September 2018

Arklow Wastewater Treatment Plant Project

Natura Impact Statement

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1 Introduction

1.1 Overview

This Natura Impact Statement has been prepared to provide information relevant to the Appropriate Assessment required to be carried out under Part XAB of the Planning and Development Act 2000 (as amended). It incorporates information required for screening, and accompanies the Environmental Impact Assessment Report and other documentation prepared by Arup on behalf of Irish Water for the proposed Arklow Wastewater Treatment Plant Project, hereinafter referred to as the proposed development.

The main aim of the proposed development is to collect and appropriately treat the wastewater generated in Arklow town (which currently discharges untreated wastewater to the Avoca River) such that the treated effluent complies with national and EU standards. Interceptor sewers proposed along the North and South Quays in Arklow will intercept the existing wastewater flows and convey them to the proposed wastewater treatment plant (WwTP). The proposed location of the WwTP is at the Old Wallboard Site at Ferrybank, immediately adjacent to the North Quay (on the northern bank of the Avoca River) and the Irish Sea. The final treated effluent from the WwTP will discharge into the Irish Sea via a c. 900m long outfall pipe with a diffuser section at its end.

The main objectives of the proposed development are to:

- Eliminate (in so far as possible) the current practice of discharging untreated wastewater to the Avoca River;
- Provide a wastewater treatment facility that will comply with all relevant legislative requirements and will service the population of Arklow into the future; and
- Improve water quality in the Avoca River.

The proposed development is not directly connected to or necessary for the management of any Natura 2000 site. Natura 2000 sites are referred to as European sites in Part XAB of the Planning and Development Act 2000 (as amended). These terms are synonymous.

This Natura Impact Statement has been prepared by Eleanor Mayes, Ecological Consultant, on behalf of Arup. Sections 1 to Section 5.2 of this document present the information required for Screening for Appropriate Assessment. Sections 6 to 9 present the information required to conclude the Natura Impact Statement.

1.2 Statement of authority

Eleanor Mayes, Ecological Consultant, graduated in 1978 with a B.A. (Mod.) in Natural Science from Trinity College Dublin, specialising in Zoology.

She also holds an M.Sc. in Zoology from Trinity College Dublin. She has carried out bird surveys and related ecological research for governmental and non-governmental conservation agencies, and has also been involved in policy work on the implementation of nature conservation legislation, and the effectiveness of conservation designations in Ireland. As Project Ecologist for the Western River Basin District (RBD) from 2004 to 2008, she developed guidance on cross-compliance issues between the Birds Directive, and Habitats Directive and the Water Framework Directive (WFD).

Eleanor has worked as an independent ecological consultant since 1989. She has carried out flora and fauna studies, and compiled and contributed to Appropriate Assessment (AA) and Environmental Impact Assessment documentation for a wide range of projects including waste water treatment plants and associated pipelines, communications masts, power lines, power stations, flood alleviation schemes, river and canal navigation schemes, and public marinas. She also carries out pre-construction, construction phase, and post construction ecological monitoring as required by planning and licensing approvals for a range of project types.

2 Legislative Background

2.1 Overview

The overall aim of the Habitats Directive 92/43/EEC (as amended) and of the Birds Directive 2009/147/EC is to maintain or restore the favourable conservation status of habitats and species of community interest. These habitats and species are listed in the Habitats Directive and in the Birds Directive. Special Areas of Conservation (SACs) are designated under the Habitats Directive, and Special Protection Areas (SPAs) are designated under the Birds Directive, to afford protection to the most vulnerable habitats and species. These two designations are collectively known as the Natura 2000 network. Sites, species and habitats protected under Directive 92/43/EEC (Habitats Directive), and sites and species protected under Directive 2009/147/EC (Birds Directive) are referred to as Natura 2000 sites. Natura 2000 sites are referred to as European sites in Part XAB of the Planning and Development Act 2000 (as amended). These terms are synonymous.

Each Natura 2000 site is designated for the protection of specified habitats and species that occur within the site, these are referred to as the Qualifying Interests in the case of SACs, and as Special Conservation Interests in the case of SPAs.

The maintenance of the habitats and species identified as Qualifying Interests and Special Conservation Interests within Natura 2000 sites at favourable conservation condition will contribute to the overall maintenance of favourable conservation status of those habitats and species at a national level, and is the primary conservation objective of the designations.

The favourable conservation status of a habitat is achieved when:

- Its natural range, and area it covers within that range, are stable or increasing, and
- the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and
- the conservation status of its typical species is favourable.

The favourable conservation status of a species is achieved when:

- Population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and
- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
- there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

These definitions of favourable conservation status are provided in Article 1 of the Habitats Directive, as amended.

Conservation objectives for each Natura 2000 site are developed and subject to on-going review under the terms of the Habitats Directive and the Birds Directive. In summary, the conservation objective is to maintain or restore the favourable conservation condition of the habitats and species listed as Qualifying Interests for individual SACs, and the bird species listed as Special Conservation Interests for SPAs.

The test that arises in the Appropriate Assessment process is whether a project or plan could have any significant adverse effects on any European site, as defined by Part XAB of the Planning and Development Act 2000 (as amended), having regard to the conservation objectives and status of the European site / Natura 2000 site.

2.2 Legislation

Article 6 of the Habitats Directive provides the legislative framework for the consideration of developments which could have an adverse effect on sites which are protected under the Habitats and the Birds Directives (i.e. European sites / Natura 2000 sites). The Habitats Directive does not prohibit development in, or affecting sites protected under the Directive. An ‘appropriate assessment’ must be carried out for a proposed plan or project, to assess the implications of the proposed development in the context of the conservation objectives for the protected site (Article 6 (3)):

“*Any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications for the site in view of the site's conservation objectives. In the light of the conclusions of the assessment of the implications for the site and subject to the provisions of paragraph 4, the competent national authorities shall agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the site concerned and, if appropriate, after having obtained the opinion of the general public.*”

The Appropriate Assessment process potentially involves four stages. Stage 1 is a screening process (in accordance with national requirements under Part XAB of the Planning and Development Act 2000, as amended), to establish whether a plan or project has a potential to give rise to adverse impacts on the conservation objectives or integrity of a European site / Natura 2000 site. The first two tests of Article 6(3) are:

- Whether a plan or project is directly connected to or necessary for the management of the European site/Natura 2000 site, and
- whether a plan or project, alone or in combination with other plans and projects, is likely to have significant effects on a European site / Natura 2000 site in view of its conservation objectives.

If the effects are deemed to be significant, potentially significant, or uncertain, then the Appropriate Assessment process must proceed to Stage 2.

Screening should be undertaken without the inclusion of mitigation, in accordance with the precautionary principle, and the People Over Wind case (Case C-323/17), and in cases of uncertainty it should be assumed that the effects could be significant (Department of the Environment, Heritage and Local Government (December 2009, revised February 2010).

Stage 2 of the Appropriate Assessment process considers whether the plan or project, alone or in combination with other projects or plans, will have adverse effects on the integrity of a Natura 2000 site, and includes any mitigation measures necessary to avoid, reduce or offset negative effects (Department of the Environment, Heritage and Local Government, 2009, revised 2010). If Stage 2 concludes that adverse effects on conservation objectives and Natura 2000 site integrity arise even after the proposed mitigation has been taken into account, Stages 3 and potentially Stage 4 of the Appropriate Assessment process arise.

Article 6(4) of the Habitats Directive discusses alternative solutions, overriding public interest and compensatory measures:

"*If, in spite of a negative assessment of the implications for the site and in the absence of alternative solutions, a plan or project must nevertheless be carried out for imperative reasons of overriding public interest, including those of a social or economic nature, the Member State shall take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected. It shall inform the Commission of the compensatory measures adopted.*

Where the site concerned hosts a priority natural habitat type and/or a priority species, the only considerations which may be raised are those relating to human health or public safety, to beneficial consequences of primary importance for the environment or, further to an opinion from the Commission, to other imperative reasons of overriding public interest"."

If Stages 3 and 4 of the Appropriate Assessment process arise, in accordance with the precautionary principle where it is uncertain whether adverse effects on conservation objectives and European site / Natura 2000 site integrity arise even after the mitigation proposed during Stage 2 has been taken into account, the following steps must be taken:

- Consider alternative solutions that do not have an adverse impact; and if no alternative solutions can be identified;
- Declare Imperative Reasons of Overriding Public Interest (IROPI Test); and
- Develop and agree compensation measures.

3 Methodology

3.1 Scope of report

With reference to Section 1.2, this Natura Impact Statement has been prepared to provide information relevant to the Appropriate Assessment required to be carried out by the competent authorities under Part XAB of the Planning and Development Act 2000 (as amended), which transposes the requirements of Article 6 (3) and 6 (4) of the Habitats Directive into Irish law. It accompanies the Environmental Impact Assessment Report and other documentation prepared by Arup on behalf of Irish Water for the proposed development.

3.2 Location

The proposed development is located in Arklow, Co. Wicklow. The extent of the scheme is shown in Figure 1. Further details of the proposed development are presented in Section 4 of this report.

