increased collision risk. In recent years, the construction of offshore wind farms have resulted in an increase of studies investigating the effect of industrial developments on marine mammals. Koschinski and colleagues (2003) examined the reactions of harbour porpoise and harbour seal to playbacks of simulated noise from an offshore wind turbine (30 and 800 Hz peak source levels of 128 dB (re 1 µPa^2 Hz^{-1} at 1 m) at 80 and 160 Hz (1/3-octave centre frequencies). Underwater recordings were modified to simulate a 2 MW and used during a controlled playback scenario monitoring seal behaviour. The results showed harbour seals reacted at a distance of 200 m from the underwater speaker by making fewer surfacings. Madsen et al. (2006) criticised the research set-up and argued that the procedure introduced high frequency noise artefacts, to which species may have reacted instead of to the low frequency.

Short-term displacement effects were reported during the construction and operation of a wind farm in the Wadden sea, Denmark (Edren et al. 2010). Here, sheet pile driving during the construction phase caused a 10 to 60% reduction in the number of seals hauled-out on a sand bank approximately 10 km away, compared to periods with no pile-driving. Simultaneously with the pile driving, a seal deterrent (189 dB re 1 _Pa at 10–15 kHz) and porpoise pingers (145 dB re 1 _Pa at 20–160 kHz) were deployed from the pile driving platform and activated 30 min prior to pile driving at the turbine foundation to limit the number of seals and porpoises exposed to physically damaging noise. After the construction period, seals continued to use the haul-out site and abundance increased similar as recorded in nearby sites, indicating no long-term effects (Edren et al. 2010). During the construction phase, sound levels were not measured and seal behaviour in water was not monitored. Therefore, it remains unknown whether the seals reacted to under-water noise by leaving the general area, or reacted to airborne sound by remaining in the water.

Harbour seal movement patterns using satellite tags, showed scattered presence of harbour seals around the construction site during baseline and construction periods and a more consistent presence during operation of the wind farm (Teilmann et al. 2006). Unfortunately, the accuracy of the positions retrieved from satellite transmitters were found to be insufficient to conclude with certainty on the degree to which construction of the wind farm has affected seal movement patterns. After completion of two wind farms in the Danish Wadden sea, a study investigating harbour seal movements indicated no significant long-term effect of the operational wind farms on seal behaviour (McConnell et al. 2013). Seal dive and movement patterns showed individual seals moved inside and outside the wind farms within close proximity to individual wind farm towers. Operational noise from wind turbines at sites in Denmark and Sweden, was reported to be measurable only above ambient noise at frequencies below 500Hz, resulting in audibility for harbour seals from <100m to several kilometres (Tougaard et al. 2009). The authors concluded that operational sound levels may cause behavioural effects of harbour seals up to distances of a few hundred meters, while it was not thought to mask important biological sounds. Aerial counts of harbour seals during moulting in August, before and during the construction of the Øresund bridge, did not observe a reduction in the number of seals lying on rocks within 1.5 km of the bridge, although there was a tendency to use rocks further away from the work than previously (Heide-Jørgensen & Teilmann 1999).

To assess population-level impacts of a proposed wind farm construction on harbour seals using the Dornoch Firth and Morrich More SAC, Moray Firth, Thompson et al (2013) developed a framework model. The impact assessment model predicted based on the spatial overlap of received sound levels and seal distribution, in combination with estimates of the impacts of noise exposure, potentially predicts a large number of seals being either displaced or experiencing PTS. However, the population modelling used within the framework showed these short term effects did not result in long-term changes to the viability of this population, and identified immediate recovery after the construction phase (Thompson et al. 2013). Despite the fact that the framework benefited from a long history of research on the Moray Firth harbour seal population, it was recognized that the impact assessment incorporated a considerable level of uncertainty.

6.1.7 Discussion and conclusions

The harbour seal occurs in estuarine, coastal and offshore waters and utilises aquatic habitat for foraging, mating, nursing and breeding. The species is widely distributed and shows large flexibility in habitat use. Generally, harbour seals forage in waters up to 100 m depth, at 10 to 50 km from their haul-out sites. Harbour seals mainly forage within 10 to 20 km from their haul-out sites, but offshore trips (20 - >50 km) form an important part of their foraging strategy. Furthermore, harbour seals can show site-fidelity to specific foraging areas.

Potentially strong variation in diving behaviour, habitat use, ranging patterns, diet and foraging strategies between age- and sex classes exists, and may render certain individuals more sensitive to disturbance, or to changes in their habitat. In addition, these differences between age- and sex-classes generally vary between areas, for example depending on prey availability or habitat-type. Most studies show large individual variation, which reduces the extent to which individual behaviour can be used to predict population level effects. With the exception of mothers with nursing calves, it is therefore not possible to conclude which part of the population in the Galway Bay cSAC may be more or less vulnerable to the proposed construction activities. Nursing calves may accompany their mothers on foraging trips and are often nursed in the water. Ranging patterns during pupping, and of nursing mothers and calves, are more limited than those of the other life stages in the population, restricted to the areas more proximate to haul-outs. This spatial restriction will render them more vulnerable to disturbance from the marine construction activities associated to the Galway Harbour Extension.

Information on the aquatic habitat use of harbour seals in Ireland remains limited. However, the proximity to harbour seal haul-outs, the presence of water depths preferred for foraging (10 – 100 m), and of suitable habitat types and prey species in the area, in combination with observations of foraging harbour seals, suggest that the area can be used for foraging. In addition, it is furthermore likely that areas in proximity to the haul-outs are used for mating, nursing and during breeding, or as a travelling corridor by individuals in the Galway Bay cSAC.

Assessment of potential impacts associated with Construction Processes

2A. Dredging

Dredging will be performed by two different types of vessels in the proposed project: Trail Suction Hopper Dredgers (TSHD), and backhoe dredgers. The type of substrate determines which vessel type will be used. As one type of dredging is noisier than the other, there are two sets of peak levels that have to be taken into account. Peak levels are 133-185 dB re 1 µPa and 143-195 dB re 1 µPa for TSHD and backhoe dredgers respectively (De Jong et al. 2011, Robinson et al. 2011, Appendix 10.2 Galway Harbour Company 2014). Permanent and Temporary hearing Threshold Shifts (PTS and TTS) can occur for both pinnipeds and cetaceans, if they venture too close to the sound source (Galway Harbour Company 2014). Unless individual animals would be very close to, or attracted by the dredging activities, (hearing) injury or death resulting from these activities is unlikely. The proposed mitigation measures would effectively mitigate against these effects (Table 1).

The intensity and duration of noise related to dredging is such that it can cause PTS, TTS and behavioural changes (Table 1) in seals. In harbour seals, behavioural changes such as area avoidance have been estimated to occur from sounds with an intensity of 55 dB above hearing threshold (Thompson et al. 2013). The peak frequency of dredging noise lies around 125 Hz, which is in the most sensitive part of harbour seal hearing range. Therefore, dredging has the potential to cause behavioural disturbance for the resident harbour seal.

2B. Pile driving

Since the construction of wind farms generally involves pile driving, a lot of documentation can be found on the effects of this sound source on marine mammals and fish alike (Carstensen et al. 2006, Bailey et al. 2010, Thompson et al. 2010, Brandt et al. 2012, Dähne et al. 2013, Kastelein et al. 2013). Because of its high intensity and pulse-like structure, pile driving noise is one of the most disturbing anthropogenic noises underwater to date. The intermittent temporal structure inhibits quick habituation (Neo et al. 2014), while the high intensity can cause TTS or and PTS (Southall et al. 2007).

For harbour seals, Thompson et al. (2013) simulated the construction of two piles in the Moray Firth, UK. Behavioural disturbance was modelled to start at 80 km from the sound source in open water. However, the amplitude of pile driving depends upon the diameter of the pile and the technique used to drive it into the ground. Since the piles used in the proposed project are smaller than average wind turbine piles, it is likely that the noise produced during the Galway Harbour Extension will be less. Furthermore, the shallow water depth in the Galway Bay cSAC, and the buffering effect caused by Mutton and Hare Island will result in a much smaller actual range of sound propagation, and hence disturbance. Impact levels have been predicted to be limited to the inner Galway Bay (EIS Appendix 10.3, Galway Harbour Company 2014). In addition, response of the harbour seal population could be affected by either habituation or sensitisation to the noise during actual construction activities (Götz & Janik 2010, Götz & Janik 2011). Pile driving can cause PTS and TTS when individual seals occur within 100 - 600 m from the sound source. The proposed mitigation measures will effectively mitigate against direct hearing injury, whereas behavioural disturbance remains likely for harbour seals (Table 1).

2C. General construction in the marine environment

General marine construction noise will consist of underwater blasting and deposition of quarry material. Deposition of quarry material can be compared acoustically to dredging sounds, since it will consist of relatively short, continuous broadband noise. Therefore, the behavioural responses as described in section 2A concerning dredging can be also applied here. Rock blasting will pose a heavier acoustic strain on the environment. Sound pressure levels for rock blasting during the Galway Harbour Extension are estimated to be 225 dB re 1 μPa at 1m.

The acoustic structure and sound levels of rock blasting are such that harbour seals will likely exhibit a startle response (Götz & Janik 2011). As repeated elicitation of the startle reflex can lead to sensitisation (Götz & Janik 2011), this would call for a minimisation of the number of blasts per day to avoid direct injury or deaths from seals in close proximity to the site. Blasting can cause TTS and PTS to seals within 50-160 m from the source (Table 1). Proposed mitigation actions will effectively reduce the likelihood of direct impacts, but behavioural changes remain likely to occur for animals present in the area (Table 1).

2D. Shipping noise

As a relatively low-level, continuous sound source, shipping noise will not pose a physical threat to pinnipeds or any of the cetacean species concerned. Behavioural disturbance however, is possible, depending on the size and velocity of the vessels. In the case of the Galway Harbour Extension project, the size of vessels entering the harbour area will increase significantly post-construction. The new harbour will be able to hold 25.000 tonnes vessels, in contrast to the current 5.000 tonnes vessels (Galway Harbour Company 2014). At the same time, however, the number of vessels docking at the harbour will decrease from 180 to 107 vessels per year (medium scenario; Galway Harbour Company 2014), resulting in a reduction of disturbance events and possibly similar or less impact per ship if the larger ships are modern vessels carrying more silent engines.

Seal responses to shipping noise have received little study. In general, seals tend to dive when faced with disturbance, but in the case of underwater noise, a surfacing response might be expected (Harris et al. 2001). Sound pressure levels of low frequency sounds can decrease up to 7 dB closer to the water surface (Urik 1983, Green & Richardson 1988, Richardson et al. 1995). Australian fur seals respond to in-air motorboat noise above 75 dB re 20 μPa, by becoming more alert, or moving away (Tripovich et al. 2012). Conversely, Harris et al. (2001) showed that Arctic seals showed only localised avoidance responses to an approaching vessel doing seismic surveys, often remaining in areas with over 190 dB re 1 μPa noise levels. Of the Northwest coast of Co. Mayo, displacement of grey and harbour seals was correlated to increasing vessel abundance during the offshore construction of a pipeline in Broadhaven Bay, Ireland (Anderwald et al. 2013). Analysis of the vessel type showed that the negative correlation was more likely caused by increased levels of underwater noise, than by increased collision risk (Anderwald et al. 2013). A controlled behavioural response study was conducted to investigate the response of vessel approaches on harbour seal haul-out behaviour (Anderson et al. 2012). The study showed that harbour seals responded to approaching vessels at significant greater distances than to an approaching pedestrian. Seals were alerted by approaching vessels heading directly towards the animals at distances ranging from 560 to 850 m (Anderson et al. 2012). These patterns of response were consistent during pre-during and post breeding periods. Johnson and Acevedo-Gutierrez (2007) observed that harbour seals were less affected when powerboats and kayaks passed by, but did flee when powerboats were approaching within 400 m. This difference may relate to an approaching vessel possible blocking the direction of the seals escape route (Anderson et al. 2012). However, since these studies concern airborne noise, and vessels approaching seals directly, it is unlikely distances will be similar for underwater shipping noise. The current residency of harbour seals near the harbour suggests a level of tolerance to shipping noise. Higher short-term peak levels in vessel noise post-construction may elicit startle responses within seals, which could lead to area avoidance (Götz & Janik 2011). However, habituation to the noise may alter this response to some extent (Götz & Janik 2010).

2E. Vessel collision

Both pinnipeds and cetaceans have been documented with mild to severe and lethal trauma after vessel collision (Moore et al. 2013). Distinctions can be made between blunt and sharp trauma, which are caused by rotating and non-rotating parts of the vessel, respectively (Moore et al. 2013). Different factors can affect the severity of the impact, such as vessel size and velocity, the angle at which collision takes place, and the anatomy of the body part that is hit (Laist et al. 2001, Vanderlaan & Taggart 2007, Moore et al. 2013). The likelihood of such collisions is thus far unclear, as frequency studies have only been conducted for species with very high incidences of collisions, such as right whales (Kraus et al. 2005).

Of the species here concerned, harbour seals will have the greatest likelihood of vessel-related injury (collision), since they are resident in the area and may be inquisitive towards vessels. In the UK, 27 stranded harbour seals with corkscrew motor injuries have been found since 2008 (SNCA 2012). Most observed lethal injuries were likely caused by seals being drawn through a ducted propeller such as a Kort nozzle or some types of Azimuth thrusters (Thompson et al. 2010). Since not all carcasses end up on the beach, actual number of deaths may be higher than currently reported. As a consequence, the effect on population levels cannot be estimated (SNCA 2012). However, it has been stated that the number of collisions generally does not pose a threat to a species on population level (Thompson et al. 2010, Weinrich et al. 2010). Possible mitigation measures include avoidance of the breeding season, and avoidance of certain engine types (SNCA 2014). Since no marine construction works will take place during the breeding season, the risk of vessel collision will be minimized during this vulnerable period. Given the absence of documentation of vessel collisions with harbour seals, and their general level of interaction with/presence in area with larger numbers of vessels, the likelihood of harbour seal trauma caused by vessel collision in the Galway Bay cSAC is expected to be limited, but increased during marine construction activities due to the increase in the number of vessels. However, the absence of documentation of vessel collisions with harbour seals may be due to the fact that these were not recorded and/or noticed.

2F. Secondary impact due to localised disruption of normal ecological activity (e.g. via displacement or removal of prey species)

Secondary impacts of the Galway Harbour Extension on harbour seals, if any, are likely to be most prominent in the effect of marine construction noise on their prey. Several fish species can be affected by anthropogenic noise, and show distinctive responses based on the sound type. For example, Atlantic herring (*Clupea harrengus*) exhibits flight behaviour to engine noise, but not to low-frequency sonar (Doksæter et al. 2012). Strong pulsed sounds such as pile driving sounds can elicit behavioural responses in mackerel, causing them to change depth (Hawkins et al. 2014). If close, the blasts created by pile driving may be so intense that they cause physical trauma to the fish exposed (Halvorsen et al. 2012). The differences in behavioural response between sound type and fish species make it difficult to give an estimation of the likely effect on harbour seals, particularly given the general lack of information on prey species and foraging behaviour in Irish waters and in the Galway Harbour cSAC. As the harbour seal is an opportunistic predator and may readily shift prey species between seasons if prey abundance changes (Brown & Mate 1983, Tollit et al. 1998, Thomas et al. 2011), it is likely to be generally resilient to changes in prey behaviour, if only part of the fish species strongly respond. However, harbour seals also display a high site-fidelity to their foraging area (Härkönen & Harding 2001). It is currently unclear what the flexibility of the species is when confronted with a change in quality of foraging area. If prey species shift their distribution, or become less abundant on the longer term due to the construction activities, this may impact the resident harbour seal population. This impact can result in a reduction in the overall energy budget of the population, resulting from lost or reduced foraging opportunities, and increased time and energy spent acquiring/searching for food in alternative, potentially less suitable, or more distant locations.

Summary of Impacts Table

Table 1. ***Summary of the likelihood of physical hearing and behavioural effects on Harbour Seal exposed to noise from five types of marine construction activities for the Galway Harbour Extension Project: 1a) Dredging Backhoe; 1b) Dredging TSHD; 1c) Pile driving; 1d) Blasting and 1e) Shipping noise in the absence (no mitigation) and presence (mitigation) of proposed mitigation measures.*** *Physical hearing effects include Permanent Threshold Shift (PTS) and Temporal Threshold Shift (TTS). Species' specific threshold levels for effects (SPL(peak)/SEL threshold) are published data from Southall et al. (2007). The impact zone (m) from source states the maximum distance or estimated range category from the source at which either SEL or SPL threshold levels are exceeded. Impact zones were calculated using received sound levels quantified in Appendix 10.2 of the EIS (Galway Harbour Company 2014), using a precautionary approach. For all sound types other than single pulses, threshold levels for behavioural effects (*) are not included, but are assumed to occur more commonly at levels below PTS/TTS threshold levels (Southall et al. 2007), and are defined as Medium (0 - 2500 m), and Large (>2500 m; Appendix 10.2 Galway Harbour Company 2014). Definitions: Likely: The likelihood of occurrence of the impact is high; Unlikely: The likelihood of occurrence of the impact is low; Possible: The impact is likely if animals are present in the area (for occasional- infrequently recorded species). Abbreviations: Trail Suction Hopper Dredgers (TSHD), Sound Pressure Level (SPL), Sound Exposure Level (SEL), Does not occur (d.n.o.). Not available (N/A), Behaviour (Beh.).*

Harbour Seal					
Process	**Acoustic Impact**	**SPL (peak)/SEL threshold**	**Impact Zone (m)**	**Impact (no mitigation)**	**Impact (with mitigation)**
1a) Backhoe Dredging	PTS TSS Beh. effect	218/203 212/183 *	8 80 Large	Likely Likely Likely	Unlikely Unlikely Likely
1b) TSHD Dredging	PTS TSS Beh. effect	218/203 212/183 100	10 100 Large	Likely Likely Likely	Unlikely Unlikely Likely
1c) Pile Driving	PTS TSS Beh. effect	218/186 212/171 212/171	100 600 Large	Likely Likely Likely	Unlikely Unlikely Likely
1d) Blasting	PTS TSS Beh. effect	218/186 212/171 212/171	50 160 Large	Likely Likely Likely	Unlikely Unlikely Likely
1e) Shipping Noise	PTS TSS Beh. effect	218/203 212/183 *	d.n.o. 3 Large	Unlikely Possible Likely	

Impacts on Population, Life Cycle and Key Functional Areas

The harbour seal is a resident species in the Galway Bay cSAC. The harbour seal population in the inner Galway Bay area consisted of 221 individuals in 2012 (Duck & Morris 2013b). The species was regularly recorded present in the water at different locations in the bay during multiple surveys for the Galway Harbour Extension Project (Galway Harbour Project 2014). Depending on their flexibility to choose alternative, non-impacted sites for functional activities that occur in the water such as mating and foraging, individuals residing at or near the harbour might be affected. Individuals residing in haul-outs at or near the harbour will likely be impacted by increased noise levels during their time in the water (e.g. during travel to and from the haul-out).

The mating season of harbour seals takes place in the water near the end of the breeding season (Coltman et al. 1997, see 3.5 *Mating Behaviour*). In the Galway Bay cSAC, this is in June-July. Nursing of pups takes place in the water, during the breeding season, in May-July (Leopold et al. 1992). Since marine construction activities will cease during that period, this part of their life cycle is unlikely to be disrupted. The mating season is followed by the annual moulting season, which takes place in August-September (NWPS 2011). Most of the harbour seal population will be hauled out on shore in this period. Harbour seals increase their time foraging in the water in the winter (see section 3.3 *Foraging behaviour*). During this period, individuals may be more susceptible to disturbance from ongoing construction activities within the proposed area.

Harbour seals show large intraspecific differences in foraging behaviour (see 3.3 *Foraging Behaviour*). Differences related to size and sex have been recorded in the Moray Firth, Scotland (Thompson et al. 1998). Males and large individuals venture out further to search for food than females. In other locations, however, juveniles were found to conduct larger movements than adults (Lowry et al. 2001). As one of the resting sites of harbour seals is located in the vicinity of Galway Harbour, this means that females, and most notably pupping and nursing females, are more likely to be affected by the proposed activities than males. Since very low numbers of grey seals are sighted in the proposed area, disturbance due to the construction activities is unlikely to impact a specific section of the population.

Harbour seals forage mainly within coastal waters and are a resident species of the Galway Bay cSAC. As a non-migratory species, they may have specific preferred areas for foraging. The quality of a foraging site is based on distance to the haul-out site, prey abundance and bathymetry. Individuals are known to generally forage within 50 km of their haul-out site, staying in the same area for over a decade (Bjørge et al. 1995, Härkönen & Harding 2001). Preferential foraging areas are generally within 20 km from the haul-out site (Tollit et al. 1998, Härkönen & Harding 2001, Grigg et al. 2009). Furthermore, harbour seals will choose areas with a long-term stable high prey abundance (Grigg et al. 2009). The high site-fidelity for both foraging and resting classifies harbour seals as central-place foragers (Orians & Pearson 1979, Thompson et al. 1998, Grigg et al. 2009).
If situated in the area of construction activities, harbour seals might not be able to use their preferred foraging location during these works. However, no preferred foraging areas have been identified from land-based surveys within the proposed area (Galway Harbour Company 2014). Furthermore, changes in prey distribution due to the acoustic disturbance could cause a deterioration of the quality of the patch. The effects of any impacts on foraging sites will depend on the availability of other suitable foraging areas in the area, and the increased time and energy spent acquiring/searching for food in alternative, potentially less suitable, or more distant locations. Harbour seals are known to be a flexible species, as can be concluded from their opportunistic prey selection and seasonal change of prey choice (Brown & Mate 1983, Tollit et al. 1998). Given the presence of alternative foraging opportunities, these characteristics make the species generally resilient to changes in the environment relating to food abundance.

Likely Recovery

The marine development work will be interrupted for several months (April-July) every year, which will give all species time to recover from the disturbances. The recovery period will be most important for harbour seals, since they reside in the area permanently, which increases their levels of disturbance and decreases possibility for recovery during development. Stress levels may be elevated for some time after cessation of activities, but will likely have returned to normal at the start of the breeding season in June (Tougaard et al. 2009). Habituation in seals occurs quickly when exposed to non-startling, long-duration sounds (Götz and Janik 2010), such as shipping and dredging noise. Sounds with a short rise-time can elicit startle-reflexes, to which seals will sensitize if exposed multiple times in a row (Götz and Janik 2011). These sounds, i.e. blasting and pile-driving, have the potential of causing long-term behavioural effects, impact individual fitness and decrease longevity (Götz and Janik 2011). Therefore, the within-project recovery of seals will depend upon the presence of pile-driving or blasting activities during the winter construction periods. A study investigating harbour seal movements after completion of two wind farms in the Danish Wadden Sea, indicated no significant long-term effect of the operational wind farms on seal behaviour (McConnell et al. 2013). Short-term displacement effects were reported during the construction and operation of a wind farm in the Wadden Sea, Denmark (Edren et al. 2010). Here, no long-term effects were found, and harbour seals continued to use the area, and population increased in accordance with an increase observed in other areas (Edren et al. 2010). In contrast, longer-term displacement of seals was recorded in Broadhaven Bay, Ireland during an offshore construction of a pipeline (Anderwald et al. 2013). Current post-construction monitoring will enable to determine long-term effects and identify if seals return to pre-construction levels. After completion of the project, the population might return to pre-construction distribution ranges within a few months (Tougaard et al. 2009).

6.2 RISK ASSESSMENT RELATED TO MARINE MAMMALS

Query:

Detailed environmental impact and Natura impact statements are provided in relation to cetaceans as part of the current application. However, these do not clearly present activity-specific assessments of risk in relation to all Annex IV cetacean species likely to occur at the site. Potential adverse impacts on cetaceans that may arise from the development as it is currently described include (i) the effect of collisions with shipping and other vessels, (ii) direct disturbance and/or injury due to sound and intensified motorized vessel/plant/construction activities, and (iii) secondary impact due to localized disruption of normal ecological activity. It is the current policy of the Department of Arts Heritage and the Gaeltacht that a proposed development of this nature should undergo an appropriate and comprehensive risk assessment specific to any and all cetacean species occurring in the operational area concerned. In the context of the proposed extensive marine development, the Department's Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters (January 2014) provides, instructive information such that the risk to protected marine mammal species arising from underwater sound can be characterized, assessed and managed as appropriate. This guidance and the associated risk assessment requirements were first published by the Department in public consultation form in March 2012. The risk assessment should be carried out with the assistance of a suitably qualified cetacean ecologist and be based on international scientific research as well as information currently available from Ireland.

The following response was compiled with the assistance of Kelp Marine Research, by Dr. Fleur Visser and Machiel Oudejans, M.Sc. A copy of their final report, including full bibliography and references, is presented as Appendix RFI 2.2.

Response:

Risk assessment for all marine mammals (excluding otter)

6.2.1 Risk assessment procedure

The additional risk assessment of the Galway Harbour Extension conducted here, for all marine mammal species occurring in the Galway Bay cSAC, was executed following the National Parks and Wildlife Service guidelines as outlined in the report "*Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters*" (DAHG 2014; available at http://www.npws.ie).

All information provided in this report was derived from existing scientific literature and reports, including site-specific reports detailing survey, monitoring and acoustic recording and modelling results, executed for the Galway Harbour Extension Project, available at http://www.galwayharbourextension.com. No targeted surveys or observations of marine mammals were conducted in the area of proposed construction activities for the purpose of this report. The risk assessment provided here focuses primarily on potential impacts in the marine habitat.

The risk assessment for marine mammals focuses on two main types of potential disturbances, physical hearing damage and changes in behaviour. Whereas a large body of efforts to investigate the effects of noise in the marine environment has focused on the likelihood of physical (hearing) damage, it has become apparent that changes in behaviour and/or habitat-use resulting from sound exposure or construction activities are often equally, or more likely to translate to a negative effect at the population-level, given the apparent fitness consequences of these responses (e.g. Southall et al. 2007, de Ruiter et al. 2013). Mild to severe behavioural responses to anthropogenic disturbance, including changes in vocalisations, area avoidance and cessation of vital activities such as foraging have been recorded across a wide range of species, areas and types of disturbances (e.g. Goldbogen et al. 2013). The type and strength of behavioural responses can vary widely between and within species and between types of disturbances and are often highly context dependent, calling for case-by-case, in depth study of biological relevance and severity of effects (e.g. Goldbogen et al. 2013).

The risk assessment conducted here provides likelihoods of effects based on available published information. Due to the general lack of detailed knowledge of many aspects of seal and cetacean marine habitat use, behaviour and temporal presence in Ireland, including in the Galway Bay cSAC, it may be that specific dependencies of the species concerned could not be evaluated, and could therefore not be taken into account in the risk assessment. Most notably, knowledge on (spatio-temporal variation in) dependencies on specific marine sites is limited. In recent years, site-specific surveys carried out as part of the Environmental Impact Statement have been undertaken (Galway Harbour Company 2014), providing visual and acoustic information on the presence of cetacean and pinniped species near the area proposed for construction, adding to survey efforts undertaken in the Galway Bay cSAC (Cronin et al. 2004, O'Brien 2009, Duck & Morris 2013a,b).

6.2.2 2.2 Marine mammal species concerned

Harbour seal (*Phoca vitulina*)
Grey seal (*Halichoerus grypus*)
Harbour porpoise (*Phocoena phocoena*)
Bottlenose dolphin *(Tursiops truncatus)*
Short-beaked common dolphin *(Delphinus delphis)*
Minke whale (Balaenoptera acutorostrata)

6.2.3 2.3 Risk assessment

Assessment 1.
Do individuals/populations of marine mammal species occur within the proposed area?

The harbour seal is resident in the Galway Bay cSAC (NPWS 2013, Galway Harbour Company 2014). Harbour porpoises are frequently recorded in the Galway Bay cSAC and near the proposed area (84% of monitoring days between June 2011 and October 2013; O'Brien 2009, CH7 Galway Harbour Company 2014). Bottlenose dolphins used to be frequently recorded (Berrow et al. 2002), but seemed to be declining (O'Brien 2009). Short-beaked common dolphins, minke whales and grey seals are recorded infrequently in the proposed area (O'Brien 2009, Duck & Morris 2013a, b, Galway Harbour Company 2014). However, dolphins (bottlenose or common dolphins) were recorded acoustically on 32% of monitoring days between June 2011 and October 2013, suggesting a more regular presence of dolphins than was found from visual monitoring studies (CH7, Galway Harbour Company 2014).

Assessment 2.
Is the plan or project likely to result in death, injury or disturbance of individuals?

2A. Dredging
Dredging will be performed by two different types of vessels in the proposed project: Trail Suction Hopper Dredgers (TSHD), and backhoe dredgers. The type of substrate determines which vessel type will be used. As one type of dredging is noisier than the other, there are

two sets of peak levels that have to be taken into account. Peak levels are 133-185 dB re 1 μPa and 143-195 dB re 1 μPa for TSHD and backhoe dredgers respectively (De Jong et al. 2011, Robinson et al. 2011, Appendix 10.2 Galway Harbour Company 2014). Permanent and Temporary hearing Threshold Shifts (PTS and TTS) can occur for both pinnipeds and cetaceans, if they venture too close to the sound source (Galway Harbour Company 2014). Unless individual animals would be very close to, or attracted by the dredging activities, (hearing) injury or death resulting from these activities is unlikely. The proposed mitigation measures would effectively mitigate against these effects (Table 1).

Seals

The intensity and duration of noise related to dredging is such that it can cause PTS, TTS and behavioural changes (Table 1). In harbour seals, behavioural changes such as area avoidance have been estimated to occur from sounds with an intensity of 55 dB above hearing threshold (Thompson et al. 2013). The peak frequency of dredging noise lies around 125 Hz, which is in the most sensitive part of harbour seal hearing range. Therefore, dredging has the potential to cause behavioural disturbance for the resident harbour seal. Auditory sensitivity levels for grey seals are estimated to be similar to those of the harbour seal. However, grey seals only occur infrequently in the harbour, and are therefore less likely to be affected (Table 1).

Bottlenose and common dolphin, and harbour porpoise

While limited information is available on the direct effects of dredging activities on dolphin and porpoise populations, dredging activities in a UK harbour resulted in an avoidance response of the bottlenose dolphins in the area (Pirotta et al. 2013). The bottlenose dolphins had begun exploiting Aberdeen Harbour as a foraging patch several years before the activities commenced. Dredging occurred several times over a period of several years, but the population did not seem to habituate. The fact that even in an area with regular disturbance, bottlenose dolphins still responded strongly to dredging suggests that it has a high disturbance potential for this species in certain areas or habitats. The mechanism behind the disturbance remains open for research, as it can either be caused by direct avoidance of the noise, be mediated by a change in prey behaviour or visibility, or a combination of the three (Pirotta et al. 2013). However, in contrast, construction work in Broadhaven Bay, Ireland (an area of generally low anthropogenic disturbance) could not be linked to any changes in population density for bottlenose dolphins, common dolphins and minke whales, whereas interannual population fluctuations were detected for harbour seals and grey seals (Anderwald et al. 2013).

Hearing sensitivities of short-beaked common dolphins and harbour porpoises are similar to those of bottlenose dolphins for the noise frequencies of dredging activities. Acoustic deterrence and/or area avoidance resulting from exposure to other types of sound (e.g. seismic airgun shooting, wind turbines, pile driving) has been demonstrated for both common dolphins and harbour porpoises (Goold 1996, Tougaard et al. 2009, Brandt et al. 2012). However, shipping noise was modelled to have little impact on the population level of harbour porpoise in Danish waters (Nabe-Nielsen et al. 2014). Using a precautionary approach, it should be considered likely that dredging for the Galway Harbour Extension project may result in behavioural disturbance (e.g. temporal area avoidance) of bottlenose dolphins, common dolphins and harbour porpoises present in the area during these activities.

Minke whale

In minke whales, main hearing sensitivity is predicted to be between 30 Hz and 7.5 kHz, or between 100 Hz and 25 kHz, depending on location of the stimulus (Tubelli et al. 2012). Hence, they can hear well within the range of sound generated by dredging activities. As an added potential disturbance, minke whale vocalisations, typically low frequency sounds at 100-400 Hz (Mellinger et al. 2000), will be masked by dredging noise, which may hinder communication (Mellinger et al. 2000). A very strong response of an individual minke whale to playback of low-frequency sonar, at 1-2 kHz, suggested that this species can be heavily affected by anthropogenic noise (Kvadsheim et al. 2011). However, minke whales only occur infrequently in the Galway Bay cSAC (O'Brien 2009), and are unlikely to venture far into the bay. This makes the occurrence of behavioural disruption by the dredging activities unlikely.