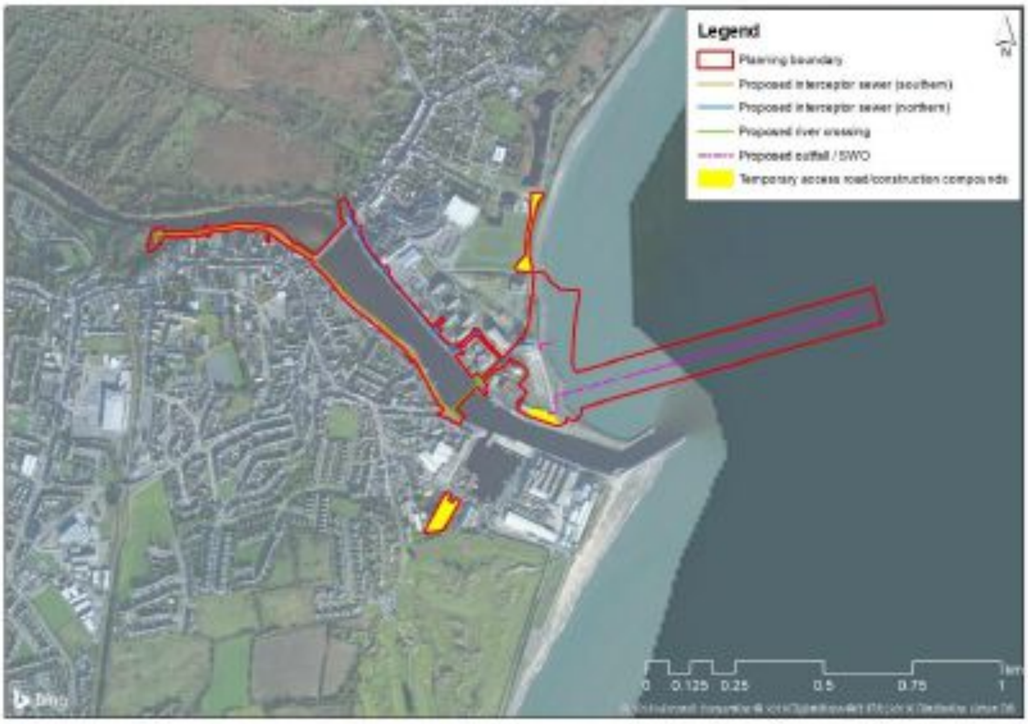

Figure 1: Proposed planning boundary for proposed development, including temporary construction compounds

3.3 Guidance and data sources

This Natura Impact Statement has been prepared in compliance with the following guidance and Regulations:

- Department of the Environment, Heritage and Local Government (December 2009, revised February 2010). Appropriate Assessment of Plans and Projects in Ireland. Guidance for Planning Authorities
- Managing Natura 2000 sites: The provisions of Article 6 of the 'Habitats' Directive 92/43/EEC. ISBN 92-828-9048-1 © European Communities, 2000
- 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. ISBN 92-828-1818-7 © European Communities, 2002
- Guidance document: The implementation of the Birds and Habitats Directives in estuaries and coastal zones, with particular emphasis on port development and dredging. © European Union, 2011
- Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters (January 2014). Department of Arts, Heritage and the Gaeltacht

A desk study was carried out to collate and review existing information on Natura 2000 sites, their Qualifying Interests and Conservation Objectives, and other available information on the terrestrial and aquatic ecology in the vicinity of the proposed development. Data sources relevant to each Natura 2000 site include the Site Synopsis, Conservation Objectives, Conservation Objectives backing documents, and the Natura 2000 Standard Data Form, all of which are publicly available online at www.npws.ie. The versions of these documents were the most recently available during 23rd to 30th July 2018. Other data sources include National Parks and Wildlife Service (NPWS) Wildlife Manuals, Inland Fisheries Ireland, records held by the National Biodiversity Data Centre including several databases compiled by the Irish Whale and Dolphin Group: IWDG Cetacean Strandings Database, IWDG Casual Cetacean Sightings, and IWDG Ferry Survey sightings Data.

Baseline ecological surveys of terrestrial and aquatic habitats, including the Avoca River, estuary and coastal waters have been carried out, and details of these are presented in the Chapter 11 of the Environmental Impact Assessment Report (Chapter 11 therein) for the proposed development. Information on protected species listed in Annex II and in Annex IV of the Habitats Directive that occur in the Avoca River catchment and in marine waters in the Arklow area, which are not listed as Qualifying Interests of SACs in these waters, is included in this report, following the Opinion of Advocate General Kokott in Holohan on 7 August 2018.

The Department of the Environment, Heritage and Local Government (DoEHLG) guidance on Appropriate Assessment states that while any Natura 2000 site within 15 km of a plan area should be considered, for some projects this could be much less, and in some cases, more. The Commission v. Germany Case C-142/16 confirms this.

This is to be decided on a case-by-case basis, depending on the nature of the proposal, and on its location in relation to individual Natura 2000/European sites, their individual Qualifying Interests and Conservation Objectives, any hydrological connectivity, and with reference to the sensitivities of the ecological receptors, and the potential for in combination effects.

The area within a 15km radius of the proposed development's outfall was taken as a starting point in this assessment. Source-pathway-receptor issues potentially arising from hydrological linkage have also been considered. A source is defined as an individual element of the proposed development that may have a potential to affect the identified ecological receptors. A pathway is defined as the means or route by which a source can affect the ecological receptor. An ecological receptor is defined as a Qualifying Interest (QI) for an SAC and a Special Conservation Interest (SCI) for an SPA, and for which Conservation Objectives (COs) have been set, for the Natura 2000 / European sites being considered. Potential *ex-situ* effects on highly mobile protected species that have known sensitivities, including sensitivity to man-made sound sources, and that may occur as Qualifying Interests in more distant Natura 2000 / European sites, have also been considered.

4 The proposed development

4.1 Overview

4.1.1 Summary

The proposed development will comprise of the following elements as illustrated in Figure 2:

- A new wastewater treatment plant (WwTP) of 36,000 population equivalent (PE) and associated infrastructure including an inlet pumping station, a storm water storage tank, preliminary and secondary treatment facilities, sludge thickening and dewatering facilities, a pump sump and tank to discharge excess stormwater flows as well as site administration facilities and associated landscaping (all located at the site of the Old Wallboard factory at Ferrybank);
- Interceptor sewers along North Quay, South Quay and under the Avoca River that will tie in with the existing wastewater collection network and bring the untreated wastewater to the WwTP (including associated manholes and vent stacks);
- A Storm Water Overflow (SWO) and stormwater storage tank to the west of River Walk on a vacant site locally referred to as 'the Alps'1;
- A SWO at South Quay to provide for emergency storm overflows;
- A SWO to discharge the excess stormwater flows from the WwTP (referenced above), to the Irish Sea;
- A long sea outfall (approximately 900m in length from the shoreline) to discharge the treated wastewater effluent to the Irish Sea; and
- An upgrade to the existing coastal revetment on the north-eastern boundary of the Old Wallboard site at Ferrybank.

[1] Note -The Alps refer to the Alps Opportunity Site as defined in the Arklow and Environs Local Area Plan 2018 – 2024. Aspects of the proposed development, i.e. the CSO and stormwater storage tank are within this site

Figure 2: Overview of the proposed development

The planning boundary (as illustrated in Figure 2) covers an area of almost 25 ha, of which the proposed WwTP site comprises approximately 2.7 ha. The planning boundary and/or the proposed development therein does not physically overlap with any European sites.

4.1.2 Elements of the proposed development

The proposed SWO and stormwater tank will be at the head of the southern interceptor sewer (i.e. at the Alps site) to intercept wastewater in this part of the catchment, provide appropriate storage as well as a new overflow to allow storm flows, in excess of this storage capacity, to discharge to the Avoca River at this location. The SWO is designed to pass forward minimum Formula A flows[2] and to limit spills to the river to no more than seven times per bathing season in accordance with the requirements of the Wastewater Discharge (Authorisation) Regulations 2007, as amended and the guidance[3].

The proposed interceptor sewers will connect to the existing network and convey flows by gravity to the proposed WwTP at the Old Wallboard Site at Ferrybank.

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[2] Formula A flows are the industry standard for design that considers the Dry Weather Flow (DWF) plus allowance for storm flows as a factor of population (i.e. Formula A = DWF +1.36P + 2E where DWF = PG + I +E; Where ‘P’ is the population served and ‘G’ is the average per capita water consumption, ‘E’ is the average industrial effluent and ‘I’ is the rate of infiltration) as per HMSO (1970) Report of the Technical Committee on Storm Overflows and the Disposal of Storm Sewage

[3] Department of the Environment (1993) Procedures and Criteria in relation to Storm Water Overflows. Available from: http://www.epa.ie/pubs/forms/lic/wwda/uwwtdirective91271eecprocedurescriteriairtstormwateroverflows.html [Accessed 22 May 2018]

Both preliminary and secondary treatment of the wastewater will be provided in a bespoke, architect designed facility. The WwTP will have an ultimate capacity of 36,000PE with an initial treatment capacity of 24,000PE installed in the first instance. Irish Water is seeking consent for the 36,000PE WwTP and the effects of such have been assessed in this report.

It has been assumed (for the specimen design) that sequencing batch reactor (SBR) treatment technology will be provided for the secondary treatment. Following treatment, the treated effluent will discharge through the long sea outfall to the Irish Sea. Excess storm flows will, in the first instance, be diverted to a stormwater holding tank in the WwTP, particularly during significant rainfall events. These excess storm flows will discharge via a proposed SWO at the WwTP, to the Irish Sea.

The existing coastal revetment adjoining the WwTP will also be upgraded and new rock armour will be installed to replace the existing rock armour revetment at this location. The crest of the existing revetment will be raised by approximately 2m and larger rocks will be installed to achieve the relevant design standard. This upgrade to the revetment will improve flood resilience by providing protection to the WwTP from the wave and tidal action of the Irish Sea.

4.2 Need for the proposed development

Wastewater in Arklow town is currently collected by means of a mixture of separate, partially separate and combined sewers. The existing network discharges untreated wastewater from homes and businesses through a number of discrete outfalls to the Avoca River which runs directly through Arklow town. The current practice of discharging untreated wastewater to the Avoca River is not compliant with obligations of Council Directive 91/271/EEC concerning urban waste water treatment (UWWT Directive). An infringement case has been brought to the European Court of Justice against the State over the discharge of untreated wastewater into rivers and the sea at various locations in Ireland and Arklow is one such location that is failing to meet the requirements of the UWWT Directive. Further, the Urban Waste Water Treatment Regulations 2001 as amended, requires relevant authorities to provide appropriate wastewater collection systems and treatment for agglomerations such as Arklow town.

The proposed development is intended to resolve this problem by providing an effective wastewater collection network, treatment capacity and suitable outfalls that can provide for Arklow town now and into the future.