2B. Pile driving

Since the construction of wind farms generally involves pile driving, a lot of documentation can be found on the effects of this sound source on marine mammals and fish alike (Carstensen et al. 2006, Bailey et al. 2010, Thompson et al. 2010, Brandt et al. 2012, Dähne et al. 2013, Kastelein et al. 2013). Because of its high intensity and pulse-like structure, pile driving noise is one of the most disturbing anthropogenic noises underwater to date. The intermittent temporal structure inhibits quick habituation (Neo et al. 2014), while the high intensity can cause TTS or and PTS (Southall et al. 2007).

Seals

For harbour seals, Thompson et al. (2013) simulated the construction of two piles in the Moray Firth, UK. Behavioural disturbance was modelled to start at 80 km from the sound source in open water. However, the amplitude of pile driving depends upon the diameter of the pile and the technique used to drive it into the ground. Since the piles used in the proposed project are smaller than average wind turbine piles, it is likely that the noise produced during the Galway Harbour Extension will be less. Furthermore, the shallow water depth in the Galway Bay cSAC, and the buffering effect caused by Mutton and Hare Island will result in a much smaller actual range of sound propagation, and hence disturbance. Impact levels have been predicted to be limited to the inner Galway Bay (EIS Appendix 10.3, Galway Harbour Company 2014). In addition, response of the harbour seal population could be affected by either habituation or sensitisation to the noise during actual construction activities (Götz & Janik 2010, Götz & Janik 2011). Pile driving can cause PTS and TTS when individual seals occur within 100 - 600 m from the sound source. The proposed mitigation measures will effectively mitigate against direct hearing injury, whereas behavioural disturbance remains likely for harbour seals (Table 1).

Harbour porpoise

The noise created by pile driving is sufficiently loud to be audible to harbour porpoises, and has been shown to deter this species for 9 to 70 hours within 20 km of a pile driving site in open waters (Tougaard et al. 2009, Brandt et al. 2012). Since generally more than one pile needs to be driven into the ground, depending on the time between two consecutive pile-driving events, harbour porpoises can be deterred from an area during the entire period of development (Brandt et al. 2012). On the other hand, Kastelein et al. (2013), when exposing a single individual to pile-driving sounds in a large pool, found that behavioural responses were limited to the time of playback. Afterwards, the individual would soon return to its baseline behaviour. The lack of long-term responses in this study could be due to the fact that the animal was held in captivity and could therefore not show avoidance behaviour of a particular site. Another study by Scheidat et al. (2011) on the effect of a wind farm construction in the North Sea showed that harbour porpoise occurrence actually increased after construction of the farm. However, no observations were conducted during construction, so it is unclear whether the site was abandoned at that time. Overall, pile driving can be considered to trigger strong short-term (avoidance) responses, which may change behaviour for multiple hours after sound exposure. Driving of multiple piles could therefore result in a carry-over effect, and deter harbour porpoises for longer periods of time, resulting in temporal loss of habitat during the period of construction. Close proximity to the pile driving activities could result in injury (TTS or PTS), but this risk is likely reduced by the tendency of harbour porpoises to avoid the area with pile driving activities. Mitigation actions, including 30 min pre construction watches and soft-start protocols will effectively reduce the likelihood of direct impact on harbour porpoise, but behavioural changes remain likely to occur.

Bottlenose and common dolphin, and minke whale

The response of mid- and low-frequency cetaceans (cetaceans whose auditory range is within 150 Hz-160 kHz (mid) and 7 Hz – 22 kHz (low) (Southall et al. 2007), in this case, short-beaked common dolphins, bottlenose dolphins and minke whales, to pile-driving sounds has been modelled by Bailey et al. (2010) for the construction of an offshore wind farm in the Moray Firth, UK. In the Moray Firth, behavioural response to pile driving was modelled to occur up to 50 km from the construction site located in open water. Goold (1996) studied the distribution of common dolphins in response to seismic airgun surveys in offshore waters using passive acoustic monitoring. During the survey, individuals tended to stay at least 10 km away from the surveying site. The acoustic spectrum of airgun noise is different from pile-driving sounds, but the temporal structure is quite similar. However, response ranges will differ per area, based on background noise levels and the acoustic properties of the abiotic environment. The piles used in the present project are of a smaller diameter and will therefore require less force (i.e. noise) to be driven into the ground. Furthermore, as stated above, the shallow water and buffering effect of Mutton and Hare Island on the underwater sound propagation will result in much smaller response ranges as opposed to open water environments. Based on the propagation models, the behavioural response range for mid- and low-frequency cetaceans is estimated to stay within the inner Galway Bay (EIS Appendix 10.3, Galway Harbour Company 2014). For cetaceans, behavioural disturbance by pile driving at medium to large distance is likely to occur, whereas injury (TTS or PTS) is possible when individuals occur at close range (19 - 100 m) from the pile driving activities. Proposed mitigation actions, including 30 min pre construction watches and soft-start protocols will effectively reduce the likelihood of direct impacts, but behavioural changes remain likely to occur (Table 1).

2C. General construction in the marine environment

General marine construction noise will consist of underwater blasting and deposition of quarry material. Deposition of quarry material can be compared acoustically to dredging sounds, since it will consist of relatively short, continuous broadband noise. Therefore, the behavioural responses as described in section 2A concerning dredging can be also applied here. Rock blasting will pose a heavier acoustic strain on the environment. Sound pressure levels for rock blasting during the Galway Harbour Extension are estimated to be 225 dB re 1 μPa at 1m.

Seals

The acoustic structure and sound levels of rock blasting are such that harbour seals will likely exhibit a startle response (Götz & Janik 2011). As repeated elicitation of the startle reflex can lead to sensitisation (Götz & Janik 2011), this would call for a minimisation of the number of blasts per day to avoid direct injury or deaths from seals in close proximity to the site. Blasting can cause TTS and PTS to seals within 50-160 m from the source (Table 1). Proposed mitigation actions will effectively reduce the likelihood of direct impacts, but behavioural changes remain likely to occur for animals present in the area (Table 1).

Bottlenose and common dolphin, harbour porpoise and minke whale

For all cetaceans, blasting sounds can invoke PTS or TTS, if animals venture too close to the site of explosion. Precise impact ranges can be calculated using the criteria set out by Southall et al. (2007), and will be in the range of 45-90 m for PTS and TTS, respectively (Table 1). Behavioural disturbance by blasting at medium to large distance is likely to occur. Proposed mitigation actions will effectively reduce the likelihood of direct impacts, but behavioural changes remain likely to occur for animals present in the area (Table 1).

2D. Shipping noise

As a relatively low-level, continuous sound source, shipping noise will not pose a physical threat to pinnipeds or any of the cetacean species concerned. Behavioural disturbance however, is possible, depending on the size and velocity of the vessels. In the case of the Galway Harbour Extension project, the size of vessels entering the harbour area will increase significantly post-construction. The new harbour will be able to hold 25.000 tonnes vessels, in contrast to the current 5.000 tonnes vessels (Galway Harbour Company 2014). At the same time, however, the number of vessels docking at the harbour will decrease from 180 to 107 vessels per year (medium scenario; Galway Harbour Company 2014), resulting in a reduction of disturbance events and possibly similar or less impact per ship if the larger ships are modern vessels carrying more silent engines.

Seals

Seal responses to shipping noise have received little study. In general, seals tend to dive when faced with disturbance, but in the case of underwater noise, a surfacing response might be expected (Harris et al. 2001). Sound pressure levels of low frequency sounds can decrease up to 7 dB closer to the water surface (Urik 1983, Green & Richardson 1988, Richardson et al. 1995). Australian fur seals respond to in-air motorboat noise above 75 dB re 20 µPa, by becoming more alert, or moving away (Tripovich et al. 2012). Conversely, Harris et al. (2001) showed that Arctic seals showed only localised avoidance responses to an approaching vessel doing seismic surveys, often remaining in areas with over 190 dB re 1 µPa noise levels. Of the Northwest coast of Co. Mayo, displacement of grey and harbour seals was correlated to increasing vessel abundance during the offshore construction of a pipeline in Broadhaven Bay, Ireland (Anderwald et al. 2013). Analysis of the vessel type showed that the negative correlation was more likely caused by increased levels of underwater noise, than by increased collision risk (Anderwald et al. 2013). A controlled behavioural response study was conducted to investigate the response of vessel approaches on harbour seal haul-out behaviour (Anderson et al. 2012). The study showed that harbour seals responded to approaching vessels at significant greater distances than to an approaching pedestrian. Seals were alerted by approaching vessels heading directly towards the animals at distances ranging from 560 to 850 m (Anderson et al. 2012). These patterns of response were consistent during pre-during and post breeding periods. Johnson and Acevedo-Gutierrez (2007) observed that harbour seals were less affected when powerboats and kayaks passed by, but did flee when powerboats were approaching within 400 m. This difference may relate to an approaching vessel possible blocking the direction of the seals escape route (Anderson et al. 2012). However, since these studies concern airborne noise, and vessels approaching seals directly, it is unlikely distances will be similar for underwater shipping noise. The current residency of harbour seals near the harbour suggests a level of tolerance to shipping noise. Higher short-term peak levels in vessel noise post-construction may elicit startle responses within seals, which could lead to area avoidance (Götz & Janik 2011). However, habituation to the noise may alter this response to some extent (Götz & Janik 2010).

Harbour porpoise

Very little conclusive information is available on the response of harbour porpoises to boat noise. The fact that harbour porpoises can currently be found in the Galway Bay cSAC suggests that current sound levels can be tolerated. On a population level, shipping noise has been modelled to have little impact for harbour porpoises (Nabe-Nielsen et al. 2014). On the other hand, studies by Amundin & Amundin (1973) and Polacheck & Thorpe (1990) show avoidance responses to shipping noise.

Bottlenose and common dolphins
Many studies, conducted across a wide range of areas and habitats have reported a broad range of behavioural changes in response to boat traffic, including population-level effects. Rako et al. (2013), for example, investigated the effect of leisure boat noise on a population of bottlenose dolphins in a Croatian archipelago, and found strong seasonal displacements of animals during periods of very high activity on the water. The results could not be explained by a change in prey abundance, and a strong correlation between vessel density and underwater noise suggests that both vessel presence as an increase in underwater noise could be the cause for the displacement. However, bottlenose dolphins did not adversely respond to increased shipping noise during construction activities in a nearby bay area, Broadhaven Bay, County Mayo (Anderwald et al. 2012). Leisure boat levels in the Galway Bay cSAC are lower than described in Rako et al. (2013), so the impact of boat traffic is expected to be lower. Furthermore, the number of ships entering the port yearly is estimated to decrease after the extension, which may help to reduce any impact.

Minke whale
In baleen whales, boat noise can cause changes in vocal behaviour (Miller et al. 2000). The acoustic properties of ship noise make it a masking sound for many baleen whale vocalisations, including those of minke whales. It may be that the future decrease in the number of ships entering the port will result in a decrease in masking time. Since the currently available information suggests that minke whales visit Galway Bay mainly during the summer months, and generally in very low numbers, masking of minke whale vocalisations during construction is deemed unlikely.

Behavioural effects of shipping noise have been shown for all species present in the Galway Bay cSAC, and short-term behavioural changes can be expected to occur for all species when present during and post construction (Table 1).

2E. Vessel collision
Both pinnipeds and cetaceans have been documented with mild to severe and lethal trauma after vessel collision (Moore et al. 2013). Distinctions can be made between blunt and sharp trauma, which are caused by rotating and non-rotating parts of the vessel, respectively (Moore et al. 2013). Different factors can affect the severity of the impact, such as vessel size and velocity, the angle at which collision takes place, and the anatomy of the body part that is hit (Laist et al. 2001, Vanderlaan & Taggart 2007, Moore et al. 2013). The likelihood of such collisions is thus far unclear, as frequency studies have only been conducted for species with very high incidences of collisions, such as right whales (Kraus et al. 2005).

Seals
Of the species here concerned, harbour seals will have the greatest likelihood of vessel-related injury (collision), since they are resident in the area and may be inquisitive towards vessels. In the UK, 27 stranded harbour seals with corkscrew motor injuries have been found since 2008 (SNCA 2012). Most observed lethal injuries were likely caused by seals being drawn through a ducted propeller such as a Kort nozzle or some types of Azimuth thrusters (Thompson et al. 2010). Since not all carcasses end up on the beach, actual number of deaths may be higher than currently reported. As a consequence, the effect on population levels cannot be estimated (SNCA 2012). However, it has been stated that the number of collisions generally does not pose a threat to a species on population level (Thompson et al. 2010, Weinrich et al. 2010). Possible mitigation measures include avoidance of the breeding season, and avoidance of certain engine types (SNCA 2014). Since no marine construction works will take place during the breeding season, the risk of vessel collision will be minimized during this vulnerable period. Given the absence of documentation of vessel collisions with harbour seals, and their general level of interaction with/presence in area with larger numbers of vessels, the likelihood of harbour seal trauma

caused by vessel collision in the Galway Bay cSAC is expected to be limited, but increased during marine construction activities due to the increase in the number of vessels. However, the absence of documentation of vessel collisions with harbour seals may be due to the fact that these were not recorded and/or noticed. Grey seals rarely occur in the vicinity of the harbour and therefore the likelihood for this species to be injured by collision is considered small.

Harbour porpoise
The harbour porpoise is a frequently occurring species in the Galway Bay cSAC. It occurs in shallow coastal areas, where it hunts for prey using echolocation. The species is shy by nature, and generally will not venture closely to large vessels. Because of its habitat and prey choice, a harbour porpoise has a relatively high chance of coming into contact with humans. For example, the mortality caused by by-catch of harbour porpoises in commercial fishing gear is so large that population sustainability may suffer (Tregenza et al. 1997). However, documentation on trauma related to vessel collisions is scarce, and incidences seem lower than for by-catch. This could be explained by the shy nature of the species, or by inadequate documentation of collision-related injuries. It is believed that anthropogenic trauma from collision does not pose a major threat to small marine mammal species on the population level (Weinrich et al. 2010), which may be a reason for the lack of documentation. More documentation exists on vessel collision with large marine mammals such as whales (Laist et al. 2001, Weinrich et al. 2010; Silber et al. 2012), which is likely caused by the fact that such incidents are more easily noticed by the ship's crew.

Bottlenose and common dolphin
Documentation on bottlenose dolphin collision with vessels indicates that injuries may range from mild to severe (Moore et al. 2013). Incidences of collision are low, and will most likely occur during the presence of large numbers of vessels on the water. In the Sarasota Bay area, 4 cases of non-lethal strike injuries on bottlenose dolphins were reported in a time-span of 13 years (Wells et al. 1997). All were recorded immediately after a day with the highest vessel density of that particular year. Hence, the likelihood of bottlenose dolphin trauma caused by vessel collision in the Galway Bay cSAC will be limited, but increased during marine construction activities due to the increase in the number of vessels and their time spent actively operating in the area. Collisions between short-beaked common dolphins and vessels are scarcely documented, whereas they are often reported to bowride (actively associate with ship) without resulting injuries. It is possible that the lack of documentation is due to a low incidence of vessel-related trauma in common dolphins, however, it may also result from inadequate documentation. Since common dolphins may be attracted to boats, similar to bottlenose dolphins, the likelihood of collision could be similar to that of the bottlenose dolphin. Combined with the fact that common dolphin sightings in the Galway Bay cSAC are relatively rare, the risk of vessel collisions with common dolphins is expected to be limited.

Minke whale
Compared to other cetaceans, vessel related incidents with baleen whales have been recorded quite regularly. This is possibly due to the size of the animals, their behaviour, or simply due to the fact that a collision with a 20 m long animal is more easily noticed. Within the baleen whales, however, reports of collisions between ships and minke whales are relatively low in number. Since minke whales are also seen on only few occasions within the Galway Bay cSAC, the risk of vessel related injuries within the current project for this species is expected to be limited.

2E. Secondary impact due to localised disruption of normal ecological activity (e.g. via displacement or removal of prey species)

Seals

Secondary impacts of the Galway Harbour Extension on harbour seals, if any, are likely to be most prominent in the effect of marine construction noise on their prey. Several fish species can be affected by anthropogenic noise, and show distinctive responses based on the sound type. For example, Atlantic herring (*Clupea harrengus*) exhibits flight behaviour to engine noise, but not to low-frequency sonar (Doksæter et al. 2012). Strong pulsed sounds such as pile driving sounds can elicit behavioural responses in mackerel, causing them to change depth (Hawkins et al. 2014). If close, the blasts created by pile driving may be so intense that they cause physical trauma to the fish exposed (Halvorsen et al. 2012). The differences in behavioural response between sound type and fish species make it difficult to give an estimation of the likely effect on harbour seals, particularly given the general lack of information on prey species and foraging behaviour in Irish waters and in the Galway Harbour cSAC. As the harbour seal is an opportunistic predator and may readily shift prey species between seasons if prey abundance changes (Brown & Mate 1983, Tollit et al. 1998, Thomas et al. 2011), it is likely to be generally resilient to changes in prey behaviour, if only part of the fish species strongly respond. However, harbour seals also display a high site-fidelity to their foraging area (Härkönen & Harding 2001). It is currently unclear what the flexibility of the species is when confronted with a change in quality of foraging area. If prey species shift their distribution, or become less abundant on the longer term due to the construction activities, this may impact the resident harbour seal population. This impact can result in a reduction in the overall energy budget of the population, resulting from lost or reduced foraging opportunities, and increased time and energy spent acquiring/searching for food in alternative, potentially less suitable, or more distant locations. Since grey seals only occasionally occur in the Galway Bay cSAC, secondary impact due to displacement or removal of prey species is unlikely to have an effect.

Harbour porpoise

Harbour porpoises are opportunistic predators and feed in both pelagic and demersal habitat (Santos & Pierce 2003). Known prey species comprise Atlantic herring, sandeel, sprat and members of the cod family (De Pierrepont et al. 2005). As mentioned before, Atlantic herring shows flight behaviour in response to engine noise. Likewise, avoidance reactions in cod were found during playback of trawler noise (Engås et al. 1995). Conversely, lesser sandeel distribution was not affected by the sound of seismic shooting (Hassel et al. 2004). Similar to the harbour seal, the impact of acoustic disturbance on harbour porpoise foraging success will therefore largely depend upon the relative abundance of different prey species, accessibility/proximity of alternative foraging locations, and preferred diet in the Galway Bay cSAC.

Bottlenose and common dolphin

Bottlenose dolphins in UK waters feed mostly on squid (*Loligo* sp.) and several cod species (De Pierrepont et al. 2005). Horse mackerel is also known as a prey species (De Pierrepont et al. 2005). Given the generally close proximity to shore of bottlenose dolphins in Irish waters, including in the Galway Bay cSAC (Oudejans et al. in press, O'Brien et al. 2009), this species likely forages mainly in inshore waters (< 5 km from shore). Fish species, most notably cod (*Gadus morhua*), can show anti-predatory responses to noise (Engås et al. 1995). Hence, the sound created by the proposed activities could disrupt the foraging efficiency of bottlenose dolphins in a similar way as described for the harbour seal. Squid can detect sound (Mooney et al. 2010), and were recently found to gain physical trauma from relatively low level (max. 175 dB re 1 µPa), low frequency sounds (André et al. 2011). Squid is generally distributed in deeper waters than found within the Galway Bay cSAC, and it is therefore unlikely that this species is affected within the proposed area. Short-beaked common dolphins are opportunistic feeders, and consume a variety of mackerel, sprat, squid, sardines, snipe fish, European hake, sand smelt, toothed goby and blue whiting (Pascoe 1986, Silva 1999). Most species are likely to occur in the Galway Bay cSAC (fishbase.org). The response to anthropogenic noise of most of those species remains unknown. However, as described above, both mackerel and squid can be affected. A goby species related to the toothed goby, however, which produces sound as a part of its sexual display, did not show a behavioural response after acoustic disturbance (Picciulin et al. 2010). As for the bottlenose dolphin, the severity of the secondary impact of the construction activities will therefore depend on the relative abundance of non-impacted prey. In addition, the general more offshore distribution of the common dolphin will make the species less dependant on near shore waters for foraging than bottlenose dolphins.

Minke whale
Minke whales, feeding predominantly on fish, are infrequent visitors of the Galway Bay cSAC during summer months. They are therefore unlikely to be affected at the population level by changes in fish behaviour due to acoustic disturbance.

Assessment 3.
Is it possible to estimate the number of individuals of each species that are likely to be affected?

Harbour seal
The harbour seal is a resident species in the Galway Bay cSAC. The harbour seal population in the inner Galway Bay area consisted of 221 individuals in 2012 (Duck & Morris 2013b). The species was regularly recorded present in the water at different locations in the bay during multiple surveys for the Galway Harbour Extension Project (Galway Harbour Project 2014). Depending on their flexibility to choose alternative, non-impacted sites for functional activities that occur in the water such as mating and foraging, individuals residing at or near the harbour might be affected. Individuals residing in haul-outs at or near the harbour will likely be impacted by increased noise levels during their time in the water (e.g. during travel to and from the haul-out).

Grey seal
In two consecutive monitoring periods, only 8 grey seals were recorded in the vicinity of Galway harbour (Duck & Morris 2013a,b). Since the monitoring study was not focussing specifically on grey seals, this can be an underestimation. However, considering this low density, it is unlikely that a substantial number of individuals will be affected by the procedures.

Bottlenose dolphin
The coastal population of bottlenose dolphins conduct long-distance movements along the Irish west coast (O'Brien et al. 2009, Oudejans et al. 2010), utilising multiple areas for foraging and other life functions, within a large home range. Bottlenose dolphins were considered a regularly occurring species in the Galway Bay cSAC. However, surveys across several years have shown a decreasing trend in occurrence. Whereas between 1994 and 1999 bottlenose dolphins were the most sighted species from Fanore, on the south end of the Galway Bay cSAC (Berrow et al. 1996), surveys conducted from 2006 found only between 4-11% of sighted species to be bottlenose dolphins (0.3 groups per survey; O'Brien 2009). A recent cetacean survey did not record any dolphin species inside in the proposed development area (Galway Harbour Company 2014). An acoustic survey using one C-POD located of the south coast of Mutton Island recorded dolphin vocalisations on 32% of 804 monitoring days (Galway Harbour Company 2014). These vocalisations likely consisted of bottlenose or common dolphins, and indicate a more regular presence of dolphins than

indicated by visual observations. Currently no abundance estimate is available for the population of coastal bottlenose dolphins in Irish waters, hence it is not possible to determine the number of individuals potentially affected by the development.

Harbour porpoise
The density of harbour porpoises in the outer part of Galway Bay in 2008 was estimated at 0.73 individuals per km^2 (Berrow et al. 2008), at a surface area of 547 km^2. More recently, acoustic monitoring in the inner bay using CPOD acoustics showed harbour porpoise presence 84% of monitoring days within 1 nm from the proposed area (Galway Harbour Company 2014). A dedicated cetacean survey recorded one sighting of two harbour porpoise approximately 800 m south of the proposed development (Galway Harbour Company 2014). The number of individuals affected depends on their distribution in the bay, and flexibility to choose alternative, non-impacted sites for functional activities such as resting and foraging.

Short-beaked common dolphins
Short-beaked common dolphins occur infrequently in the vicinity of the proposed area of development or in the Galway Harbour Bay cSAC (O'Brien 2009). Due to the sporadic sightings of this species, the number of individuals affected is estimated to be small.

Minke whale
This species occurs sporadically, and likely seasonally, in the proposed area. Given the current available information, it is estimated that the potential number of individuals affected is small.

Assessment 4.
Will individuals be disturbed at a sensitive location or sensitive time during their life cycle?

Harbour seal
The mating season of harbour seals takes place in the water near the end of the breeding season (Coltman et al. 1997, see 3.5 *Mating Behaviour*). In the Galway Bay cSAC, this is in June-July. Nursing of pups takes place in the water, during the breeding season, in May-July (Leopold et al. 1992). Since marine construction activities will cease during that period, this part of their life cycle is unlikely to be disrupted. The mating season is followed by the annual moulting season, which takes place in August-September (NWPS 2011). Most of the harbour seal population will be hauled out on shore in this period. Harbour seals increase their time foraging in the water in the winter (see section 3.3 *Foraging behaviour*). During this period, individuals may be more susceptible to disturbance from ongoing construction activities within the proposed area.

Harbour porpoise
The calving period of harbour porpoises takes place from May till July (Van Utrecht 1978, Verwey & Wolff 1983, Evans et al. 1986, Evans 1990, Kinze, 1990). In the North Sea, relatively high calf densities in certain areas suggested the presence of preferred calving calving grounds (Sonntag et al. 1999). These high calf densities have not been found for the Galway Bay cSAC (Berrow et al. 2008), but high proportions further south along the Irish coast suggest harbour porpoises along the Irish coast also have preferred calving grounds (Leopold et al. 1992, Sonntag et al. 1999). Since the main calving period takes place in summer, this will not be directly affected by anthropogenic disturbances due to marine construction activities.

Bottlenose dolphin
Reproduction in bottlenose dolphins is only partly seasonal, with females being able to give birth throughout the year (Urian et al. 1996). Populations at the same latitude can have distinctly different breeding seasons, so breeding is not related to day length, as it is in many

other species. However, breeding mostly took place within the period March-August (Urian et al. 1996). In Ireland, young calves and newborn bottlenose dolphins have been observed throughout the year (Oudejans, unpublished data), so the period of calving could possibly be affected by the proposed marine activities in the Galway Bay cSAC. Bottlenose dolphin calves remain dependant on their mothers for several years, and the majority of groups will be partly composed of dependant young animals throughout the year. Some records exist of cetacean mother-calf separations following severe disruption or disturbance, resulting from high intensity sounds sources (e.g. killer whales; Miller et al. 2012). These separations are considered highly stressful, and may be lethal for the calf. Hence, while these occurrences would be rare (also given the low number of animals recorded), the risk involved in these rare occurrences is very high. The same may apply for common dolphin and harbour porpoise. The proposed mitigation measures, including 30 min pre-construction monitoring and soft start procedures, will effectively mitigate against these possible effects.

Short-beaked common dolphin
Conception in short-beaked common dolphins is estimated to take place in July-August (Westgate et al. 2006). Gestation takes about a year, so giving birth occurs in the same period. It is unclear whether common dolphins give birth in special calving grounds. It is assumed therefore, that dolphins that are present in the Galway Bay cSAC during that July-August, may also mate and give birth there. These activities therefore can potentially be interrupted by construction activities. However, occurrences of common dolphins in the Galway Bay cSAC have been rare. Hence, for groups present in the bay during the breeding period, breeding activities could potentially be affected. However, given the limited number of common dolphin sightings in the Galway Bay cSAC, and near the area proposed for construction, this is unlikely to occur and the number of animals potentially affected is estimated to be low.

Minke whale
Minke whale breeding grounds are currently unknown, but are believed to lie in waters of the North Atlantic Ocean near the equator (Víkingsson & Heide-Jørgensen 2005). It is unclear when the minke whale breeding season takes place, but since this is not likely to occur near the Galway Bay cSAC, minke whale breeding activities are unlikely to be affected by the construction activities.

Assessment 5.
Are the impacts likely to focus on a particular section of the species' population, e.g., adults vs. juveniles, males vs. females?

Seals
Harbour seals show large intraspecific differences in foraging behaviour (see 3.3 *Foraging Behaviour*). Differences related to size and sex have been recorded in the Moray Firth, Scotland (Thompson et al. 1998). Males and large individuals venture out further to search for food than females. In other locations, however, juveniles were found to conduct larger movements than adults (Lowry et al. 2001). As one of the resting sites of harbour seals is located in the vicinity of Galway Harbour, this means that females, and most notably pupping and nursing females, are more likely to be affected by the proposed activities than males. Since very low numbers of grey seals are sighted in the proposed area, disturbance due to the construction activities is unlikely to impact a specific section of the population.

Harbour porpoise
Limited information is currently available on the harbour porpoise population structure. Harbour porpoises in the Galway Bay live in groups of two individuals, on average (Berrow et al. 2008). Of the population about 7% of individuals consists of juveniles, which is similar to the ratio found in other coastal waters of Ireland. Differences between males and females and juveniles in habitat-use have so far not been investigated.

Bottlenose dolphins
The social structure of bottlenose dolphins is a fission fusion society (Connor et al. 2000). This entails that group formations may change on a day-to-day basis, and group composition frequently changes. Aggregations and groups of animals are generally composed of mixed age- and sex-classes. Therefore, outside of the generally larger sensitivity of mother-calf pairs, it does not appear that any particular section of the species' population might be more affected than others.

Short-beaked common dolphin
Short-beaked common dolphins live in large aggregations of mixed sex- and age-classes. Therefore, outside of the generally larger sensitivity of mother-calf pairs, it does not appear that any particular section of the species' population might be more affected than others.

Minke whale
There is insufficient information available to consider different impacts on a particular section of the population of minke whales visiting the Galway Bay cSAC.

Assessment 6.
Will the plan or project cause displacement from key functional areas, e.g., for breeding, foraging, resting or migration?

Harbour seal
Harbour seals forage mainly within coastal waters and are a resident species of the Galway Bay cSAC. As a non-migratory species, they may have specific preferred areas for foraging. The quality of a foraging site is based on distance to the haul-out site, prey abundance and bathymetry. Individuals are known to generally forage within 50 km of their haul-out site, staying in the same area for over a decade (Bjørge et al. 1995, Härkönen & Harding 2001). Preferential foraging areas are generally within 20 km from the haul-out site (Tollit et al. 1998, Härkönen & Harding 2001, Grigg et al. 2009). Furthermore, harbour seals will choose areas with a long-term stable high prey abundance (Grigg et al. 2009). The high site-fidelity for both foraging and resting classifies harbour seals as central-place foragers (Orians & Pearson 1979, Thompson et al. 1998, Grigg et al. 2009).

If situated in the area of construction activities, harbour seals might not be able to use their preferred foraging location during these works. However, no preferred foraging areas have been identified from land-based surveys within the proposed area (Galway Harbour Company 2014). Furthermore, changes in prey distribution due to the acoustic disturbance could cause a deterioration of the quality of the patch. The effects of any impacts on foraging sites will depend on the availability of other suitable foraging areas in the area, and the increased time and energy spent acquiring/searching for food in alternative, potentially less suitable, or more distant locations. Harbour seals are known to be a flexible species, as can be concluded from their opportunistic prey selection and seasonal change of prey choice (Brown & Mate 1983, Tollit et al. 1998). Given the presence of alternative foraging opportunities, these characteristics make the species generally resilient to changes in the environment relating to food abundance.

Grey seal
Grey seals occur infrequently in the area (O'Brien 2009). Grey seals generally conduct large offshore movements and individuals tagged on the Blasket Islands, Co. Kerry, did not utilize the inner Galway Bay, despite individuals travelling multiple times up and down the west coast passing Galway Bay (Jessops et al. 2013). Hence, it is therefore unlikely the developed area comprises important habitat for the species.

Harbour porpoise
Harbour porpoises are currently the most frequently recorded cetacean species in the Galway Bay cSAC (O'Brien 2009). Given the general lack of knowledge on the fine-scale habitat use including foraging and mating/breeding areas, currently insufficient information exists to conclude whether construction activities would result in displacement from key functional areas.

Bottlenose dolphin
The population of bottlenose dolphins that frequents the Galway Bay cSAC is likely to be part of a coastal population that travels along the entire west coast of Ireland. It is possible that the Galway Bay cSAC is used as a part of their coastal habitat (Oudejans et al. in review). If the area is used as a migratory corridor, increased noise levels might cause the population to venture further offshore.

Short-beaked common dolphin
Short-beaked common dolphins occur occasionally in the area (O'Brien 2009). Generally, insufficient scientific information exists to conclude whether construction activities would result in displacement from a key functional area for this species. In Ireland, the common dolphin is mainly distributed in offshore waters and waters covering the coastal shelf (Wall et al. 2013). As such, the shallow waters of the proposed site likely do not comprise important habitat for this species.

Minke whale
Minke whales occur infrequently in the area (O'Brien 2009). Given the low number of sightings, it can be assumed the area does not comprise of important habitat for this species.

Assessment 7.
How quickly is the affected population likely to recover once the plan or project has ceased?

Seals
The marine development work will be interrupted for several months (April-July) every year, which will give all species time to recover from the disturbances. The recovery period will be most important for harbour seals, since they reside in the area permanently, which increases their levels of disturbance and decreases possibility for recovery during development. Stress levels may be elevated for some time after cessation of activities, but will likely have returned to normal at the start of the breeding season in June (Tougaard et al. 2009). Habituation in seals occurs quickly when exposed to non-startling, long-duration sounds (Götz and Janik 2010), such as shipping and dredging noise. Sounds with a short rise-time can elicit startle-reflexes, to which seals will sensitize if exposed multiple times in a row (Götz and Janik 2011). These sounds, i.e. blasting and pile-driving, have the potential of causing long-term behavioural effects, impact individual fitness and decrease longevity (Götz and Janik 2011). Therefore, the within-project recovery of seals will depend upon the presence of pile-driving or blasting activities during the winter construction periods. A study investigating harbour seal movements after completion of two wind farms in the Danish Wadden Sea, indicated no significant long-term effect of the operational wind farms on seal behaviour (McConnell et al. 2013). Short-term displacement effects were reported during the construction and operation of a wind farm in the Wadden Sea, Denmark (Edren et al. 2010). Here, no long-term effects were found, and harbour seals continued to use the area, and population increased in accordance with an increase observed in other areas (Edren et al. 2010). In contrast, longer-term displacement of seals was recorded in Broadhaven Bay, Ireland during an offshore construction of a pipeline (Anderwald et al. 2013). Current post-construction monitoring will enable to determine long-term effects and identify if seals return to pre-construction levels. After completion of the project, the population might return to pre-construction distribution ranges within a few months (Tougaard et al. 2009).