4.3 Design

4.3.1 Alps CSO and Stormwater Storage Tank

The existing Storm Water Overflow (SWO), located in the north-east corner of the Alps site will be upgraded and associated site works will be undertaken to link with the existing sewer network and provide storm water storage. The scope of works at this section of the proposed development will include:

- Provision of a new online enclosed storage tank structure (c. 26m x 7.5m x 4.5m) that will consist of a reinforced concrete base, walls and roof;
- Installation of a non-powered static overflow screen inside the storage tank and provision of access covers in the roof structure (included at ground level);
- Raising of existing ground profile by c. 1m to accommodate the tank– with appropriate landscaping provided in the form of grassing above the tank and tarmac surfacing to provide vehicular access;
- Provision of a gabion retaining wall approximately 40 m in length (c. 1.8m in height to the toe of existing embankment) in the area between the tank and access gate;
- Diversion of existing foul sewer via two new manholes (MHA1 and MHA2) to enable construction of the proposed storage tank. The smaller (c. 225mm diameter) pipeline will be permanently diverted to connect to the larger (c. 1200mm diameter) pipeline[4];
- Provision of a new manhole (MHA3) to divert upstream foul flows in the c. 1200mm diameter pipeline into the storage tank;
- Provision of three manholes (MHA5, MHA6 and MHA7) and c. 300mm diameter pipeline to collect downstream flows from the storage tank (including additional interceptor sewers to divert the existing sewers to the manhole [MHA7]);
- Upgrade of existing manhole (MH1) to divert existing flows to the proposed interceptor sewer (via MHA7);
- Connection of overflow pipework (via a new c. 900mm diameter pipeline) to the existing c. 1200mm diameter foul sewer, manhole (MHA4) and box culvert which discharges to the Avoca River;
- Installation of fence (up to c. 2.4m high) to secure the storage tank and facilitate ongoing maintenance and operation;
- Provision of a gate suitable for vehicular access (required for maintenance);
- Provision of power supply/control panel to enable monitoring of tank levels and overflow events;
- Installation of water supply hose reel (in kiosk) to allow wash down of overflow screen/chamber floor within the storage tank; and
- Abandonment of approximately 130m of sewer in this area of which approximately 80m will be left in situ and approximately 50m will be removed.

[4] The existing sewer would be maintained from this point until the proposed development is commissioned. On completion, flows would be diverted to the proposed CSO and storage tank from the same manhole.

4.3.2 Interceptor Sewers

4.3.2.1 Overview

Interceptor sewers will be provided to the north and south of the river channel and a sewer will also be provided under the Avoca River (i.e. the ‘river crossing’). The proposed sewers will intercept the existing network (that currently discharges untreated wastewater to the Avoca River) and join at Mill Road (to the north of the river channel) to convey wastewater to the WwTP for appropriate treatment.

The scope of works for this portion of the proposed development includes:

- Provision of approximately 1.1km of sewer on the southern side of the Avoca River between River Walk and South Quay (of which c. 300m will be in the river channel);
- Provision of approximately 1km of sewer on the northern side of the Avoca River along North Quay;
- Provision of approximately 120m of tunnelled sewer under the Avoca River; and
- Abandonment of approximately 590m of existing sewers.

Up to 12 vent stacks will also be provided along the length of the interceptor sewers for ventilation at each of the tunnel shaft locations.

SWO’s will also be provided at South Quay (at tunnel shaft TSS3 i.e. at the river crossing) and at the Inlet Works building, to provide emergency relief for excess flows in the sewered catchment during extreme rainfall events and to cater for extended power outages at the WwTP. The SWO at the WwTP will discharge through the proposed upgraded revetment to the Irish Sea, with the SWO on South Quays discharging to the Avoca River through a high level overflow.

Emergency spills via the SWO’s will be screened through a static upward flow screen to ensure particles of more than 10mm in diameter are retained. The spills will discharge no more than seven times per bathing season in accordance with requirements in the guidance and in the Wastewater Discharge Authorisation Regulations 2007, as amended.

4.3.2.2 River Walk/South Quay

The interceptor sewer on the southern side of the river channel will commence adjacent to the proposed Alps SWO and storage tank (at MHS1) and continue east along River Walk to Arklow Bridge. Immediately upstream of Arklow Bridge, the sewer will enter the Avoca River (i.e. it will be within the river channel) and pass under the most southerly arch of Arklow Bridge to just downstream of South Green.

The sewer will exit the river channel adjacent to the junction of South Quay – South Green, re-join the existing road and continue east to the proposed river crossing at Harbour Road. The sewer will traverse under the existing roadway and green space along this section of South Quay to Harbour Road.

Approximately 30m of sewer will be installed to the east of the river crossing to collect flows from the existing network in this area.

The interceptor sewer network has been designed to tie in with the existing foul sewer network along River Walk and South Quay.

4.3.2.1 River Crossing

The river crossing will be a c. 1500mm diameter pipeline tunnelled c. 4m beneath the river bed for approximately 120m between the junction of South Quay - Harbour Road (on the southern side of the river channel) and Mill Road (on the northern side of the river channel). A tunnel shaft will be provided to the north and south of the river channel (TSS3 and TSN6 respectively).

This c. 1500mm diameter pipeline will continue along Mill Road to meet the proposed interceptor sewer from North Quay. These sewers will ultimately join to convey wastewater and enter the WwTP at the pumping station located at the Inlet Works building.

There are two locations along this section (to the north of the river channel) where flows will be transferred from the existing network to the proposed sewer upon operation, therefore the following will be provided:

- c. 525mm diameter spur pipeline at TSS3 to connect to the existing foul sewer; and
- c. 150mm diameter spur pipeline at TSN6 (which decreases to 100mm in diameter) to connect to the existing foul sewers.

4.3.2.2 North Quay

To the north of the river channel, a c. 525mm diameter pipeline will be provided upstream of Arklow Bridge to collect from the existing foul sewer to the west of the Arklow Town Marsh pNHA, up to c. 2m below ground level. Flows from the existing foul sewer (that runs along the rear of properties to the west of Ferrybank) will be intercepted at a new manhole (MHN1). This pipeline will connect to the existing foul sewer and continue east to TSN1 which is located at 1 Ferrybank (i.e. on the site of a demolished property).

At TSN1, the c. 1050mm diameter pipeline will increase to c. 1200mm in diameter in order to provide capacity to accommodate population growth and anticipated future network improvements in Ferrybank and north Arklow. This c. 1200mm diameter pipeline will cross under the roundabout to the north of Arklow Bridge before traversing along North Quay following the alignment of the road around Arklow Harbour until it joins the river crossing on Mill Road. The pipeline will be c. 1200mm in diameter all along North Quay and entirely tunnelled, typically 3-4m below ground level.

At TSN7 on Mill Road, the c. 1200mm diameter pipeline will meet the proposed river crossing, convey wastewater and enter the WwTP at the pumping station located at the Inlet Works building (which is c. 18 m below ground level).

The interceptor sewer network has been designed to tie in with the existing foul sewer network along North Quay.

4.3.3 WwTP

4.3.3.1 Overview

The WwTP will be located on the Old Wallboard Site at Ferrybank. There are a number of buildings and structures on this site, that will be required to be demolished and the site will require clearance, prior to the commencement of construction. There are four buildings proposed as part of the WwTP (Illustrated in Figure 3) including:

- The Inlet Works building to the north;
- The Process building to the south-east;
- The Sludge Tank enclosure to the east; and
- The Administration Building to the south.

Figure 3: Proposed site layout for WwTP buildings

4.3.3.2 Architecture

Wastewater treatment processes at the WwTP will take place within the stand-alone buildings, however the Inlet Works and Process buildings will be connected by an underground services tunnel. There will also be an underground stormwater storage tank and pumping station provided as part of the Inlet Works building.

The architecture of the proposed development is anticipated to become an important part of Arklow's visual character given the prominent location between the Avoca River and the Irish Sea. The form and massing of each of the buildings will be as described in Table 1

Table 1: Building dimensions for the WwTP

Building	Maximum height (above ground level)	Maximum depth (below ground level)	Plan area
Inlet Works building	16.5m[5]	18m	63.6m x 38.5m
Process building	14.5m[5]	3.5m	66m x 39m
Sludge tank enclosure	8.5m	0m	54.3m x 16m
Administration building	10.1m	0m	18.5m x 9.4m

4.3.3.3 Site Access and Landscaping

Vehicular and pedestrian access to the site will be via the entrance on Mill Road. This entrance will be normally closed by a security gate. For safety and security control access will be restricted to employees and contractors accessing the WwTP (i.e. the site will not generally be accessible to the public).

Landscaping around the four buildings will follow a basic grid, derived from the primary geometries of the site. This will include hard landscaping between the buildings in addition to soft landscaping planted around the site perimeter. Soft landscaping is likely to be native plant shrub, grass and trees species found locally such as gorse, grasses, birch and pine trees. The selection of plant species has been undertaken in consultation with the lead ecologist for the proposed development.

Hard landscaping between the buildings will include concrete and gravel finishes with marked areas for workers on foot to navigate between the buildings. Parking will be provided on site for c. 20 vehicles (including 2 electric car charging points), with loading bays for fork lifts and standby areas for trucks collecting sludge also provided.

External lighting will be installed around the WwTP for the safety and security of staff on the site. The lighting will be kept close to the buildings and will only operate when there is movement. The lighting will be designed in accordance with the relevant street light standards and no external flood lighting will be provided on the WwTP site (i.e. flood lighting is located behind the louvred façade).

[5] Note – Vent stack extends 1m above the maximum height of the building

4.3.4 Long Sea Outfall and SWO at WwTP

4.3.4.1 Overview

A long sea outfall and SWO will be provided as part of the proposed development at the WwTP. The long sea outfall, to the south, will discharge treated effluent to the Irish sea. The SWO to the north, will discharge excess storm flows.

The long sea outfall and SWO will cross under the upgraded revetment and discharge into the Irish Sea. While pumping of stormwater is required to the SWO, flow through both the long sea outfall and SWO pipeline will be via gravity and sufficient capacity will be provided to allow for a periodic high velocity pumped flush, therefore avoiding any blockages in the pipelines during continuous periods of low rainfall.

4.3.4.2 SWO

The SWO will terminate at the toe of the revetment (below the MLWS level). The SWO likely comprise concrete material and have an internal diameter of approximately 2m. The SWO will discharge excess stormwater (over and above the capacity of the WwTP and stormwater holding tank as well as acting as an emergency relief for excess flows from the sewered catchment in extreme rainfall events and during extended power outages.

A precast culvert concrete structure will be installed through the revetment to accommodate the SWO. Appropriate non-return valves will be fitted on the SWO pipelines (prior to the discharge point).

4.3.4.3 Long Sea Outfall

The long sea outfall will be approximately 955m in length (i.e. up to c. 900m from shoreline), likely comprise high density polyethene (HDPE) and have an internal diameter of c. 555mm.

The specimen design provides for six elastomeric variable orifice check valves as part of a subsurface diffuser located at the seaward end of the long sea outfall. The riser valves will be vertical and be equipped with a non-return flex valve. Navigational aids will also be installed to mark the location of the outfall.

4.3.5 Revetment

4.3.5.1 Overview

The existing rock armour revetment adjoining the Old Wallboard site will be upgraded as part of the proposed development. The existing rock armour will be removed and subsequently replaced over a distance of approximately 350m along the coast.

The alignment of the revetment will follow the existing shoreline on its northern and southern ends, however the curve of the central part will be slightly softened to provide additional space between the Inlet Works building and the revetment.

4.3.5.2 Structure

The revetment will consist of a double layer of rock armour of c. 6-10 tonnes (T) on an underlayer of c. 0.3 to 1T. The thickness of the armour layer and underlayer will be c. 2.9m and c. 1.3m respectively. The revetment will have a finished crest level of c. 7.5mOD (i.e. approximately 1 to 3m above the level of the existing revetment crest) with a crest width of approximately 9 – 10m. The total width of the upgraded revetment at the base will be approximately 50m (including the toe of the revetment that is to be buried under the seabed). Fill material will form the foundation of the revetment and a geotextile layer will be placed between the underlayer and the fill material to provide an adequate interface.

4.4 Construction

4.4.1 Duration and phasing

In summary, the estimated construction programme is anticipated to take approximately 3.5 – 4 years and it is anticipated that the following will occur, and in some cases activities may overlap:

- Detailed design by the contractor - approximately 8 months;
- Establishment of the site compound and enabling works for the interceptor sewer - approximately 8 months;
- Installation of the temporary causeway during the summer of 2020;
- Installation of the tunnel shafts - approximately 15 months;
- Tunnelling of the interceptor sewer - approximately one year;
- Open cut construction of the interceptor sewer - approximately 9 months;
- Removal of the temporary causeway during the summer of 2021;
- Civil works for the WwTP, including the SWO, long sea outfall and the revetment - approximately 22 months;
- Installation of process, mechanical and electrical equipment as well as site landscaping - approximately one year; and
- Testing and commissioning - approximately 7 months.

4.4.2 Detailed design

The proposed development is likely to be procured using a Design and Build type contract. This form of contract has the benefit of encouraging innovation and value engineering, particularly for a project of this nature and scale, by giving the contractor ownership of both the detailed design and construction phases.

Under this form of contract, the successful contractor will ultimately be responsible for the final detailed design of the proposed development, within the constraints as outlined herein.

Irish Water has developed a specimen design of the proposed development and this assessment has considered the likely significant effects associated with the specimen design. The contractor will develop this design further, in accordance with the proposed mitigation measures, and any conditions that may be prescribed as part of the consent for the proposed development, ensuring that there is no material change in terms of significant effects. As such, the assessment herein is considered to be the 'reasonable worst-case scenario' in terms of significant effects with regard to the overall planning boundary of the proposed development. The detailed design by the contractor should seek to identify opportunities for reducing further any significant adverse effects where practicable.

4.4.3 Construction compounds and working areas

Construction of the proposed development will require temporary land take to accommodate construction activities in addition to the permanent land take required to accommodate specific elements of the proposed development. Land will be temporarily required to accommodate construction compounds and temporary on-site activities, hereafter referred to as the 'working areas'.

Two construction compounds have been identified and are considered to be capable of accommodating the construction activities. The construction compounds and working areas have been included in the planning boundary for the proposed development as illustrated in Figure 4.

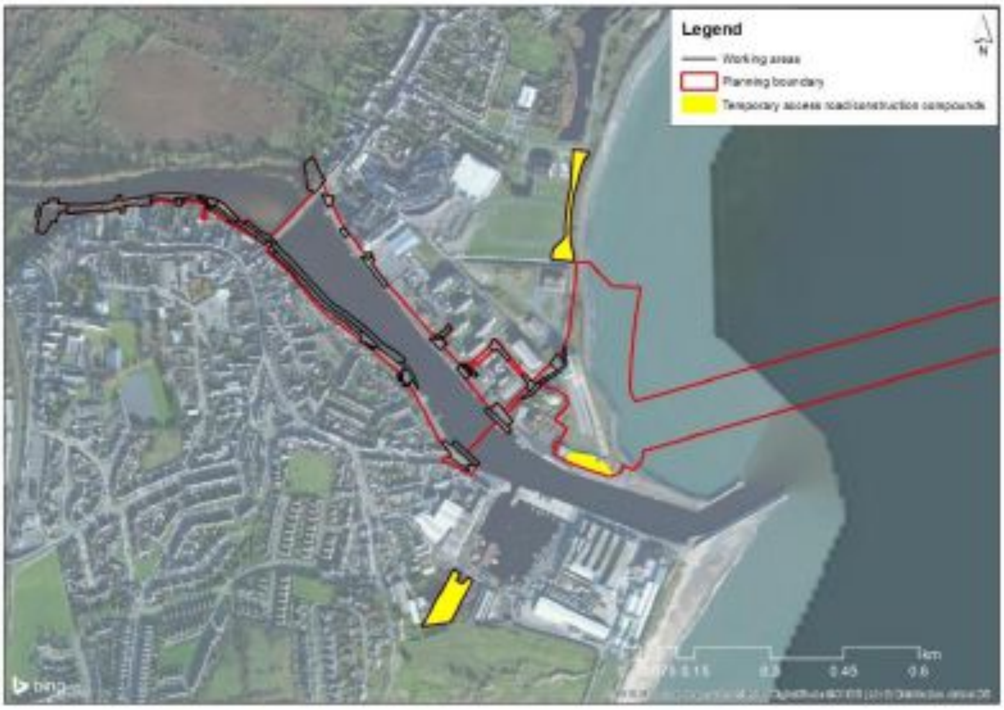


Figure 4: Overview of the working areas and construction compounds

The construction of the interceptor sewers is linear in nature, requiring a number of working areas (that have been identified within the planning boundary) to accommodate the construction compounds, temporary access roads and relevant activities within those working areas on a temporary basis (as illustrated in Figure 4). The working areas will be made available to the contractor for use during the construction period. The working areas will be secured and not be accessible to the public for the duration of the construction in the relevant working area.

4.4.4 Enabling works

4.4.4.1 Overview

Enabling works are those generally undertaken to provide space or access for the permanent works and/or construction activities. By their nature, these works must be completed before the main works can start. The timing of enabling works depends on the programmed start of the phase of main works that they are designed to enable. Some may start well in advance of the main construction activities.

To accommodate the proposed development, enabling works will be required to prepare the various working areas for construction. The following will typically be required at each of the working areas:

- Establish and get appropriate approvals for construction traffic management requirements for diversions and haulage routes;
- Construct temporary site access from the existing road network and install trafficable surfaces where required;
- Install secure hoarding and fencing (c. 2.4m in height as a minimum);
- Install vehicle set down and material storage areas (typically by laying down hardcore to a depth of up to c. 300mm) at Working Area S1 and each of the tunnel shaft working areas;
- Undertake vegetation removal and stripping of topsoil in relevant working areas;
- Install the construction compounds at WwTP site and at Arklow Harbour; and
- Undertake all required utility and services diversions and provide a connection to the local wastewater, water distribution and electrical networks as required.

4.4.4.2 Site investigation

It is anticipated that the contractor may undertake further site investigation works within the planning boundary to confirm the existing information on the land and soils. This will be monitored by the project archaeologist and some further archaeological testing may be required within the river channel as part of the enabling works.

At this stage, it is possible that further site investigation may be required along the alignment of the interceptor sewer and within the WwTP under the footprint of the existing buildings, however the specification of such works will be developed by the contractor during the detailed design.

4.4.4.3 Site Specific Enabling Works

Alps SWO and Interceptor Sewers

The following specific enabling works will be undertaken at those working areas as described in Table 2.

Table 2: Enabling works required at each of the working areas

Working Area	Location and Scope	Enabling Works
Working Areas S1, S2 and S3	Adjacent to the Alps development site and on the western side of River Walk to support the construction of the Alps SWO and storage tank as well as the interceptor sewer on River Walk.	These working areas will be subject to typical enabling works as outlined in Section 4.4.4.1.
Working Area S4	River Walk to support the construction of the interceptor sewer	Demolish an existing wall to the north-east of Working Area S4 (fronting onto River Walk) to facilitate traffic movements around Working Area S3 and install temporary trafficable surface
Working Areas S5 and S6	River Walk to support the construction of the interceptor sewer	These working areas will be subject to typical enabling works as outlined in Section 4.4.4.1.
Working Area S7, S8 and S11	River Walk and extend into the river channel to support the construction of the interceptor sewer	Required to facilitate traffic movements around the adjoining working areas on the landside of River Walk (i.e. Working Areas S5, S6 and S9), therefore a temporary trafficable surface will be installed.
Working Areas S9 and S10	River Walk to support the construction of the interceptor sewer	These working areas will be subject to typical enabling works as outlined in Section 4.4.4.1.
Working Area S11	River Walk to support the construction of the interceptor sewer	Required to facilitate traffic movements around the adjoining working areas on the landside of River Walk (i.e. Working Areas S5, S6 and S9), therefore a temporary trafficable surface will be installed.