Based on the currently available information, with grey seals only sighted occasionally in the Galway Bay cSAC, the proposed activities are not expected to cause an impact at population-level.

Harbour porpoise

Knowledge of harbour porpoise population structure and disturbance effects on population level are currently limited, Short term responses have been reported during the construction of a windfarm, where harbour porpoise activity was reduced between 24 and 70 h after pile driving activities (Brandt et al. 2012). Studies of long-term responses of harbour porpoises to acoustic disturbance have shown conflicting results. Teilmann and Carstensen (2012) studied the effects of the construction of an offshore wind farm in the Baltic, and found that ten years after construction population numbers were still not up to their previous level. On the other hand, Scheidat et al. (2011) found that harbour porpoise presence in the Dutch North Sea actually increased during and after the construction of the wind farm. This phenomenon was explained by the fact that previously the site was on a busy travel pathway for commercial shipping, which was rerouted for the windfarm. Furthermore, the two areas probably differed in significance for the respective populations, which would influence the necessity of return: In the Baltic, harbour porpoise presence had been infrequent already before construction, suggesting the area was relatively unimportant for the population. Galway Bay is currently an urbanised but relatively undisturbed marine area, and harbour porpoise sightings are common. The probability and speed of recovery after the construction period will therefore depend on the relationship between the relative importance of the area for harbour porpoises and area quality post-construction.

Bottlenose and common dolphin, and minke whale

The relatively small number of sightings of bottlenose dolphins, common dolphins and minke whales in the Galway Bay cSAC suggest that impacts on animals of these species frequenting the bay will not lead to population-level effects (Table 1). However, in general, information on population sizes, habitat-use and behaviour in Irish waters is limited, and conclusive evidence for the likelihood of population-level effects resulting from the project is currently unavailable.

Table 2. ***Summary of the likelihood of physical hearing and behavioural effects on individual marine mammals exposed to noise from five types of marine construction activities for the Galway Harbour Extension Project: 1a) Dredging Backhoe; 1b) Dredging TSHD; 1c) Pile driving; 1d) Blasting and 1e) Shipping noise in the absence (no mitigation) and presence (mitigation) of proposed mitigation measures.*** *Physical hearing effects include Permanent Threshold Shift (PTS) and Temporal Threshold Shift (TTS). Species' specific threshold levels for effects (SPL(peak)/SEL threshold) are published data from Southall et al. (2007). The impact zone (m) from source states the maximum distance or estimated range category from the source at which either SEL or SPL threshold levels are exceeded. Impact zones were calculated using received sound levels quantified in Appendix 10.2 of the EIS (Galway Harbour Company 2014), using a precautionary approach. For all sound types other than single pulses, threshold levels for behavioural effects (*) are not included, but are assumed to occur more commonly at levels below PTS/TTS threshold levels (Southall et al. 2007), and are defined as Medium (0 - 2500 m), and Large (>2500 m; Appendix 10.2 Galway Harbour Company 2014). Definitions: Likely: The likelihood of occurrence of the impact is high; Unlikely: The likelihood of occurrence of the impact is low; Possible: The impact is likely if animals are present in the area (for occasional- infrequently recorded species). Abbreviations: Trail Suction Hopper Dredgers (TSHD), Sound Pressure Level (SPL), Sound Exposure Level (SEL), Does not occur (d.n.o.). Not available (N/A), Behaviour (Beh.).*

1a) BACKHOE DREDGING					
Species	**Acoustic impact**	**SPL(peak)/SEL threshold**	**Impact zone (m)**	**Impact (no mitigation)**	**Impact (mitigation)**
Harbour seal	PTS TTS Beh. effect	218/203 212/183 *	8 80 Large	Likely Likely Likely	Unlikely Unlikely Likely
Grey seal	PTS TTS Beh. Change	218/203 212/183 *	8 80 Large	Possible Possible Possible	Unlikely Unlikely Possible
Bottlenose dolphin	PTS TTS Beh. effect	230/215 224/195 *	2 15 Large	Unlikely Unlikely Likely	Unlikely Unlikely Likely
Common dolphin	PTS TTS Beh. effect	230/215 224/195 *	2 15 Large	Unlikely Unlikely Likely	Unlikely Unlikely Likely
Harbour porpoise	PTS TTS Beh. effect	230/215 224/195 *	1 15 Large	Unlikely Likely Likely	Unlikely Unlikely Likely
Minke whale	PTS TTS Beh. effect	230/215 224/195 *	N/A N/A N/A	Unlikely Unlikely Unlikely	Unlikely Unlikely Unlikely

1b) TSHD DREDGING					
Species	**Acoustic impact**	**SPL(peak)/SEL threshold**	**Impact zone (m)**	**Impact (no mitigation)**	**Impact (mitigation)**
Harbour seal	PTS	218/203	10	Likely	Unlikely
	TTS	212/183	100	Likely	Unlikely
	Beh. effect	100	Large	Likely	Likely
Grey seal	PTS	218/203	10	Possible	Unlikely
	TTS	212/183	100	Possible	Unlikely
	Beh. effect	*	Large	Possible	Possible
Bottlenose dolphin	PTS	230/215	2	Unlikely	Unlikely
	TTS	224/195	20	Unlikely	Unlikely
	Beh. effect	*	Large	Likely	Likely
Common dolphin	PTS	230/215	2	Unlikely	Unlikely
	TTS	224/195	20	Unlikely	Unlikely
	Beh. effect	*	Large	Likely	Likely
Harbour porpoise	PTS	230/215	9	Unlikely	Unlikely
	TTS	224/195	90	Likely	Unlikely
	Beh. effect	*	Large	Likely	Likely
Minke whale	PTS	230/215	N/A	Unlikely	Unlikely
	TTS	224/195	N/A	Unlikely	Unlikely
	Beh. effect	*	N/A	Unlikely	Unlikely

1c) PILE DRIVING					
Species	**Acoustic impact**	**SPL(peak)/SEL threshold**	**Impact zone (m)**	**Impact (no mitigation)**	**Impact (mitigation)**
Harbour seal	PTS	218/186	100	Likely	Unlikely
	TTS	212/171	600	Likely	Unlikely
	Beh. effect	212/171	Large	Likely	Likely
Grey seal	PTS	218/186	100	Possible	Unlikely
	TTS	212/171	600	Possible	Unlikely
	Beh. effect	212/171	Large	Likely	Likely
Bottlenose dolphin	PTS	230/198	17	Possible	Unlikely
	TTS	224/183	100	Possible	Unlikely
	Beh. effect	224/183	Large	Likely	Likely
Common dolphin	PTS	230/198	17	Possible	Unlikely
	TTS	224/183	100	Possible	Unlikely
	Beh. effect	224/183	Large	Likely	Likely
Harbour porpoise	PTS	230/198	16	Likely	Unlikely
	TTS	224/183	90	Likely	Unlikely
	Beh. effect	224/183	Large	Likely	Likely
Minke whale	PTS	230/198	N/A	Unlikely	Unlikely
	TTS	224/183	N/A	Unlikely	Unlikely
	Beh. effect	224/183	N/A	Unlikely	Unlikely

1d) BLASTING					
Species	**Acoustic impact**	**SPL(peak)/SEL threshold**	**Impact zone (m)**	**Impact (no mitigation)**	**Impact (mitigation)**
Harbour seal	PTS TTS Beh. effect	218/186 212/171 212/171	50 160 Large	Likely Likely Likely	Unlikely Unlikely Likely
Grey seal	PTS TTS Beh. effect	218/186 212/171 212/171	50 160 Large	Possible Possible Likely	Unlikely Unlikely Likely
Bottlenose dolphin	PTS TTS Beh. effect	230/198 224/183 224/183	45 90 Large	Possible Possible Likely	Unlikely Unlikely Likely
Common dolphin	PTS TTS Beh. effect	230/198 224/183 224/183	45 90 Large	Possible Possible Likely	Unlikely Unlikely Likely
Harbour porpoise	PTS TTS Beh. effect	230/198 224/183 224/183	45 90 Large	Likely Likely Likely	Unlikely Unlikely Likely
Minke whale	PTS TTS Beh. effect	230/198 224/183 224/183	N/A N/A N/A	Unlikely Unlikely Unlikely	Unlikely Unlikely Unlikely

1e) SHIPPING NOISE				
Species	**Acoustic impact**	**SPL(peak)/SEL threshold**	**Impact zone (m)**	**Impact (no mitigation)**
Harbour seal	PTS TTS Beh. effect	218/203 212/183 *	d.n.o. 3 Large	Unlikely Possible Likely
Grey seal	PTS TTS Beh. effect	218/203 212/183 *	d.n.o. 3 Large	Unlikely Possible Possible
Bottlenose dolphin	PTS TTS Beh. effect	230/215 224/195 *	d.n.o. d.n.o. Medium	Unlikely Unlikely Possible
Common dolphin	PTS TTS Beh. effect	230/215 224/195 *	d.n.o. d.n.o. Medium	Unlikely Unlikely Possible
Harbour porpoise	PTS TTS Beh. effect	230/215 224/195 *	d.n.o. d.n.o. Large	Unlikely Unlikely Likely
Minke whale	PTS TTS Beh. effect	230/215 224/195 *	N/A N/A N/A	Unlikely Unlikely Unlikely

6.2.4 Mitigation

Mitigation measures as proposed in the EIS (Galway Harbour Company 2014) are likely to minimise strong and direct effects of the construction activities, thereby also mitigating population-level effects resulting from those effects. Harbour seals, grey seals, bottlenose dolphins, short-beaked common dolphins, harbour porpoises and minke whales have all been observed in the area of the proposed activities. Due to differences in abundance, behaviour and life-strategy, some species are more likely to be affected by the construction activities than others. In light of the possible impacts of the proposed activities, qualified marine mammal observers should conduct visual observations before and during developmental work in the water, and all activities will be put to a halt or postponed if the situation so requires. Mitigation measures should be performed as described in detail in "The Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters" by the Department of Arts, Heritage and Gaeltacht (DAHG 2014). All construction activities (see 4.3.1. NPWS 2014), that may impose an impact on marine mammals should adhere to these technical guidelines. A brief summary of the main topics of the guidelines are provided below:

- One or more qualified marine mammal observer(s) (MMO) conduct monitoring in the "monitored zone" or exclusion zone for a minimum of 30 min (pre-start monitoring) before the start of construction activity (pile driving, dredging, drilling and blasting), and when construction activities cease for more than 30 min.
- Construction activities shall start only after confirmation given by the MMO, and will not commence if marine mammals are detected within a 500 - 1,000 m radial distance of the sound source, depending on activity type (see DAHG 2014).
- Ramp-up (soft start) mitigation procedures should be implemented for all pile driving and geophysical surveys undertaken, and only commence after confirmation given by the MMO.
- Marine mammal observers will provide daily reports including the monitoring and construction operations, mitigation measures undertaken, and description of any observed reaction by marine mammals, using the standard operation forms for Coastal/Marine works.
- Daily reports are to be submitted to the relevant regulatory authority within 30 days after completion of the operations.

Next to direct monitoring during the construction activities, we recommend that dedicated research is undertaken in the Galway Bay cSAC, with a focus on the area affected by the construction activities, investigating:

1) Distribution and abundance of all marine mammals species prior, during and post-construction, including mark-recapture studies and ongoing acoustic monitoring.
2) Behavioural patterns and aquatic habitat-use of all marine mammals species prior, during and post-construction, including on-animal data loggers.
3) Prey species presence and abundance prior, during and post-construction.
4) Marine mammal responses to construction activities.

6.2.5 Summary

Two pinniped and four cetacean species occur in Galway Bay cSAC and the greater Galway Bay. Based on current available information, the harbour seal is resident in the area, harbour porpoises are frequently sighted, bottlenose dolphins and common dolphins are infrequently sighted but regularly recorded acoustically, and minke whales and grey seals are infrequently present.

Given the scale of the development and associated loss of marine habitat resulting from the project, significant impacts on marine life in the cSAC area cannot be ruled out. These activities have the potential of disturbing the marine mammals in the area, both physically and behaviourally. Dredging, pile driving, blasting, general construction and shipping will likely cause acoustic disturbance, while physical presence of vessels may increase the risk to collision. Acoustic disturbance in close proximity to the animals can cause temporary or permanent hearing threshold shifts and may lead to behavioural changes at larger distances. However, the proposed mitigation actions are likely to effectively reduce and minimise the risk of direct physical (hearing) injuries (PTS, TTS) and behavioural changes caused by underwater noise or collisions. Secondary impacts, by changes in prey abundance and distribution, may also occur.

In general, the current knowledge of fine-scale habitat use in Irish waters is insufficient to determine if marine mammals will be deterred from key functional areas, and to what extent essential parts of their life cycle might be affected. Of the marine mammal species present in the Galway Bay cSAC, harbour seals and harbour porpoises have the highest probability to be affected by the construction works, due to their residency/frequent occurrence in the Galway Bay cSAC, and, in case of the harbour seal, use of the area for essential life functions (foraging, nursing, breeding, mating, resting and moulting). Of these essential life functions, the terrestrial activities (terrestrial resting, breeding and moulting, not assessed here), are not directly affected by the marine construction works. These activities constitute of three of the five conservation objectives for harbour seals in the Galway Bay cSAC (NPWS 2013). The remaining two conservation objectives (access to suitable habitat and disturbance) will potentially be affected due to either direct or indirect effects of the construction activities. Marine mammals either are unlikely to be affected at a population level (grey seal, minke whale, common dolphin, bottlenose dolphin), or are likely to recover from any impacts of the construction activities (harbour seal, harbour porpoise). Here, the probability and speed of recovery will depend on the relative importance of the area for the species, behavioural characteristics and area quality post-construction. Proposed mitigation measures are likely to minimise strong and direct effects in close proximity to the construction activities for all marine mammals.

6.3 SEAL COUNTS

6.3.1 Seal Counts Methodology, Observations and Results

A full dataset of seal observation records (based on various surveys) has been presented in Appendix 2.1. This data is based on six different surveys, which encompassed different areas and included a variety of methodologies in terms of location and duration of surveys. An outline of the methodologies is provided below.

6.3.2 Observations from Nimmo's Pier

Aquafact observation information was originally provided as Figure 7.5.29 in the EIS document, but has been updated with data since the submission of the EIS and planning application. This survey included observations of seal numbers from Nimmo's Pier. Observations were made with x10 binoculars from the end of Nimmo's Pier with broad scale sweeps from the Dock Gates around to Mutton Island. Observation periods were of 10 – 15 minutes duration, within varying weather and tidal conditions. 147 surveys of this nature have been completed to date. A maximum number of 50 seals was observed during the winter of 2010/11, which was associated with a shoal of sprat within the area. Outside that time, the maximum count was six individuals.

6.3.3 Marine Mammal Observer Records

As part of site investigation works in 2012, a marine mammal observer completed observations of the marine area within the development site. Eight days of surveys averaging over 10 hours each were completed, in good visibility and weather conditions. No marine mammals were present before operations began but a number of observations were made during the works. A maximum number of three seals were observed.

6.3.4 Observations from Mutton Island Lighthouse

From June 2011 until May 2012, Chris Peppiatt undertook twelve monthly 100-minute cetacean and marine mammal watches over the site of the proposed development. The vantage point used was the top of the Mutton Island Lighthouse. The optical equipment used was an 8.5x magnification Swarovski binoculars with 42mm objective lenses and a tripod-mounted Swarovski telescope with a 20-60 x zoom eyepiece lens and an 80mm objective lens. Only one individual common seal was observed on two occasions during the 12 month count.