Working Area	**Location and Scope**	**Enabling Works**
Working Areas S12 and S13	South Quay and into the river channel to support the construction of the interceptor sewer and tunnel shaft (TSS1)	These working areas will be subject to typical enabling works as outlined in Section 4.4.4.1.
Working Area S14	South Quay and into the river channel to support the construction of the interceptor sewer and tunnel shaft (TSS1)	Required to provide access and parking for local residents, therefore a temporary pedestrian walkway and two temporary on street parking spaces will be installed.
Working Areas S15A & S15B	South Quay to support the construction of the tunnel shaft (TSS2) and interceptor sewer	Required to provide a shared temporary trafficable access road (in each working area) while works are ongoing at the adjoining working area (Working Area S16). Each access road will serve two properties and there will be a requirement to create an access through the dividing garden wall.
Working Area S16	South Quay to support the construction of the tunnel shaft (TSS2) and interceptor sewer on South Quay	These working areas will be subject to typical enabling works as outlined in Section 4.4.4.1.
Working Area S17	South Quay to support the construction of the tunnel shaft (TSS2) and interceptor sewer on South Quay	This working area is required to facilitate traffic movements around the adjoining working area S16. A temporary trafficable surface will be installed as part of the enabling works.
Working Area S18 and S20	South Quay to support the construction of the tunnel shafts (TSS2A and TSS3) and interceptor sewer on South Quay	These working areas will be subject to typical enabling works as outlined in Section 4.4.4.1.
Working Area S19	South Quay, south of the harbour to provide the construction compound to support the construction of the interceptor sewer on River Walk/South Quay.	These working areas will be subject to typical enabling works as outlined in Section 4.4.4.1.
River Working Area S1	In the river channel, extending from upstream of Arklow Bridge to just upstream of the tunnel shaft (TSS2) on South Quay	Construction of the temporary causeway
River Working Area S2	In the river channel, in the vicinity of the proposed river crossing at tunnel shaft (TSS3) on South Quay	Construction of the cofferdams

Working Area	Location and Scope	Enabling Works
Working Area N1	At No. 1 Ferrybank to support the construction of the interceptor sewer on North Quay, specifically tunnel shaft (TSN1) and connection pipework.	These working areas will be subject to typical enabling works as outlined in Section 4.4.4.1.
Working Areas N2 and N3	North Quay to support the construction of the interceptor sewer and connection pipework.	These working areas will be subject to typical enabling works as outlined in Section 4.4.4.1.
Working Areas N4 and N5	North Quay to support the construction of the interceptor sewer, tunnel shaft (TSN2) and connection pipework	These working areas will be subject to typical enabling works as outlined in Section 4.4.4.1.
Working Area N6	North Quay to support the construction of the tunnel shaft (TSN3) and interceptor sewer	There is a requirement to provide a temporary pedestrian walkway to facilitate pedestrian movements around Working Area N6
Working Area N7	North Quay to support the construction of the interceptor sewer and connection pipework	These working areas will be subject to typical enabling works as outlined in Section 4.4.4.1.
Working Areas N8 and N9	North Quay to support the construction of the interceptor sewer, tunnel shaft (TSN4) and connection pipework.	Working area N8 will be subject to typical enabling works as outlined in Section 4.4.4.1. For Working Area N9, there is a requirement to provide a temporary pedestrian walkway and temporary access road around the adjoining working area to the north (Working Area N8). Further, the existing boundary wall for Marina Village will be removed and a new vehicular entrance will be required as part of the enabling works.
Working Area N10	North Quay to support the construction of the interceptor sewer and tunnel shaft (TSN5).	These working areas will be subject to typical enabling works as outlined in Section 4.4.4.1.
Working Areas N11 and N13	Mill Road to support the construction of the tunnel shafts (TSN7 and TSN8) and interceptor sewer	A temporary haul access road to be provided to facilitate vehicular movements on 6m wide temporary trafficable surfaces that can accommodate construction vehicles entering the adjoining WwTP site.
Working Area N12	Mill Road to support the construction of the tunnel shafts (TSN6), interceptor and connection pipework	These working areas will be subject to typical enabling works as outlined in Section 4.4.4.1.

Working Area	Location and Scope	Enabling Works
Working Area N14	Seaview Avenue to Mill Road, to provide temporary access and connect Seaview Avenue to Mill Road during construction	These working areas will be subject to typical enabling works as outlined in Section 4.4.4.1.

WwTP site

Enabling works are required at the WwTP site including the following:

- Removal of asbestos from the existing structures and site;
- Demolition of the existing structures on the site; and
- Excavation of soil and remediation of contaminated land and groundwater.

In the first instance, a Refurbishment/Demolition Asbestos Survey will be undertaken so that all asbestos containing materials are identified and can be dealt with in accordance with the Safety, Health and Welfare at Work (Exposure to Asbestos) Regulations, 2006, as amended and all relevant guidelines. All asbestos containing materials will be removed by a competent contractor, with the appropriate trained staff, equipment and resources. All asbestos containing material will be extracted, double wrapped and labelled before being safely stored in an appropriately protected area.

All asbestos containing material will be removed and disposed of at an appropriately licensed facility in accordance with the relevant procedures and legislation. No other construction activities will occur on the site during this phase of works.

Upon completion of the asbestos removal, demolition of the existing buildings and structures on the WwTP site will be undertaken. The following activities will take place:

- Removal of all materials from the ground floor of each of the buildings on the site;
- Removal of metal cladding sheets generally;
- Demolition of building frames; and
- Demolition of ground floor slabs/grubbing up of foundations.

Demolition and excavation waste will be removed and transferred to an appropriately authorised facility which operates under an appropriate and valid waste facility permit or waste licence. No other construction activities will occur on the site during this phase of works.

During the construction of the subsurface structures (i.e. the inlet sump, storm tanks, the service corridor, SWO and the long sea outfall), excavation will be below the water table. It will therefore be necessary to prevent groundwater ingress or dewater the water bearing sand and gravels. Considering the high permeability of the soils, groundwater intrusion will be minimised by installing deep temporary sheet pile walls.

Any groundwater encountered is likely to be contaminated and therefore will be either removed by tanker off site to a suitable licensed facility or treated on site, prior to discharge under licence.

4.4.5 Construction activities

4.4.5.1 Alps SWO and Stormwater Storage Tank

The proposed SWO and stormwater storage tank will be constructed using conventional open cut methods that will involve the stripping of topsoil, excavation, placement of bedding material, construction of the structure, backfilling with excavated soils, and replacement of the topsoil. Construction of the pipework will be undertaken in parallel and connections will be established to divert existing flows during construction.

4.4.5.2 Interceptor Sewers

It is envisaged that the interceptor sewers will be constructed using a combination of open cut and tunnelling techniques.

Open cut sewers (land based)

The sewer on River Walk and upstream on South Quay will be laid using open cut techniques.

To form the trench for the sewer, the overburden will be excavated and a drag box or trench box installed as the excavation progresses. The excavation will be sized accordingly to accommodate the trench box/drag box.

Following the excavation of overburden, rock breaking or rock ripping will take place and dewatering will occur. This process will be repeated until formation level has been reached to enable the laying of the sewer. Once the excavation is dewatered, the sewer will be laid on its bedding material and the trench filled with suitable material to ground level. The ground level will subsequently be reinstated and where appropriate topsoil and grass seed will be laid.

Open cut sewers (river based)

The proposed interceptor sewer will pass under the most southern arch of Arklow Bridge. The construction of the interceptor sewer within the river channel will also require the construction of a temporary causeway from the river bank that will facilitate a 10m wide haul road for vehicles and larger plant. The temporary causeway will be constructed from clean, suitable engineered fill[6] in a sequential manner from upstream to downstream. An overview of the temporary causeway is illustrated in Figure 5.

[6] Note – Suitable material shall be coarse granular material free from fines with a maximum particle size of 500mm

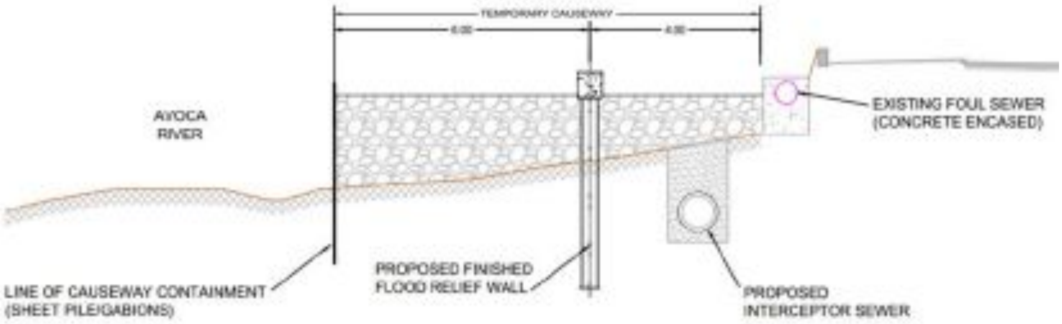


Figure 5: Overview of proposed temporary causeway required to construct the river based sewers

A typical sequence for the construction of a temporary causeway of this nature is summarised below:

- Access route from South Quay will be installed from downstream to upstream (i.e. from east to west direction) to reduce construction traffic in Arklow town centre.
- The causeway will be contained on the river side to mitigate against siltation migration into the Avoca River by installing an additional row of sheet piles on the river side of the causeway or alternatively a row of stone gabions wrapped in a geotextile membrane. The containing material (i.e. sheet piles or gabion walls) will be extended (i.e. to a height above the surface of the causeway).
- The clean engineered fill material to be used as deposit material will be tipped directly into the previously contained area of the river channel from the delivery vehicles. A smaller size clean engineering fill material could be used along the line of the permanent sheet piles to aid their installation.
- Following the deposition of initial loads, material will be spread out to form the temporary causeway (within the contained area) using a combination of excavators and dozers and compacted to a height of c. 300mm above mean high water spring levels.
- The construction of the temporary causeway will continue upstream in this manner until the full route of the temporary causeway is constructed.
- Following completion of construction of the river based sewer (i.e. when the causeway is no longer required), the causeway will be removed in a similar sequential manner via long reach excavators. Within the river channel, the riverbed will be reinstated and cobbles will be laid under the first arch.

Tunnelled sewers

Tunnelling techniques will be used to install the downstream section of the interceptor sewer on South Quay, the river crossing and the interceptor sewer on North Quay. Tunnelling will be undertaken on a 24-hour basis 7 days a week by a tunnel boring machine between the launch and reception shaft until completion.

Tunnel shafts will be required during construction to facilitate the subsurface tunnelling operations. The tunnel shafts comprise launch shafts, reception shafts or a shaft may serve as both launch and reception shafts (dependent on the specific contractor tunnelling methodology).

Once the tunnel shafts have been constructed, the pipeline will be installed using standard micro-tunnelling methods. Micro-tunnelling will be achieved by using a tunnel boring machine to install the pipeline. The tunnel boring machine will enter the ground from a launch shaft and pass to a reception shaft using pipe jacking techniques.