6.3.5 Observations from Current Harbour Park

In addition, monthly observations from a vantage point above the foreshore of the current harbour park (i.e. from the area from which the reclamation of land out into the current harbour area is proposed) at E130500 N24595 were also undertaken by Chris Peppiatt. The survey area consisted of the shoreline of the current harbour park (i.e. from Rinmore Point to just to the West of Renmore Beach), including all of the intertidal area that is exposed at low tide and the marine area from this shoreline out as far as the end of Mutton Island and bounded by Mutton Island in the west and Hare Ireland in the east. The survey included observations of known seal haul out locations at Renmore Barracks and Rabbit island which were visible from the vantage point. This marine area within the survey was approx. 2.5km^2 in extent at high tide. Initially watches lasted three hours, but in 2012 these were later extended to eight hours (effectively covering the whole day). All states of the tide were covered. Watches were carried out in acceptable visibility conditions (minimum 2km) and when the sea conditions were no worse than Sea State 4 (in most cases, sea state 2 or better). The optical equipment used was 8.5x magnification Swarovski binoculars and a tripod-mounted Swarovski telescope with a 20-60 zoom lens. The maximum count recorded in the water were five individuals, with an average of 1.07 recorded over the 228 hours of surveying. A maximum of five individuals were recorded hauled out at Renmore site during these surveys, with 14 individuals the maximum hauled out at Rabbit Island.

6.3.6 Observations from Seal Haul Out Locations Surveys

Twelve monthly surveys of known seal haul out sites in the area around the site of the proposed development were conducted in 2011-2012. Haul out site surveys were conducted over the four-hour period lasting from two hours before low tide until two hours after low tide. The surveys were completed by Chris Peppiatt using 8.5x magnification Swarovski binoculars and a tripod-mounted Swarovski telescope with a 20-60 x zoom lens. The haul out sites covered during this survey work were situated along the coastline of inner Galway Bay from the vicinity of the site of the proposed development eastwards and then south as far as known haul-out sites in Kinvara Bay and at Deer Island. Some sites were observed from the shoreline, while for others (e.g. Deer Island, Earl's Rock/St. Brendan's Island and the seaward side of Hare Island) observations were made from a rigid inflatable boat. The haul out survey work gave counts of between 31 and 169 common seal at or close to the eleven haul out sites between Renmore and Deer Island. There was some variation, although the numbers were higher in the months before and after the birth of pups (June/July), with the lowest counts being made in the December-March period. On the 14th of July 2011, pups were recorded at the breeding sites in Oranmore Bay (8), Kinvara Bay (17) and Deer Island (6).

6.3.7 Observations from Lough Atalia Surveys

Between November 2011 and May 2012, 25 visits were made specifically to Lough Atalia to conduct surveys for seals. The survey method included general observation using binoculars and a scope from four locations along Lough Atalia Road and at the mouth of Lough Atalia, to encompass possible haul out areas and ensure full visibility of the lagoon. Approximately ten minutes observation was spent at each location, in all states of the tide. A maximum of two seals were observed hauled out and a maximum of one seal was observed in the water at any time. Seals were recorded on ten occasions out of 28 overall visits to the Lough Atalia area (note that 28 visits includes three additional records from Chris Peppiatt based on bird count visits and a specific seal haul out survey record).

6.3.8 Mapping of Seal Haul Haul Out Locations

Map No. 1 included in RFI Appendix 2.1 of this document presents the locations of known seal haul outs and locations of survey observation points, for reference.

6.3.9 Summary

The survey data demonstrates that Common Seal are often seen at the mouth of the River Corrib, close to Nimmo's Pier, use Lough Atalia as an occasional haul out and can generally be said to be a common sight all around Galway Bay. There are no colonies of seals within the harbour itself and the number of seals using the marine development site area are not extensive, with the exception of an occasion where a shoal of sprat were within the harbour area, the maximum counts were up to six individuals and average counts were very low numbers and single individuals. There are a number of seal haul-outs in the Inner Galway Bay, including a large colony on Tawin Island, although this is not a breeding colony. The closest important site to the proposed development is at Oranmore Bay, which is home to a breeding colony of approximately 30 – 40 seals. Common seal occasionally haul out on Rabbit Island (approximately 2km from the development site).

7 ECOLOGY ISSUES – BIRDS

The information prepared in response to the queries raised by An Bord Pleanala with regard to birds, is included within the EIS and NIS Addenda / Errata documents and also provided as Appendices RFI 3.1 and RFI 3.3 of this document which were prepared by Dr. Tom Gittings and Dr. Chris Peppiatt. Where feasible, the relevant information has been included directly in the responses below; in other instances, the reader is directed to the location within the EIS and NIS Addenda / Errata where the information is included. Where multiple points of information were required within a single point of the Request for Further Information, the points have been broken down, for ease of understanding.

7.1 (A) ASSESSMENT OF BIRD DISTRIBUTION AND BEHAVIOUR

Query:

The assessment of bird distribution and behavior in the proposed development area should be supplemented with additional data. Bird data of this type is inherently variable and it is unlikely that the duration of the proposers study would have been sufficient to characterize the birds at the site.

Response:

Waterbird monitoring of the GHE count has been carried out through monthly counts from March 2011 – March 2012 (as presented in the EIS and NIS) in addition to October 2012 – March 2013 and from March – September 2014. The full data set is presented in Appendix RFI 3.1. Each count involved an eight hour watch from a vantage point at the northern edge of the GHE development site. Maximum counts of all species were recorded for each 30 minute interval during these counts. Some counts also recorded bird numbers in the adjacent intertidal areas at Renmore Beach and the eastern end of Nimmo's Pier – South Park Shore. It is considered that the full data set is sufficient to characterize the birds within the GHE site.

For this assessment, the occurrence of the non-breeding SCI populations within the GHE count area has been analysed using the count data from September 2011 – March 2012 and October 2012 – March 2013. These periods correspond to the seasonal period normally used for assessing non-breeding waterbird populations (September-March), and can be compared with I-WeBS data for the same winters. The counts from March 2011 and 2014 have not been included, as comparisons between counts from a single month and I-WeBS data for a whole winter would not be representative.

The occurrence of the breeding SCI populations within the GHE count area has been analysed using the count data from April-July 2011 and 2014 (Cormorant) and May-July 2011 and 2014 (Sandwich Tern and Common Tern).

The occurrence of the non-breeding SCI populations in the adjacent areas of intertidal habitat has been analysed using all available counts from the September-March period, due to the limited number of counts.

For species associated with intertidal/shallow subtidal habitat, only the counts that included the low tide period were included in the analysis.

7.1 (b) Additional Bird Data

While the proposer's assessment did incorporate data from additional sources, including bird atlases and the Irish Wetland Bird Survey (I-WeBS), these data are generally more than ten years old, and many are much older. The EIS does not cite the latest I-WeBS survey of waterbirds in Ireland (Crowe et al, 2012). This study ranks Inner Galway Bay as being 15th of Ireland's internationally important sites in terms of waterbird abundance rather than 24th as stated in the EIS. The EIS also does not report that Inner Galway Bay is currently listed as having the highest number of several species in Ireland including Great Northern Diver and Red-breasted Merganser (Boland and Crowe, 2102). While not available at the time of EIS and NIS submission, the most recent revision of Birds of Conservation Concern in Ireland (Colhoun and Cummins, 2013) is now available and pertinent information from this study should be included in the revised submission. Of particular importance is the change in status of Great Northern Diver to an amber-listed species because of Ireland's importance on a European scale in supporting significant numbers of this species in the non-breeding period.

Response:

The EIS and NIS have been updated to include latest I-WeBS survey of waterbirds in Ireland results (Crowe et al, 2012) and information from the most recent Birds of Conservation concern in Ireland (Colhoun and Cummins, 2013). This information was taken into consideration as part of detailed species profiles which were prepared (Appendix RFI 3.2) by Dr. Chris Peppiatt including a detailed review of Great Northern Diver and Red-breasted Merganser, and throughout the review of the impact assessment process by Dr. Tom Gittings, which is included as Appendix RFI 3.3 of this RFI document and as Appendix 3.4 of NIS Addendum / Errata.

The Species Assessments (Appendix RFI 3.3) make extensive use of I-WeBS data, supplemented by data from the NPWS Baseline Waterbird Survey from various periods, including the most recent available. These uses include: analyses of species distributions and habitat associations within Inner Galway Bay; examination of recent population trends to inform assessment of potential sensitivity to displacement impacts; the use of recent I-WeBS data to provide the denominator in calculations of percentage displacement.

7.2 ANALYSIS OF SPECIES SPECIFIC INFORMATION

Query:

(a) The assessment of sensitivity of the listed bird species to potential impacts from the proposed development would be greatly improved by a comprehensive desk study that incorporated species specific information concerning the ecology of each species. The desk study should be carried out with the assistance of a suitably qualified waterbird ecologist and be based on international scientific research as well as information currently available from Ireland. Many species appear to have been assessed as being the same group despite having markedly different ecologies.

(b) The effects of many potential impacts on birds are listed as "indeterminate". The desk study may resolve many of the "indeterminate" classifications. As noted above, the potential impact of any activity may not be classified as "indeterminate" and should be classified as "likely significant" in the case of uncertainty.

Response:

A comprehensive desk study and species-specific assessment, based on and including national and international scientific research undertaken by Dr. Tom Gittings and Dr. Chris Peppiatt. The information is presented as two documents, Species Profiles and Species Assessments (included as Appendices RFI 3.2 and RFI 3.3 of this response) which presents the information comprehensively on a species-by-species basis.

The species Profiles, prepared mainly by Dr. Chris Peppiatt, include general reviews of species ecology, Irish status and distribution, occurrence within Inner Galway bay; detailed assessment of their occurrence within and adjacent to the development site; and review of their sensitivities to potential impacts.

The species assessments provide site and species-specific assessments of the potential impacts of the Galway harbour Extension project on the Special Conservation Interest species (SCI) species of the Inner Galway Bay SPA.

The main impact assessments (of habitat loss/degradation and disturbance) are presented separately for the non-breeding and breeding SCI populations. This reflects differences in the data available for the assessments, which dictated the methodology of the assessments, and in some of the issues potentially affecting the populations.

The Species Assessment which was undertaken included a more thorough and critical assessment of the likely levels of impacts on a species-by species level. This included an assessment of impacts on breeding and non-breeding populations from habitat loss and degradation, disturbance, construction activities and in-combination effects, among others. The assessment, which was based on the detailed desk study, has resulted in the ability to assign more specific levels of potential impact associated with the proposed development, and none of the conclusions are now indeterminate with regard to the level or significance of associated impact. This information has been compiled into the EIS and NIS Addenda / Errata documents accompanying this response to An Bord Pleanala.

7.3 MITIGATION MEASURES FOR WATERBIRDS

Query:

There is a notable lack of proposed mitigation measures in the NIS to offset potential impacts on waterbirds. The detailed desk study requested may go some way to informing this. As for Annex I habitats, topics raised in the EIS concerning good environmental practice during construction and operation of the proposed development may partially address this issue.

Response:

Within the NIS and EIS documents, a selection of mitigation measures were included the prevention of significant impacts to the Natura 2000 sites, including the Inner Galway Bay SPA and its special conservation interests. A holistic approach was taken with regard to mitigation measures, taking into consideration that some broader mitigation such as protection of water quality, will mitigate impacts for various species and habitats. While perhaps not outlined specifically for birds, the following mitigation measures were proposed within the NIS and EIS to reduce or minimize impacts to bird species.

Mitigation by Design – The layout and footprint of the proposed development has evolved over the course of the design process with a view to minimizing impacts on Natura 2000 sites, including the Inner Galway Bay SPA and its special conservation interests. A sensitive lighting plan to avoid lighting of the water body has been proposed and rock built sea walls on the eastern side of the development will more than replace existing rock walls to be lost. The use of textured construction material has been proposed, which will enhance settlement by algae and invertebrates, which are food sources for bird species.

Conastruction Methods and Timing – The proposed use of geotextiles to minimize escape of silt during construction of lagoons will ensure minimized impact on water quality and associated impacts on the SPA and its special conservation interests. Suspended solids and dissolved oxygen, which have the potential to effect the quality of the aquatic habitat and food resources, will be monitoring as part of the Environmental Management Plan.

The Species Assessment which was undertaken included a more thorough and critical assessment of the likely levels of impacts on a species-by-species level. The assessment, which was based on the detailed desk study, included and considered species specific mitigation measures which were relevant to breeding and non-breeding populations. This information has been compiled into the EIS and NIS Addenda / Errata documents accompanying this response to An Bord Pleanála.

A summary of the relevant mitigation measures are included below:

Blasting and piling will not be carried out during the tern breeding seasons (01 April to 31 July, inclusive).

Pile driving and blasting will not be undertaken during the night, thus limiting the effects of noise on the marine environment, which will reduce disturbance impacts on prey species such as fish.

With particular regard to Red-breasted Merganser, Great Northern Diver and Cormorant, the RIB will quarter over and around the blast site immediately prior to blasting with the intention that any birds present will be scared away from the danger zone. Blasting will be delayed /

postponed if individuals are seen in the area when blasting is scheduled. Therefore any such impact will be very unlikely. Even in the worst case scenario of such an impact occurring, given the numbers present in the area and dispersed distribution of the birds, the number of birds suffering injury would be very low and would not cause population level consequences.

In addition, the NIS Addendum / Errata document includes additional mitigation measures including Oil Contingency and Emergency Management Plans.

7.4 POTENTIAL IMPACTS FOR EACH BIRD SPECIES

Query:

Some potential impacts on waterbirds were not considered in the NIS. Any additional impact requiring consideration is the effect of extreme weather on bird species and the interaction of the proposed development with this. There is also a potential impact to some bird species from increased recreational boating and shipping that is not associated with noise. Some species, such as Great Northern Diver, are displaced from foraging areas by the proximity of vessels at distances of more than a kilometer (Furness et al, 2012). Maintenance dredging of the turning circle may be a permanent impact of some diving species. These impacts, as with all potential impacts, should be considered separately for each species.

Response:

The Species Assessment (Appendix 3.2) which was undertaken included a more thorough and critical assessment of the likely levels of impacts on a species-by-species level. This included an assessment of impacts on breeding and non-breeding populations from habitat loss and degradation, disturbance, construction activities and in-combination effects, among others. The assessment, which was based on the detailed desk study, has resulted in the ability to assign more specific levels of potential impact associated with the proposed development. This information has been compiled into the EIS and NIS Addenda/Erata documents accompanying this response to An Bord Pleanala.

With regard to some of the specific points raised in No. 4 above, relevant information from the Species Assessment document has been copied below.

Extreme Weather

Extreme weather causes increased energetic demands, requiring birds to feed for longer to meet these demands. Extreme weather may also reduce the availability of food resources (e.g., frozen fields), causing increased densities of birds in the remaining available habitats. Extreme weather may also cause influxes of birds from continental regions causing increased densities of birds in the site. These factors can, potentially, cause the local population to reach, or exceed, the effective carrying capacity of the site, and cause increased mortality rates due to density-dependent processes. In addition, birds may be more susceptible to disturbance impacts in extreme weather due to the energetic costs of responding to the disturbance (when birds are already energetically stressed) and the loss of feeding time (when birds are already having difficulty meeting their food requirements).

With reference to the GHE development, there is no evidence that any of the above factors is a significant issue. The levels of displacement that will be caused by the GHE development are so small that it is not reasonable to suppose that such displacement will significantly increase densities in the remaining habitat to the extent that would be required for this displacement to contribute to increased mortality rates in extreme weather. The area around the GHE development site is already subject to high levels of disturbance, and birds using these areas will be habituated to some degree to disturbance impacts. Therefore, it is not reasonable to suppose that the birds will be so sensitive to disturbance impacts that there will be significant increases in energetic costs/loss of feeding time in extreme weather.

Disturbance from additional shipping and boating traffic (Section 4.3.5 of Species Assessment document)

Additional shipping and boating traffic will also be generated by the development and may cause disturbance impacts outside the GHE site.

The shipping traffic will follow the existing shipping lane in the middle of the bay and will only, therefore, potentially affect species associated with deep subtidal habitat (> 5 m deep). The assessment of the impact of additional shipping traffic within the GHE site will also apply to the impact of additional shipping traffic in the shipping lane outside the GHE site.

A tenfold increase in recreational boat traffic may also be generated. It is anticipated that most of this extra marina traffic will follow established routes from the harbour to the South and West, since many of the areas at the eastern end of the bay can be dangerously shallow, even for small boats. Disturbance from this boat traffic will only affect species associated with moderately deep and deep subtidal habitat, as the boats will not travel into the shallow subtidal habitat. Of these species, the gulls will not be sensitive to such disturbance impacts (see Species Profiles document). Red-breasted Merganser, Great Northern Diver and Cormorant may show avoidance reactions to such boat traffic. However, given the more or less uniform very low densities at which these species occur in Inner Galway Bay (2-5 birds per 100 ha), and the fact that highest intensity of recreational boat traffic will be in the summer, outside the main season of occurrence of these populations, it is unlikely that the increased recreational boat traffic will cause significant disturbance impacts.

Great Northern Diver

The disturbance sensitivity of subtidal species to shipping and boat traffic is reviewed in the relevant species profiles. In particular, the review in the species profile for Great Northern Diver demonstrates that the figure that has been quoted of Great Northern Divers been disturbed by shipping traffic at distances of more than 1 km does not have any firm basis in the literature and is not relevant to the situation in Inner Galway Bay.
A detailed species profile on Great Northern Diver is presented, in addition to the consideration of impacts on the species within the Species Assessment document. This information has been incorporated into relevant sections of the NIS and EIS Addenda/Errata documents.

Maintenance Dredging of the Turning Circle

Maintenance dredging of the turning circle has been considered within the Species Assessments prepared by Dr. Tom Gittings. An assumption of the worst case scenario of complete exclusion of birds form the turning circle was considered as part of the assessment.

7.5 CLASSIFICATION OF IMPACTS

Query:

There appears to be some inconsistency in the information provided about waterbirds in the NIS. For example, Inner Galway Bay is listed for three breeding species: Cormorant, Sandwich Tern and Common Tern. For each of these breeding species, all attributes were assessed with no significant impacts predicted. However, the assessment goes on to assess the impacts separately (i.e. impacts during construction phase; impacts during the operational phase; and in-combination effects). This results in a common and repeated statement of "this impact is not likely to be significant, but is indeterminate". With no proposed mitigation stated in Table 3.11, the residual impact for all these three breeding species is considered to be "indeterminate". The applicant is required to re-evaluate the section on waterbirds contained in the NIS in the context of the above comments.

Response:

The Species Assessment (Appendix RFI 3.3) which was undertaken included a more thorough and critical assessment of the likely levels of impacts on a species-by-species level. This included an assessment of impacts on breeding and non-breeding populations from habitat loss and degradation, disturbance, construction activities and in-combination effects, among others, and considered species specific and general mitigation measures where applicable. The assessment, which was based on the detailed desk study, has resulted in the ability to assign more specific levels of potential impact associated with the proposed development, and none of the conclusions are now indeterminate with regard to the level or significance of associated impact. This information has been compiled into the EIS and NIS Addenda/Errata documents accompanying this response to An Bord Pleanala.

Table 3.27 of the NIS Addendum summarises the impacts on birds species following the more detailed desk study and Species Assessment. This is presented below.

Table 3.27 from NIS(A)

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
Annex I species	**Great Northern Diver (*Gavia immer*) [A003]**
Level of Residual Impact	The predicted displacement impact from habitat loss is 0.3 birds, or 0.3% of the Inner Galway Bay population, and, from combined habitat loss and a worst-case habitat degradation scenario, 1.0 birds or 1.0% of the Inner Galway Bay population. This would cause an increase in density of less than 0.1 bird per 100 ha. Therefore, it is reasonable to conclude that this very minor displacement impact will not cause any population-level consequences. A RIB will quarter over and around the blast site immediately prior to blasting with the intention that any birds present will be scared away from the danger zone. Blasting will be delayed/postponed if individuals are seen in the area when blasting is scheduled. Therefore any such impact will be very unlikely. Even in the worst case scenario of such an impact occurring, given the numbers present in the area and dispersed distribution of the birds, the number of birds suffering injury would be very low and would not cause population-level consequences. The intertidal habitat lost from the development of the GHEP would have been available to these species on all high tides, while the saltmarsh and *Scirpus maritimus* habitat would have been available on spring high tides. However, given that the loss of 75 ha of subtidal habitat is predicted to cause displacement of 1%, or less, of the Inner Galway Bay population of these species, the loss of 16.5 ha of habitat that will only have been partially available to the species is unlikely to have caused any measurable displacement impact. ***Significant impacts on the SCI and conservation objectives of the SPA have therefore been excluded.***

Table NIS(A) 3.27 Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
	Cormorant (*Phalacrocorax carbo*) [A017]
Level of Residual Impact	The predicted displacement impact from habitat loss is 0.4 birds, or 0.2% of the Inner Galway Bay population, and, from combined habitat loss and a worst-case habitat degradation scenario, 1.2 birds, or 0.7% of the Inner Galway Bay population. This would cause an increase in density of less than 0.1 bird per 100 ha. Therefore, it is reasonable to conclude that this very minor displacement impact will not cause any population-level consequences. The Cormorant breeding colony is located at Deer Island around 8.5 km from the GHE site. The mean Cormorant count in the GHE count area across all counts carried out during the April-July period was 2.5 (s.d = 1.8, n = 7). The Cormorant breeding population has been recently estimated as 128 AON (Alyn Walsh, NPWS, unpublished data), implying an adult population of around 250 birds, although there are also likely to be additional non-breeding birds present. Therefore, the mean summer GHE count is around 1% of the adult breeding population. This would equate to a potential displacement impact of less than 0.1%, due to habitat loss, and 0.25%, from combined habitat loss and a worst-case habitat degradation scenario. However, this will overestimate the potential displacement impact due to the presence of non-breeding birds. It is considered reasonable to conclude that this very minor displacement impact will not cause any population-level consequences. The breeding colony is 8.5 km from the development site of the proposed development and well away from the main shipping route. Therefore, there will be no direct disturbance impacts to the breeding colony. A RIB will quarter over and around the blast site immediately prior to blasting with the intention that any birds present will be scared away from the danger zone. Blasting will be delayed/postponed if individuals are seen in the area when blasting is scheduled. Therefore any such impact will be very unlikely. Even in the worst case scenario of such an impact occurring, given the numbers present in the area and dispersed distribution of the birds, the number of birds suffering injury would be very low and would not cause population-level consequences. The intertidal habitat lost from the development of the GHEP would have been available to these species on all high tides, while the saltmarsh and *Scirpus maritimus* habitat would have been available on spring high tides. However, given that the loss of 75 ha of subtidal habitat is predicted to cause displacement of 1%, or less, of the Inner Galway Bay population of these species, the loss of 16.5 ha of habitat that will only have been partially available to the species is unlikely to have caused any measurable displacement impact. ***Significant impacts on the SCI and conservation objectives of the SPA have therefore been excluded.***

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
	Grey Heron (*Ardea cinerea*) [A028]
Level of Residual Impact	The predicted displacement impact from habitat loss is 1.0 birds, or 1.2% of the Inner Galway Bay population. This would cause an increase in density of less than 0.1 bird per 100 ha. Therefore, it is reasonable to conclude that this very minor displacement impact will not cause any population-level consequences. In addition, any displaced birds would have a high potential ability to use alternative terrestrial habitats in the vicinity of Inner Galway Bay. The habitat loss from the development of the GHEP, in combination with the 5.9 ha remaining within the GHE site, would have amounted to 22.2 ha of potential foraging habitat. Based on the nature of the habitat (fucoid-dominated) and the mean occurrence of the species in the adjacent subsites 0G497 and 499 (1.8 and 5.4% of the SPA count, respectively), the intertidal habitat and saltmarsh in the GHEP site is unlikely to have held significant numbers of Grey Heron. Therefore, the cumulative impact of the historical habitat loss from the development of the Galway Harbour Enterprise Park in-combination with the projected habitat loss from the GHE development will not result in significant displacement impacts. ***Significant impacts on the SCI and conservation objectives of the SPA have therefore been excluded.***

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
	Light-bellied Brent Goose (*Branta bernicla hrota*) [A046]
Level of Residual Impact	The predicted displacement impact is 3.0 birds, or 0.2% of the Inner Galway Bay population. The continuing strongly increasing trend of this species indicates that the Inner Galway Bay population is not at, or close to, carrying capacity. Therefore, it is reasonable to conclude that this very minor displacement impact will not cause any population-level consequences. The habitat loss from the development of the GHEP, in combination with the 5.9 ha remaining within the GHE site, would have amounted to 22.2 ha of potential foraging habitat. This may have provided a sufficient area for birds to remain foraging throughout the low tide period and, therefore, the potential usage of this habitat may have been significantly greater than would be implied by a simple pro-rata calculation from the numbers using the remaining habitat. Therefore, it is possible that the historical habitat loss from the development of the Galway Harbour Enterprise Park caused a measurable level of displacement. However, as the GHE development is not predicted to cause measurable displacement impacts to these species, there will be no cumulative impact from habitat loss due to the GHE development in combination with the historical habitat loss from the development of the Galway Harbour Enterprise Park. ***Significant impacts on the SCI and conservation objectives of the SPA have therefore been excluded.***

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
	Wigeon (*Anas penelope*) [A050]
Level of Residual Impact	The predicted displacement impact is 1.6 birds, or 0.1% of the Inner Galway Bay population. Wigeon have low site fidelity, are not sensitive to interference effects, and have some potential ability to use alternative under-utilised habitats in the vicinity of Inner Galway Bay. Therefore, it is reasonable to conclude that this very minor displacement impact will not cause any population-level consequences. The habitat loss from the development of the GHEP, in combination with the 5.9 ha remaining within the GHE site, would have amounted to 22.2 ha of potential foraging habitat. This may have provided a sufficient area for birds to remain foraging throughout the low tide period and, therefore, the potential usage of this habitat may have been significantly greater than would be implied by a simple pro-rata calculation from the numbers using the remaining habitat. Therefore, it is possible that the historical habitat loss from the development of the Galway Harbour Enterprise Park caused a measurable level of displacement. However, as the GHE development is not predicted to cause measurable displacement impacts to these species, there will be no cumulative impact from habitat loss due to the GHE development in combination with the historical habitat loss from the development of the Galway Harbour Enterprise Park. ***Significant impacts on the SCI and conservation objectives of the SPA have therefore been excluded.***

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
	Teal (*Anas crecca*) [A052]
Level of Residual Impact	No significant residual impact is expected.

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
	Shoveler (*Anas clypeata*) [A056]
Level of Residual Impact	No significant residual impact is expected.

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
	Red-breasted Merganser (*Mergus serrator*) [A069]
Level of Residual Impact	The predicted displacement impact from habitat loss is 0.1 bird, or 0.1% of the Inner Galway Bay population, and, from combined habitat loss and a worst-case habitat degradation scenario, is still only 0.2% of the Inner Galway Bay population. This would cause an increase in density of less than 0.1 bird per 100 ha. Therefore, it is reasonable to conclude that this very minor displacement impact will not cause any population-level consequences. A RIB will quarter over and around the blast site immediately prior to blasting with the intention that any birds present will be scared away from the danger zone. Blasting will be delayed/postponed if individuals are seen in the area when blasting is scheduled. Therefore any such impact will be very unlikely. Even in the worst case scenario of such an impact occurring, given the numbers present in the area and dispersed distribution of the birds, the number of birds suffering injury would be very low and would not cause population-level consequences. The intertidal habitat lost from the development of the GHEP would have been available to these species on all high tides, while the saltmarsh and *Scirpus maritimus* habitat would have been available on spring high tides. However, given that the loss of 75 ha of subtidal habitat is predicted to cause displacement of 1%, or less, of the Inner Galway Bay population of these species, the loss of 16.5 ha of habitat that will only have been partially available to the species is unlikely to have caused any measurable displacement impact. ***Significant impacts on the SCI and conservation objectives of the SPA have therefore been excluded.***

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
	Ringed Plover (*Charadrius hiaticula*) [A137]
Level of Residual Impact	No significant residual impact is expected.

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
Annex I species	**Golden Plover (*Pluvialis apricaria*) [A140]**
Level of Residual Impact	No significant residual impact is expected.

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
	Lapwing (*Vanellus vanellus*) [A142]
Level of Residual Impact	No significant residual impact is expected.

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
	Dunlin (*Calidris alpina alpina*) [A149]
Level of Residual Impact	No significant residual impact is expected.

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
Annex I species	**Bar-tailed Godwit (*Limosa lapponica*) [A157]**
Level of Residual Impact	No significant residual impact is expected.

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
	Curlew (*Numenius arquata*) [A160]
Level of Residual Impact	The predicted displacement impact from habitat loss is 1.0 birds, or around 0.2% of the Inner Galway Bay population. This would cause an increase in density of less than 0.1 bird per 100 ha. While Curlew have high site fidelity and high potential sensitivity to interference effects, the current density (0.3 birds/ha) is over an order of magnitude below the level (10 birds/ha) where interference effects are likely to start becoming important. In addition, any displaced birds would have some potential ability to use alternative terrestrial habitats in the vicinity of Inner Galway Bay. Therefore, it is reasonable to conclude that this very minor displacement impact will not cause any population-level consequences. The intertidal habitat lost from the development of the GHEP would have been potential low tide foraging habitat, while the saltmarsh and *Scirpus maritimus* habitat may have been used as roosting habitat. Based on the nature of the habitat (fucoid-dominated) and the mean occurrence of the species in the adjacent subsites 0G497 and 499 (3.1 and 6.0% of the SPA count, respectively, for Curlew; 3.1 and 6.3% of the SPA count, respectively, for Redshank), the intertidal habitat in the GHEP site is unlikely to have held significant numbers of Curlew or Redshank, while it is likely that the saltmarsh habitat would have only been used infrequently. Therefore, the cumulative impact of the historical habitat loss from the development of the Galway Harbour Enterprise Park in-combination with the projected habitat loss from the GHE development will not result in significant displacement impacts. ***Significant impacts on the SCI and conservation objectives of the SPA have therefore been excluded.***

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
	Redshank (*Tringa totanus*) [A162]
Level of Residual Impact	The predicted displacement impact from habitat loss is 0.6 birds, or around 0.1% of the Inner Galway Bay population. This would cause an increase in density of less than 0.1 bird per 100 ha. While Redshank have high site fidelity and high potential sensitivity to interference effects, the current density (0.4 birds/ha) is over an order of magnitude below the level (10 birds/ha) where interference effects are likely to start becoming important. In addition, any displaced birds may have some potential ability to use alternative terrestrial habitats in the vicinity of Inner Galway Bay. Therefore, it is reasonable to conclude that this very minor displacement impact will not cause any population-level consequences. The intertidal habitat lost from the development of the GHEP would have been potential low tide foraging habitat, while the saltmarsh and *Scirpus maritimus* habitat may have been used as roosting habitat. Based on the nature of the habitat (fucoid-dominated) and the mean occurrence of the species in the adjacent subsites 0G497 and 499 (3.1 and 6.0% of the SPA count, respectively, for Curlew; 3.1 and 6.3% of the SPA count, respectively, for Redshank), the intertidal habitat in the GHEP site is unlikely to have held significant numbers of Curlew or Redshank, while it is likely that the saltmarsh habitat would have only been used infrequently. Therefore, the cumulative impact of the historical habitat loss from the development of the Galway Harbour Enterprise Park in-combination with the projected habitat loss from the GHE development will not result in significant displacement impacts. ***Significant impacts on the SCI and conservation objectives of the SPA have therefore been excluded.***

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

<table>
<tr><th colspan="2">Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA</th></tr>
<tr><td colspan="2">SCI Species</td></tr>
<tr><td></td><td>Turnstone (Arenaria interpres) [A169]</td></tr>
<tr><td>Level of Residual Impact</td><td>The predicted displacement impact from habitat loss is 5.9 birds, or around 2.1% of the Inner Galway Bay population. Turnstone has a high potential sensitivity to displacement impacts, due to its high site fidelity, its sensitivity to interference effects and the limited potential for displaced birds to use alternative habitats. However, the predicted displacement impact is likely to be a substantial overestimate of the true displacement impact due to differences in the survey intensity between the GHE and I-WeBS counts, while it is also possible that Turnstone will be able to use structures within the completed development. Therefore, the actual displacement impact is likely to be very minor and it is reasonable to conclude that this very minor displacement impact will not cause any population-level consequences.

The fucoid-dominated intertidal habitat lost from the development of the GHEP would have been very suitable foraging habitat for Turnstone and, in combination with the 2.1 ha remaining within the GHE site, would have amounted to 10.7 ha of foraging habitat (around 1% of the total area of fucoid-dominated biotope within the SPA). This may have provided a sufficient area for birds to remain foraging throughout the low tide period and, therefore, the potential usage of this habitat may have been significantly greater than would be implied by a simple pro-rata calculation from the numbers using the remaining habitat.

The population trend for the Inner Galway Bay Turnstone population between 1995/96 and 2007/08 was strongly positive and the increasing trend appears to have begun around 1990 (following a decline in the second half of the 1980s; Nairn et al., 2000). The population trend graph for Turnstone is not included in NPWS (2013a), but examination of the raw I-WeBS count data indicates that the 1995/96-2007/08 indicates that there was a fairly consistent rate of increase across most of this period. Therefore, it appears that the Inner Galway Bay Turnstone population had not reach the effective carrying capacity during this period, so any displacement impact caused by the development of the GHEP would not have had population-level consequences.