Arklow Bridge Works

Underpinning of two arches of the Arklow Bridge is required, to facilitate the construction of the sewer through the first arch and to reduce any potential flood risk associated with the proposed development. Underpinning is likely to entail the following:

- Grouting each of the piers and the abutments of Arklow Bridge and the river bed to a depth of c. 2m below the piers and abutments, including drilling of holes to accommodate the grouting from the bridge deck, to stabilize the bridge and its formation during the underpinning works;
- Construction of a temporary causeway from the river bank to provide access to each of the piers and abutments;
- Creation of a bund around each pier or group of piers to allow works to be carried out in a dry environment;
- Removal of existing formation in a phased manner from the underside of each pier and abutment to a depth of approximately 1.6m below existing bed level and replacement with concrete; OR
- Construction of mini-piles around each pier to support the pier foundation; OR
- Construction of piles through the piers and abutments from the bridge deck to support the bridge during the underpinning works;
- Demolition of the existing concrete scour protection slabs and lowering of the floor of the bridge by approximately 1m on average (It should be noted that the floors of a number of the arches will be lowered by c. 1.2m); and
- Construction of a new concrete scour protection slab between approximately 10m upstream to approximately 15m downstream of the bridge and beneath the arches of the bridge and the placement of riprap along the upstream and downstream edges of the concrete slab.

Other

- Up to 12 vent stacks will be installed along the alignment of the interceptor sewers and manholes (including connections manholes to the existing network) will be constructed.
- An SWO will also be constructed at TSS3 (tunnel shaft on southern side of river crossing). The SWO will comprise approximately 1200 mm diameter pipeline, extending from TSS3 through the quay wall. A 10mm screen will be fitted within TSS3 to screen flows through this SWO.

Upon completion of construction, testing and commissioning will be undertaken. It should be noted that the interceptor sewers will not be commissioned until such time as the WwTP is accepting wastewater for treatment (i.e. fully commissioned).

4.4.5.3 WwTP

The proposed WwTP will be constructed using conventional construction techniques. Upon completion of the enabling works, the following sequential activities will occur:

- Construction of the building structures (i.e. excavation and construction of foundations, followed by construction of the structure, backfilling and internal fit out);
- Process, mechanical and electrical installation (of relevant plant and equipment) in each of the buildings;
- Landscaping and development of site infrastructure (including grid connections, ancillary infrastructure as well as landscaping and planting); and
- Testing and commissioning of the WwTP (including pre-commissioning, site acceptance test and performance tests).

In the first instance, excavation will be undertaken as required and groundwater controls will be provided and dewatering will occur in areas of deep excavation. Suitable temporary support and piling will be installed as required to provide reinforcement and transfer loads accordingly. The structures will be constructed and backfilling will be undertaken.

The appropriate plant, equipment, mechanical and electrical equipment will be installed upon completion of the construction of the buildings. It is likely that major installations such as the process equipment, the transformer and substation will be installed in the first instance followed by smaller equipment and then services in the buildings. The installation of site wide infrastructure, services, utilities and associated grid connections will be undertaken as necessary. Any ancillary civil infrastructure works will be completed once the structures have been constructed and landscaping will occur thereafter.

Upon completion of construction of the proposed development, a period of testing and commissioning will be undertaken comprising the following sequential activities:

- Level 1 testing - Pre-commissioning;
- Level 2 testing – Site acceptance tests; and
- Level 3 testing – Performance tests.

4.4.5.4 Long Sea Outfall and SWO at WwTP

Long Sea Outfall

The long sea outfall can be constructed by a number of methods and the contractor is responsible for determining the appropriate method. The likely methods that can be undertaken to construct the long sea outfall are outlined below, based on current practice and site constraints/characteristics. These are:

- Horizontal directional drilling method;
- Flood and float method; and
- Bottom-pull method.

Horizontal Directional Drilling method

Construction of the outfall would be carried out by the use of a drilling rig located in either the WwTP site or on a barge or jack-up platform near the seaward end of the outfall. The installation would comprise three phases: drilling of a pilot boring, pre-reaming and pipe positioning, illustrated in Figure 6.

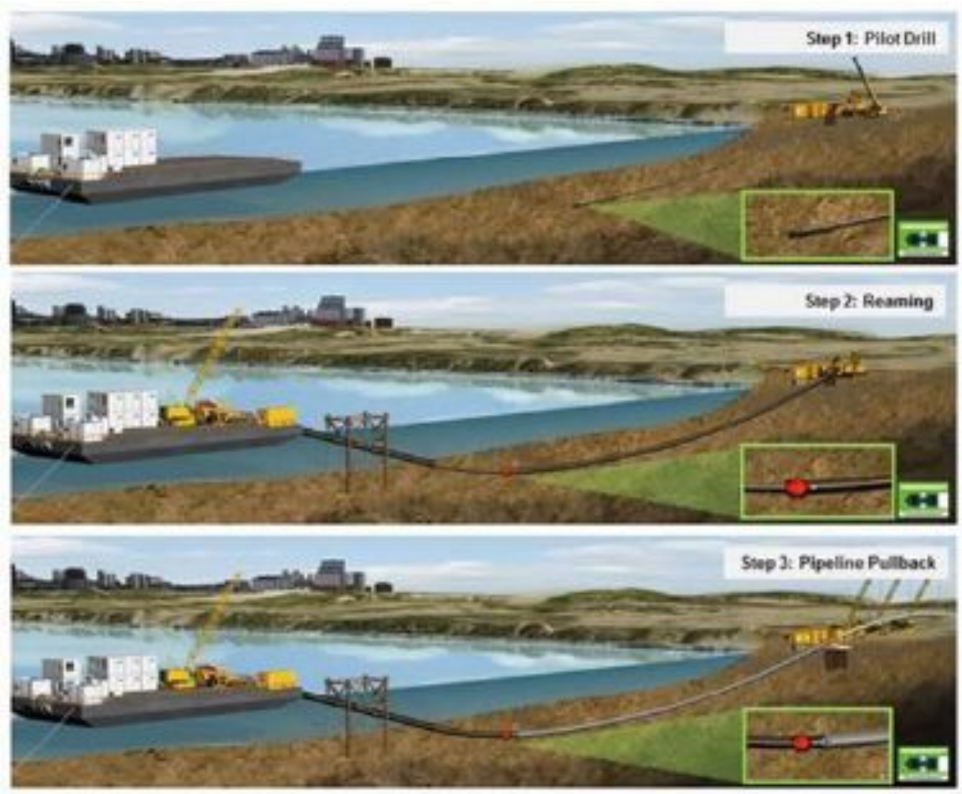


Figure 6: Typical HDD process for a sea outfall (Source: Stevens [7]).

First, a drill rig would be positioned at a designated launch point (i.e. within the WwTP site), from which pilot boring would be carried out. The pilot boring would be undertaken to excavate along the alignment of the outfall.

Following the pilot boring, a reamer would be used to enlarge the hole in order to accommodate the outfall. Subsequently, the pipe positioning phase would take place, during which the outfall pipeline would be laid out at the exit point and connected to the previous hollow pipe.

It is noted that there is no need to install scour protection along the route of the outfall in this case.

Float and flood method

The use of the float and flood method would require the formation of trenches and the placement of suitable material to support and protect the long sea outfall once it is in position.

Trenching and placement of bedding layer

Like the installation of the SWO, a temporary sheet pile cofferdam would likely be required to facilitate the installation of the outfall at the location of the revetment. This section of the outfall would be routed underneath the upgraded revetment and would consist of a HDPE pipeline encased in concrete boxes. The installation will take place prior to the construction of the revetment. The dewatering methodology would follow that for the SWO outlined above.

Prior to the installation of the marine section of the pipeline, the trench in which the outfall is to be laid would be excavated along its route.

The total volume of seabed material to be removed to form the trench is estimated to be c. 18,000m3. This excavated/ dredged material will be left to the side of the trench. It is anticipated that approximately 50% of the material would be later reused as fill material whilst the rest may be naturally dispersed. The dredging equipment that will be used will depend on the contractor, but it is envisaged that either backhoe dredgers or grab dredgers will be used.

Once the seabed material has been removed and the trench has been formed, the imported bedding material would be placed along the bottom of the trench to form the bedding layer.

Installation of the outfall pipeline

The float and flood method, also known to as the ‘S-Bend method’ would involve floating and towing the entire marine section of the outfall pipeline into position on the surface of the sea and the subsequent lowering down of the pipe into the trench as illustrated in Figure 7.

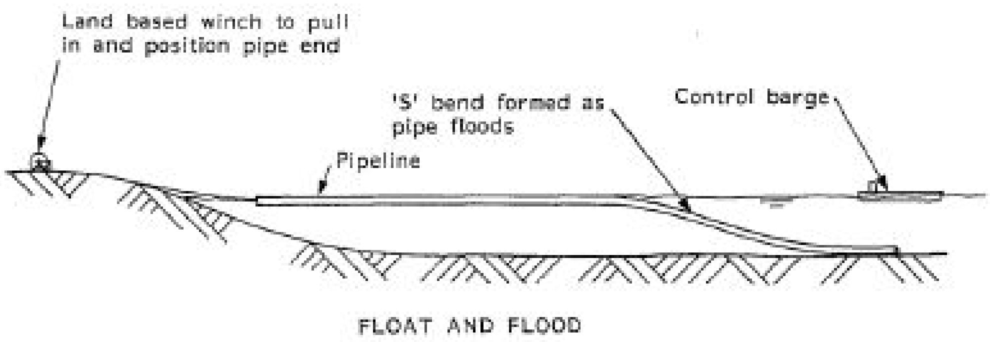


Figure 7: Flood and float method of installing the outfall (Source: WRC [8]).

Sections of the outfall pipe would be assembled on land and readied for moving to the water. The pipe and diffuser would be sealed temporarily while full of air, which provides the buoyancy necessary to float.

The pipeline would then be floated into the water using barges, which would tow and manoeuvre the outfall into position. The lowering operation would be achieved by replacing the air with water, which causes the outfall to sink into position. The rate of submergence would be controlled by the rate of air release.

Additional weight would be added where required (e.g. by using concrete ballast collars) in order to provide the negative buoyancy needed to sink the pipeline and place it in the bottom of the trench.

Backfilling the Trench

Once the outfall is laid in place, the fill material and the scour protection would be placed to surround the outfall pipe. Figure 8 below shows an indicative detail for the trench and scour protection.

As previously mentioned, the fill material will be comprised of seabed material as well as imported material. The excavated seabed material, previously placed parallel to the trench, and the imported material, brought by barges, would be placed back into the trench most likely by the use of backhoe or grab dredgers, or similar equipment. Given the nature of the contract, the exact equipment that will be used will be determined by the contractor.