Significant impacts on the SCI and conservation objectives of the SPA have therefore been excluded.</td></tr>
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Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
	Black-headed Gull (*Chroicocephalus ridibundus*) [A179]
Level of Residual Impact	The predicted displacement impact from habitat loss is 0.5 birds, or less than 0.1% of the Inner Galway Bay population, and, from combined habitat loss and a worst-case habitat degradation scenario, 1.4 birds or 0.1% of the Inner Galway Bay population. Any displaced birds would have a very high potential ability to use alternative terrestrial habitats in the vicinity of Inner Galway Bay. Therefore, it is reasonable to conclude that this very minor displacement impact will not cause any population-level consequences. The probability of injury to individuals during blasting and piling is very low given the very shallow dives and short immersion periods of this species when foraging in the sea. The intertidal habitat lost from the development of the GHEP would have been potential low tide foraging habitat, while the saltmarsh and *Scirpus maritimus* habitat may have been used as roosting habitat and/or as subtidal habitat on spring high tides. Based on the mean occurrence of the species in subsite 0G497 and 499 (1.6 and 18% of the SPA count, respectively, for Black-headed Gull; 1.4 and 4.7% of the SPA count, respectively, for Common Gull), the intertidal habitat in the GHEP site is unlikely to have held significant numbers of these species, while it is likely that the saltmarsh habitat would have only been used infrequently. Therefore, the cumulative impact of the historical habitat loss from the development of the Galway Harbour Enterprise Park in-combination with the projected habitat loss from the GHE development will not result in significant displacement impacts. ***Significant impacts on the SCI and conservation objectives of the SPA have therefore been excluded.***

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
	Common Gull (*Larus canus*) [A182]
Level of Residual Impact	The predicted displacement impact from habitat loss is 0.4 birds, or less than 0.1% of the Inner Galway Bay population, and, from combined habitat loss and a worst-case habitat degradation scenario, 1.1 birds or 0.1% of the Inner Galway Bay population. Any displaced birds would have a very high potential ability to use alternative terrestrial habitats in the vicinity of Inner Galway Bay. Therefore, it is reasonable to conclude that this very minor displacement impact will not cause any population-level consequences. The probability of injury to individuals during blasting and piling is very low given the very shallow dives and short immersion periods of this species when foraging in the sea. The intertidal habitat lost from the development of the GHEP would have been potential low tide foraging habitat, while the saltmarsh and *Scirpus maritimus* habitat may have been used as roosting habitat and/or as subtidal habitat on spring high tides. Based on the mean occurrence of the species in subsite 0G497 and 499 (1.6 and 18% of the SPA count, respectively, for Black-headed Gull; 1.4 and 4.7% of the SPA count, respectively, for Common Gull), the intertidal habitat in the GHEP site is unlikely to have held significant numbers of these species, while it is likely that the saltmarsh habitat would have only been used infrequently. Therefore, the cumulative impact of the historical habitat loss from the development of the Galway Harbour Enterprise Park in-combination with the projected habitat loss from the GHE development will not result in significant displacement impacts. ***Significant impacts on the SCI and conservation objectives of the SPA have therefore been excluded.***

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
Annex I species	**Sandwich Tern (*Sterna sandvicensis*) [A191]**
Level of Residual Impact	The Sandwich Tern breeding colony is located at Illaunnaguroge in Corranroo Bay around 12 km from the GHE site. The breeding colony is 12 km from the development site and well away from the main shipping route. Therefore, there will be no direct disturbance impacts to the breeding colony. The distance of the GHE development site from the Sandwich Tern colony suggests that it is unlikely that the site provides important foraging resources for the colony. Therefore, loss and degradation of habitat within the GHE site is unlikely to cause any population-level consequences. Foraging Sandwich Terns are generally tolerant of human disturbance and Furness et al. (2013) gave Sandwich Tern a low vulnerability score for disturbance by ship traffic, referencing “slight avoidance at short range”. In Irish coastal waters they often feed in very close proximity to human activity. Blasting and piling will not be carried out during the tern breeding season (01 April to 31 July, inclusive), so major construction disturbance impacts on foraging terns during the breeding season are unlikely. In addition, the distance of the GHE development site from the Sandwich Tern colony suggests that it is unlikely that the site provides important foraging resources for the colony. Therefore, construction disturbance from harbour-related activity, disturbance from harbour-related activity during operation of the completed development, and disturbance from increased shipping and boating traffic, are not likely to cause significant displacement of foraging terns. Blasting and piling will not be carried out during the tern breeding season (01 April to 31 July, inclusive), so the main breeding population cannot be affected. The probability of injury to individuals during blasting and piling will be very low given the very shallow dives and short immersion periods of this species when fishing. Any individuals present during passage periods or during the winter will be very obvious to observers, so the detonation of explosive charges while birds are in the blasting area is very unlikely to occur. The intertidal habitat lost from the development of the GHEP would have been available to these species on all high tides, while the saltmarsh and *Scirpus maritimus* habitat would have been available on spring high tides. Given the small area involved, its restricted availability, and its distance from the breeding colonies, it is highly unlikely that the habitat lost from the development of the GHEP was ever of significant importance to this species. ***Significant impacts on the SCI and conservation objectives of the SPA have therefore been excluded.***

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA	
SCI Species	
Annex I species	**Common Tern (*Sterna hirundo*) [A193]**
Level of Residual Impact	The permanent habitat loss within the GHE development would correspond to around 2% of this foraging range, while the total area affected by permanent habitat loss and habitat degradation in the areas subject to maintenance dredging would correspond to around 6% of this foraging range. The biotopes and depth zones within the minimum foraging ranges around the three locations used by the main Common Tern colony in Inner Galway Bay does not suggest that the Common Tern colony location is constrained by close proximity to particular habitats. The main prey of Common Terns in marine waters are small pelagic fish, such as sprat and sandeels, which are generally distributed independently of the benthic habitat, and occur widely throughout Inner Galway Bay. There is no reason to suppose that the GHE site contains particularly high densities of suitable fish prey for Common Terns. The mobile nature of the prey, and their lack of dependence on benthic habitats, mean that habitat loss and degradation of a very small amount of the marine habitat within Inner Galway Bay will not significantly affect the prey resources for Common Terns. Therefore, it can be reasonably concluded that there will be no population-level impacts on Common Terns in Inner Galway Bay. Common Terns appear to be sensitive to disturbance within a zone of around 100-150 m around their breeding colonies. Carney and Sydeman (1999) quote two studies that reported flush distances of 142 m and 80 m for Common Tern colonies approached by humans. Burger (1998) studied the effects of motorboats and personal watercraft (jet skis, etc.) on a Common Tern colony. She found that the personal watercraft caused more disturbance than the motor boats, the factors that affected the terns were the distance from the colony, whether the boat was in an established channel, and the speed of the craft, and she recommended that personal watercraft should not be within 100 m of colonies. Blasting piling and backhoe dredging will not be carried out during the tern breeding season (01 April to 31 July, inclusive). The Mutton Island colony is 1 km from the construction area and 300 m from the dredging area. These distances are sufficient to prevent any direct disturbance to the breeding colony from construction or operational activities within the GHE site.

	Foraging Common Terns are generally tolerant of human disturbance and Furness et al. (2013) gave Common Tern a low vulnerability score for disturbance by ship traffic, referencing "slight avoidance at short range". In Irish coastal waters they often feed in very close proximity to human activity. For example in Galway Bay, they regularly feed in the mouth of the Corrib inside Nimmo's Pier. Therefore, construction disturbance from harbour-related activity, disturbance from harbour-related activity during operation of the completed development, and disturbance from increased shipping and boating traffic, are not likely to cause significant displacement of foraging terns. Blasting and piling will not be carried out during the tern breeding season (01 April to 31 July, inclusive), so the main breeding population cannot be affected. The probability of injury to individuals during blasting and piling will be very low given the very shallow dives and short immersion periods of this species when fishing. Any individuals present during passage periods or during the winter will be very obvious to observers, so the detonation of explosive charges while birds are in the blasting area is very unlikely to occur. The intertidal habitat lost from the development of the GHEP would have been available to these species on all high tides, while the saltmarsh and *Scirpus maritimus* habitat would have been available on spring high tides. Given the small area involved, its restricted availability, and its distance from the breeding colonies, it is highly unlikely that the habitat lost from the development of the GHEP was ever of significant importance to this species. Mussel bottom culture in Inner Galway Bay also has the potential to cause impacts to fish-eating species as tightly packed mussels will result in homogeneous habitat and little provision of refugia for fishes, thereby reducing the availability of prey resources. The Appropriate Assessment of aquaculture and fisheries in Inner Galway Bay (Gittings and O'Donoghue, 2014) considered potential impacts from mussel bottom culture to the fish-eating SCI species of Inner Galway Bay. ***In the case of the Common Tern, the GHE development could possibly have a measurable, but not significant, impact, so, based on the assessment in the aquaculture AA, there is a possibility for significant cumulative impacts in-combination with impacts from mussel bottom culture for this species.***

Table NIS(A) 3.27 contd/.. Attributes and targets to provide for favourable conservation condition of relevant Special Conservation Interests of SPA

7.6 REVIEW OF IN-COMBINATION EFFECTS

Query:

The applicant is requested to assess in a more comprehensive manner the 'In combination effects' of the proposed development with other developments. To clarify; the Inner Galway Bay SPA was designated in 1994 before the Port development of the 1990s. The SPA boundary was set at the high water mark. For some species such as Ringed Plover, the impact of the Port development is listed in table 3.15 as the loss of terrestrial habitat. It was in fact the loss of intertidal habitat, and should be considered so in combination with the proposed development. There is little consideration in the NIS of the effect of the loss of this habitat on waterbirds. The NIS does not go into a sufficient level of detail in relation to the likely areas associated with the take-off, landing and approach areas that are associated with the consented Galway Harbour flights operation. This is relevant in terms of assessing the in-combination disturbance levels to those birds associated with the subtidal areas of Inner Galway Bay SPA.

Response:

The Species Assessment which was undertaken included a more thorough and critical assessment of the likely levels of impacts on a species-by-species level. This included an assessment of impacts on breeding and non-breeding populations, including likely in-combination effects.

7.6.1 Galway Harbour Enterprise Park

Historical habitat loss from the development of the Galway Harbour Enterprise Park is estimated to have caused the loss of 8.6 ha of intertidal sediments and another 7.7 ha of saltmarsh and *Scirpus maritimus* habitat.

The timing of this habitat loss is not clearly described anywhere. However, OSI orthophotography indicates that by 1995 work had commenced, but had been largely restricted to the terrestrial zones, while by 2000 the infill had been largely completed.

7.6.1.1 Light-bellied Brent Goose and Wigeon

The habitat loss from the development of the GHEP, in combination with the 5.9 ha remaining within the GHE site, would have amounted to 22.2 ha of potential foraging habitat. This may have provided a sufficient area for birds to remain foraging throughout the low tide period and, therefore, the potential usage of this habitat may have been significantly greater than would be implied by a simple pro-rata calculation from the numbers using the remaining habitat. Therefore, it is possible that the historical habitat loss from the development of the Galway Harbour Enterprise Park caused a measurable level of displacement. However, as the GHE development is not predicted to cause measurable displacement impacts to these species, there will be no cumulative impact from habitat loss due to the GHE development in combination with the historical habitat loss from the development of the Galway Harbour Enterprise Park.

7.6.1.2 Red-breasted Merganser, Great Northern Diver and Cormorant

The intertidal habitat lost from the development of the GHEP would have been available to these species on all high tides, while the saltmarsh and *Scirpus maritimus* habitat would have been available on spring high tides. However, given that the loss of 75 ha of subtidal habitat is predicted to cause displacement of 1%, or less, of the Inner Galway Bay population of these species, the loss of 16.5 ha of habitat that will only have been partially available to the species is unlikely to have caused any measurable displacement impact.

7.6.1.3 Grey Heron

The habitat loss from the development of the GHEP, in combination with the 5.9 ha remaining within the GHE site, would have amounted to 22.2 ha of potential foraging habitat. Based on the nature of the habitat (fucoid-dominated) and the mean occurrence of the species in the adjacent subsites 0G497 and 499 (1.8 and 5.4% of the SPA count, respectively), the intertidal habitat and saltmarsh in the GHEP site is unlikely to have held significant numbers of Grey Heron. Therefore, the cumulative impact of the historical habitat loss from the development of the Galway Harbour Enterprise Park in-combination with the projected habitat loss from the GHE development will not result in significant displacement impacts.

7.6.1.4 Curlew and Redshank

The intertidal habitat lost from the development of the GHEP would have been potential low tide foraging habitat, while the saltmarsh and *Scirpus maritimus* habitat may have been used as roosting habitat. Based on the nature of the habitat (fucoid-dominated) and the mean occurrence of the species in the adjacent subsites 0G497 and 499 (3.1 and 6.0% of the SPA count, respectively, for Curlew; 3.1 and 6.3% of the SPA count, respectively, for Redshank), the intertidal habitat in the GHEP site is unlikely to have held significant numbers of Curlew or Redshank, while it is likely that the saltmarsh habitat would have only been used infrequently. Therefore, the cumulative impact of the historical habitat loss from the development of the Galway Harbour Enterprise Park in-combination with the projected habitat loss from the GHE development will not result in significant displacement impacts.

7.6.1.5 Turnstone

The fucoid-dominated intertidal habitat lost from the development of the GHEP would have been very suitable foraging habitat for Turnstone and, in combination with the 2.1 ha remaining within the GHE site, would have amounted to 10.7 ha of foraging habitat (around 1% of the total area of fucoid-dominated biotope within the SPA). This may have provided a sufficient area for birds to remain foraging throughout the low tide period and, therefore, the potential usage of this habitat may have been significantly greater than would be implied by a simple pro-rata calculation from the numbers using the remaining habitat.

The population trend for the Inner Galway Bay Turnstone population between 1995/96 and 2007/08 was strongly positive and the increasing trend appears to have begun around 1990 (following a decline in the second half of the 1980s; Nairn et al., 2000). The population trend graph for Turnstone is not included in NPWS (2013a), but examination of the raw I-WeBS count data indicates that the 1995/96-2007/08 indicates that there was a fairly consistent rate of increase across most of this period. Therefore, it appears that the Inner Galway Bay Turnstone population had not reach the effective carrying capacity during this period, so any displacement impact caused by the development of the GHEP would not have had population-level consequences.

7.6.1.6 Black-headed Gull and Common Gull

The intertidal habitat lost from the development of the GHEP would have been potential low tide foraging habitat, while the saltmarsh and *Scirpus maritimus* habitat may have been used as roosting habitat and/or as subtidal habitat on spring high tides. Based on the mean occurrence of the species in subsite 0G497 and 499 (1.6 and 18% of the SPA count, respectively, for Black-headed Gull; 1.4 and 4.7% of the SPA count, respectively, for Common Gull), the intertidal habitat in the GHEP site is unlikely to have held significant numbers of these species, while it is likely that the saltmarsh habitat would have only been used infrequently. Therefore, the cumulative impact of the historical habitat loss from the development of the Galway Harbour Enterprise Park in-combination with the projected habitat loss from the GHE development will not result in significant displacement impacts.

7.6.1.7 Sandwich Tern and Common Tern

The intertidal habitat lost from the development of the GHEP would have been available to these species on all high tides, while the saltmarsh and *Scirpus maritimus* habitat would have been available on spring high tides. Given the small area involved, its restricted availability, and its distance from the breeding colonies[2], it is highly unlikely that the habitat lost from the development of the GHEP was ever of significant importance to this species.

7.6.2 Harbour Flights

Permission to apply for Planning Permission to operate Flights within the Galway Harbour Company jurisdiction was granted to the Flights Company, Harbour Air Ireland Ltd. (HAI) by Galway Harbour Company subject to the granting of a Foreshore License by the relevant Government Department. Planning Permission was granted for the operation of Harbour Flights by An Bord Pleanala on 25/11/2010. A Foreshore License Application was lodged for the Flights and a request for Further Information was issued to the applicant in June 2012. To date the applicant has failed to provide the Further Information requested. An operational licence, under harbour management requirements, has not been approved or signed by GHC for HAI. GHC will not grant such a licence unless HAI can prove no cumulative impact will arise. Hence this R.F.I. has not included for air flight impacts in the assessment of cumulative impacts.

[2] In the 1990s, the only known tern breeding colonies were on the southern shore of Inner Galway Bay, with the Sandwich Tern colony in Corranroo Bay (its current location) and the main Common Tern colony in Ballyvaughan Bay (no longer occupied).