To ensure against potential medium/long term effect from scour, suitable protection of the pipeline is required. A concrete mattress layer of approximately 300mm thickness is proposed for this purpose. The concrete mattress will finish at existing bed level.

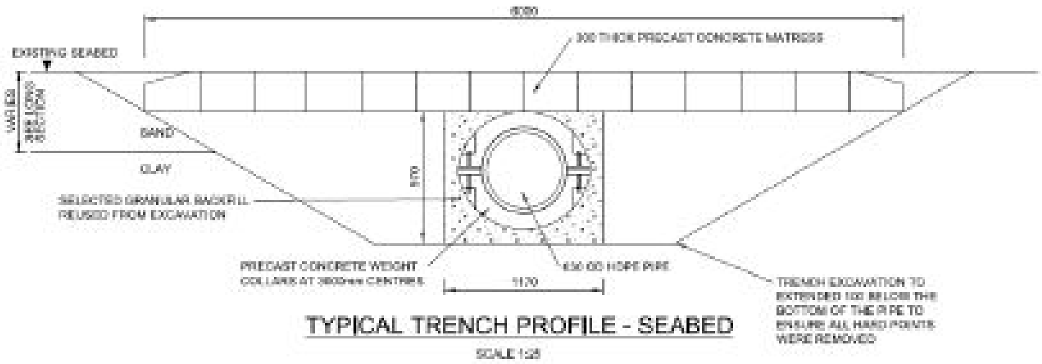


Figure 8: Typical detail for scour protection of an outfall.

The total duration of the works is estimated to be 3-4 months (dependent on weather conditions).

Bottom-pull method

Overview

The use of the bottom-pull method would, in a similar manner to the float and flood method, require the formation of trenches and the placement of suitable bedding material to support and protect the positioned pipeline. The revetment crossing, trenching, placement of the bedding layer, scour protection, backfilling of the trench and the diffuser assembly procedures would also be the same as described in the Float and flood method section above. Laying of the outfall would be undertaken as described below.

Installation of the outfall pipeline

The bottom-pull method would involve joining and pulling sections of the outfall pipeline towards the sea by using a barge. The pipes would be pulled into place by the barge as illustrated in Figure 9.

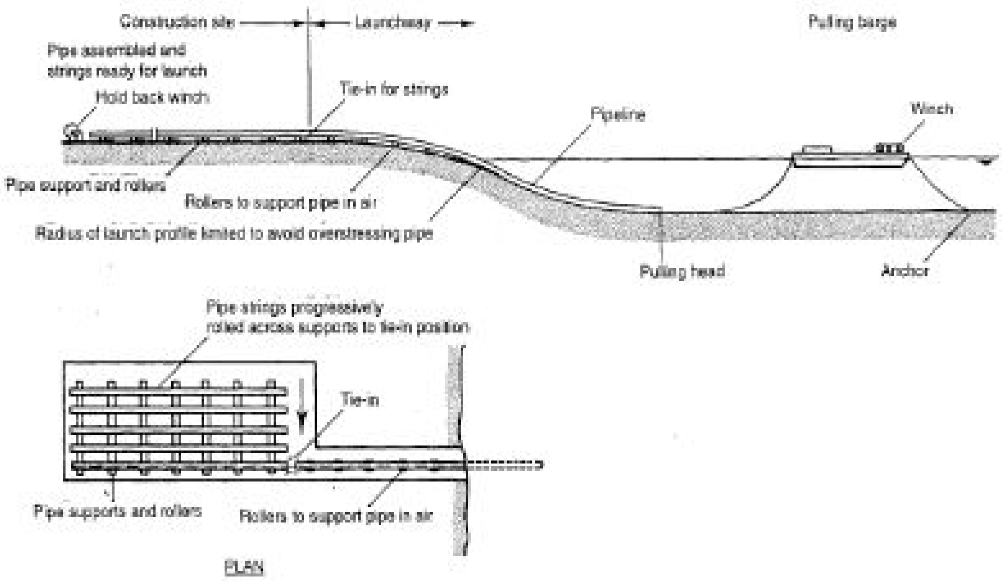


Figure 9: Bottom pull method of installing the outfalls (Source: CIRIA [9]).

Small sections of the outfall pipe would be arranged on land (within the WwTP site) and readied for placing on rollers. The rollers would be aligned with the route of the outfall and the location of the revetment crossing to ensure that the correct pipe alignment is achieved. The sections of the pipe would be joined in sequence to make pipe strings that could be placed onto the rollers. The number and length of the pipe strings would be determined by the contractor based on the space that is made available within the WwTP site.

The pipe strings would be pulled by winches mounted on a barge anchored offshore in a stepped process. The first pipe string would be pulled towards the sea then the next string would be moved across the rollers and joined to the first string at the tie-in position. This procedure would be repeated until all the strings have been joined and the outfall pipe has been laid in position. Following the completion of pulling, the culvert (i.e. the interface between the outfall and the revetment) would be installed.

The total duration of the works is estimated to be 4-5 months (dependent on weather conditions).

Diffuser assembly

Once the long sea outfall has been laid, by whichever method (HDD, float and flood or bottom-pull), the diffuser would be assembled on the seaward end of the outfall. The diffuser arrangement would include up to 6 diffusers of approximately 0.16m diameter at a spacing of c. 10m intervals.

The diffuser would be prefabricated on land and placed on the seabed by barge as one complete unit. The exact procedure and depths of backfill required would depend on the equipment available from the contractor along with programme and cost considerations, however it is anticipated that this would be undertaken from the barges and it will likely require open excavation of the seabed, along the length of the diffusers.

SWO

Construction of the SWO at the WwTP site will involve the installation of a temporary sheet pile cofferdam (temporary enclosures to keep out water and soil) to facilitate excavation. Trenching will occur along the length of the SWO pipeline to the required depths, followed by the placement of the bedding later, laying the pipe and backfill of the trench. A precast concrete culvert will be constructed over the SWO through the revetment to protect the outfall in this location. The culvert will be constructed prior to the revetment upgrade in this area using conventional methods. Appropriate headwalls and scour protection at the discharge location will also be provided.

4.4.5.5 Revetment

Upgrading the revetment will require the removal of the existing rock revetment and its subsequent realignment and replacement of the rock armour. This will be carried out in a staged process along the revetment in sections of approximately 15 to 25m in order to protect against storm events and thus reduce the risk of flooding during the construction phase. The revetment construction will be carried out from toe to crest by using suitable excavators located on the WwTP site. A schematic summary of the construction of the revetment is provided in Figure 10.

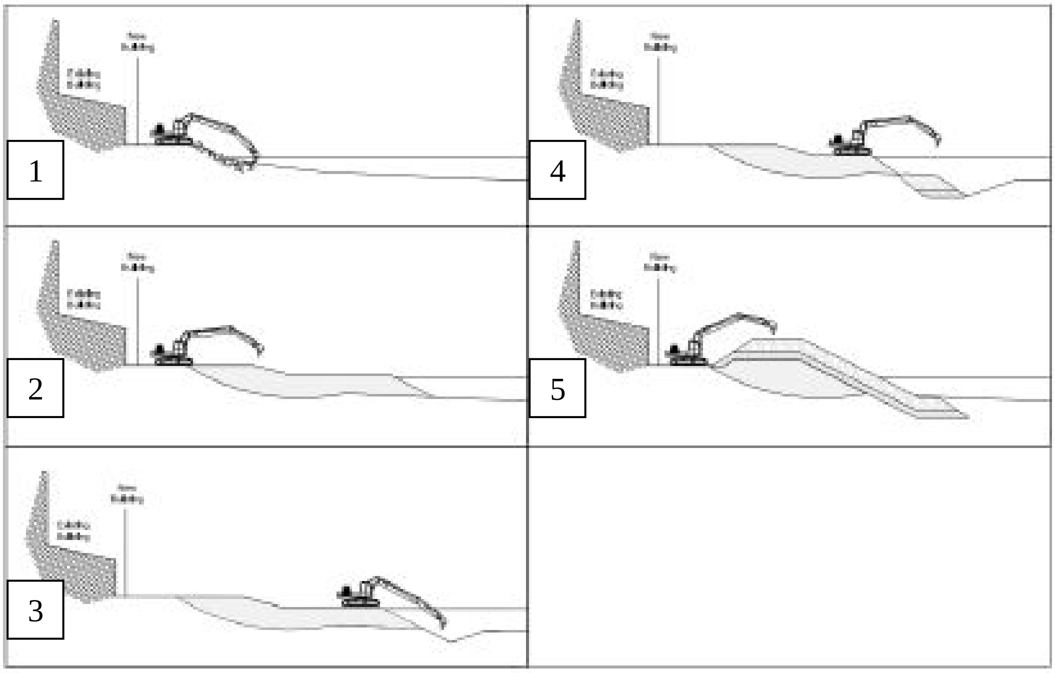


Figure 10: Envisaged procedure for the removal and subsequent replacement of the rock revetment

4.4.6 Demobilisation

On completion of construction, all construction facilities and equipment such as plant, materials, signage, contractors’ offices, site compounds and laydown areas, etc. will be removed from site.All ground will be reinstated to an appropriate standard, in accordance with the landscaping strategy.

4.5 Operation

4.5.1 Alps SWO and Stormwater Storage Tank

Flows will be passed through the SWO once operational with the wastewater conveyed to the interceptor sewers and with excess storm flows passed to and stored in the stormwater holding tank. During significant rainfall events where storm flows exceed the tank storage capacity, excess flows will spill via the tank overflow to the Avoca River (via the existing culvert). These spills will be screened through a static upward flow screen to ensure particles of more than 6mm in diameter are retained within the tank. The spills will discharge to the Avoca River no more than seven times per bathing season in accordance with requirements in the guidance and in the Wastewater Discharge Authorisation Regulations 2007, as amended.

4.5.2 Interceptor Sewers

At the commencement of operation, approximately 130m of the existing sewer along North Quay will be abandoned and left in situ. The redundant pipelines will typically be pumped with concrete to form a plug at either end of the line.

The proposed sewers will intercept the existing network and join at Mill Road in order to convey wastewater to the WwTP (by gravity) for appropriate treatment and thus eliminate (in so far as possible) the discharge of untreated wastewater into the Avoca River.

As detailed, a SWO will be provided on the interceptor network on South Quays. Spills through this SWO will discharge to the Avoca River. Any spills will be screened through a static upward flow screen to ensure particles of more than 10mm in diameter are retained. The spills will discharge to the Avoca River no more than seven times per bathing season in accordance with requirements in the guidance and in the Wastewater Discharge Authorisation Regulations 2007, as amended.

4.5.3 WwTP

The EPA will ultimately dictate the Emission Limit Values to be achieved in its Waste Water Discharge Authorisation, however the treatment processes have been designed on the basis that any discharge from the WwTP (i.e. effluent) will be treated to achieve those standards outlined in Table 3.

Table 3: Effluent Emission Limit Values (Source: Urban Wastewater Treatment Regulations 2001, as amended)

Parameter	Design Emission Limit Values
BOD	25mg/l
TSS	35mg/l
COD	125mg/l
TN	15mg/l

Once operational, the WwTP will achieve these Emission Limit Values to guarantee compliance with the requirements of the UWWT Directive and therefore meet all regulatory requirements and significantly improve the quality of effluent being discharged in Arklow town.

4.5.4 Long Sea Outfall and SWO at WwTP

An outfall is required to discharge the treated effluent to receiving waters. The long sea outfall will discharge treated effluent to the Irish Sea in accordance with those Emission Limit Values outlined in Table 3.

The SWO will be provided for excess storm flows during significant rainfall events that exceed treatment and storm water storage capacity and to provide emergency relief for excess flows in the sewered catchment during extreme rainfall events and in the event of an emergency such as an extended power outage. All flows through the SWO will be screened. Flows through the SWO will also be discharged to the Irish Sea.

4.5.5 Maintenance

The proposed development will form part of the maintenance contracts and all elements will be maintained on a regular basis to ensure all elements function as per their design and achieve the required standards.

5 Ecological Overview

5.1 Baseline overview of the receiving environment

The Avoca River drains a primarily upland catchment of some 650km^2. It enters the Irish Sea at Arklow via a short riverine estuary that is largely contained by existing sea and harbour walls. The Avoca River is formed by the joining of the Avonmore and Avonbeg rivers, which rise in the Wicklow Mountains. The Avonmore River flows from Lough Dan, just west of Roundwood, and flows in a generally south-easterly direction for approximately 30 km before meeting the Avonbeg River (which rises near Table Mountain at the top of Glenmalure valley), just north of the village of Avoca, and becoming the Avoca River. Closer to Arklow, the Aughrim River and the Avoca River flow through steeply sloping wooded valleys, and join at Woodenbridge. The valley sides, with both coniferous and deciduous woodlands, are included within Avoca River Valley pNHA (Site Code 001748).

The Avoca River flows through lower ground from Shelton Abbey towards the Irish Sea, and forms a west - east corridor through Arklow town. Arklow Town Marsh pNHA includes the Avoca River channel upstream of Arklow Bridge, and the wetland habitats that extend northwards from the bank of the river. The proposed development included works along the south bank of the river in this area.

There is a coastal north - south corridor of sand dunes habitats, interspersed with rocky headlands, along the coast of Wicklow and Wexford (see Figure 11). In the Arklow area, this coastal corridor is modified by recreational, commercial and industrial land uses on both sides of the Avoca estuary and Arklow Harbour. To the south of Arklow, there is a narrow strip of modified sand dune habitat, including a golf course, between Arklow Head and the south harbour wall. To the north of Arklow Harbour, part of an area of estuary and sandhills was reclaimed in the Ferrybank area during the 19th Century for commercial and industrial uses (see Appendix E, Figure 15), while lands in the vicinity of Arklow Pond and to the north remain relatively natural although modified by residential, commercial and recreational land uses. Further north at Seabank and Arklow North beach, c. 200ha of sand dune and woodland habitat is listed as Arklow Sand Dunes proposed Natural Heritage Area (Site Code 001746).

Baseline desk studies and field surveys carried out for the proposed development are described in detail in the Biodiversity Chapter of the EIAR (Chapter 11). Habitats recorded within the planning boundary, and in the vicinity of the planning boundary, are listed in Table 4. No Annex 1 listed habitats occur within the planning boundary of the proposed development. In the context of the urban area of Arklow, the terrestrial flora and habitats recorded during field survey within the planning boundary of the proposed development represent locally important biodiversity and ecological connectivity.

Information on protected species listed in Annex II and in Annex IV of the Habitats Directive that occur in the Avoca River catchment and in marine waters in the Arklow area, which are not listed as Qualifying Interests of SACs in these waters, is included in this report, following the Opinion of Advocate General Kokott in Holohan on 7 August 2018.

Table 4: Terrestrial and non-marine habitats present within the planning boundary, and in the study area outside the planning boundary of the proposed development

Habitat (Fossitt[7] classification)	The Alps SWO and Stormwater Storage Tank	River Walk and South Quay	North Quay	WwTP site	Habitats in the study area outside the planning boundary
Exposed siliceous rock ER1	✓				✓
Scrub WS1	✓		✓	✓	✓
Treelines WL2		✓	✓		✓
Riparian woodland WN5					✓
Buildings and artificial surfaces BL3	✓	✓	✓	✓	✓
Stone walls and other stonework BL1		✓	✓		✓
Spoil and bare ground ED2		✓	✓	✓	
Recolonising bare ground ED3		✓	✓	✓	
Amenity grassland GA2		✓	✓	✓	✓
Ornamental non-native shrub WS3	✓	✓	✓	✓	✓
Flower beds and borders BC4		✓			✓
Depositing lowland rivers FW2	✓	✓	✓		✓

7 Fossitt, Julie A (2000). *A Guide to Habitats in Ireland*. The Heritage Council.

Habitat (Fossitt[7] classification)	The Alps SWO and Stormwater Storage Tank	River Walk and South Quay	North Quay	WwTP site	Habitats in the study area outside the planning boundary
Drainage ditches FW4			✓		
Tidal rivers CW2		✓	✓		✓
Wet grassland GS4					✓
Improved agricultural grassland GA1					✓
Reed and large sedge swamp FS1					✓
Dune scrub and woodland CD4					✓

The freshwater and estuarine ecology of the Avoca River, and the marine ecology, in the vicinity of the proposed development have been described through field survey and desk study.

The study area has been highly modified by human activity through the construction of estuarine retaining walls, harbour breakwaters, and a stretch of coastal rock armour revetment, with the river impacted by acid mine drainage from the Avoca Mines upstream and the estuary also influenced by the input of untreated wastewater. While the intertidal and estuarine habitats of the study area are of depressed species richness and low ecological value, the estuary does continue to support a fish community and provides a corridor for fish including Habitats Directive Annex II listed species Atlantic Salmon *Salmo salar* and River Lamprey *Lampetra fluviatilis*. Though not recorded in the course of recent surveys carried out under the Water Framework Directive (WFD), Sea Lamprey (*Petromyzon marinus*) are also known from the Avoca River.

The marine benthic community outside the Avoca Estuary has a depressed species richness compared to what might be expected from the habitat present. It is likely that the discharge of untreated wastewater and acid mine drainage to the Avoca River is having an influence in terms of contaminant load, as suggested in previous benthic surveys. The area is dominated by a single biotope *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment. This biotope is common and widespread along the east coast of Ireland.

European sites that may be in the Zone of Influence of the proposed development are considered in Section 5.2.

5.2 Natura 2000 Sites that may be within the Zone of Influence

5.2.1 Overview of the potential Zone of Influence

The proposed development does not lie within or adjoining any European sites. The proposed development includes works in the terrestrial and in the aquatic environment (Avoca River, estuary, and coastal waters) within the planning boundary shown in Figure 1, as described in Section 4.

The area within a 15km radius of the proposed Arklow WwTP development, including the long sea outfall, was taken as a starting point in this assessment (Figure 11). Three European sites located along the Wicklow and Wexford coasts lie at least partially within 15km of the proposed development. These three coastal SACs are:

- Buckroney – Brittas Dunes and Fen SAC (Site Code 000729) which lies 4.5km to the north at its closest point
- Kilpatrick Sandhills SAC (Site Code 001742) which lies 6.5km to the south at its closest point
- Part of Magharabeg Dunes SAC (Site Code 001766) also lies within 15km of the proposed development.

All of the Habitats Directive Annex 1 habitats (see Table 5) that are listed as Qualifying Interests for these three SACs are considered to be water dependent, including dependency on coastal and transitional waters (O'Riain *et al*, 2005[8]). These three SACs may have a potential to be within the Zone of Influence of the proposed development, and are considered further in section 5.2.2.

Part of the upper River Slaney catchment, within the Slaney River Valley SAC (Site Code 000781) lies within 15km to the south west of the proposed development (Figure 11), but is not hydrologically linked to the Avoca River catchment or to the proposed development, other than via Wexford Harbour, located more than 50km South of the proposed development. This SAC does not have a potential to be within the Zone of Influence of the proposed development and is therefore not considered further.

Source-pathway-receptor issues potentially arising from hydrological linkage with more distant Natura 2000 sites have also been considered. There are two marine SACs located more than 15km away from the proposed development (Figure 11); these are the Wicklow Reef SAC (Site Code 002274) and the Blackwater Bank SAC (Site Code 002953).
Wicklow Reef SAC is located c. 20km to the north, while Blackwater Bank SAC is located c. 30km to the south. These SACs are located in marine waters, may

[8] Ó Riain, Gearóid Katherine Duff and Maria Long (2005). *Water Framework Directive – Water Status: identifying and ranking of Nature Conservation Designated Areas (2005)*. Prepared by Compass Informatics Limited and Natura (Environmental Consultants) Ltd. Environmental RDTI Programme 2000-2006 (2002-W-DS-10).

have a minor potential to be within the Zone of Influence of the proposed development, and are considered further in section 5.2.2.

Some of the headwaters of the Avoca River, the Avonbeg and Ow Rivers rise within the Wicklow Mountains SAC (Site Code 002122), and Wicklow Mountains SPA (Site Code 004040), located some 25 to 30km upstream of the proposed development in Arklow. The Avonmore River flows through the Vale of Clara (Rathdrum Wood) SAC (Site Code 000733), located 15km or more upstream of Arklow (Figure 11). These European sites are hydrologically linked to the proposed development via the Avoca River catchment, and are considered further in section 5.2.2, to assess whether any of their Qualifying Interests or Special Conservation Interests have any potential to be included in the Zone of Influence of the proposed development.

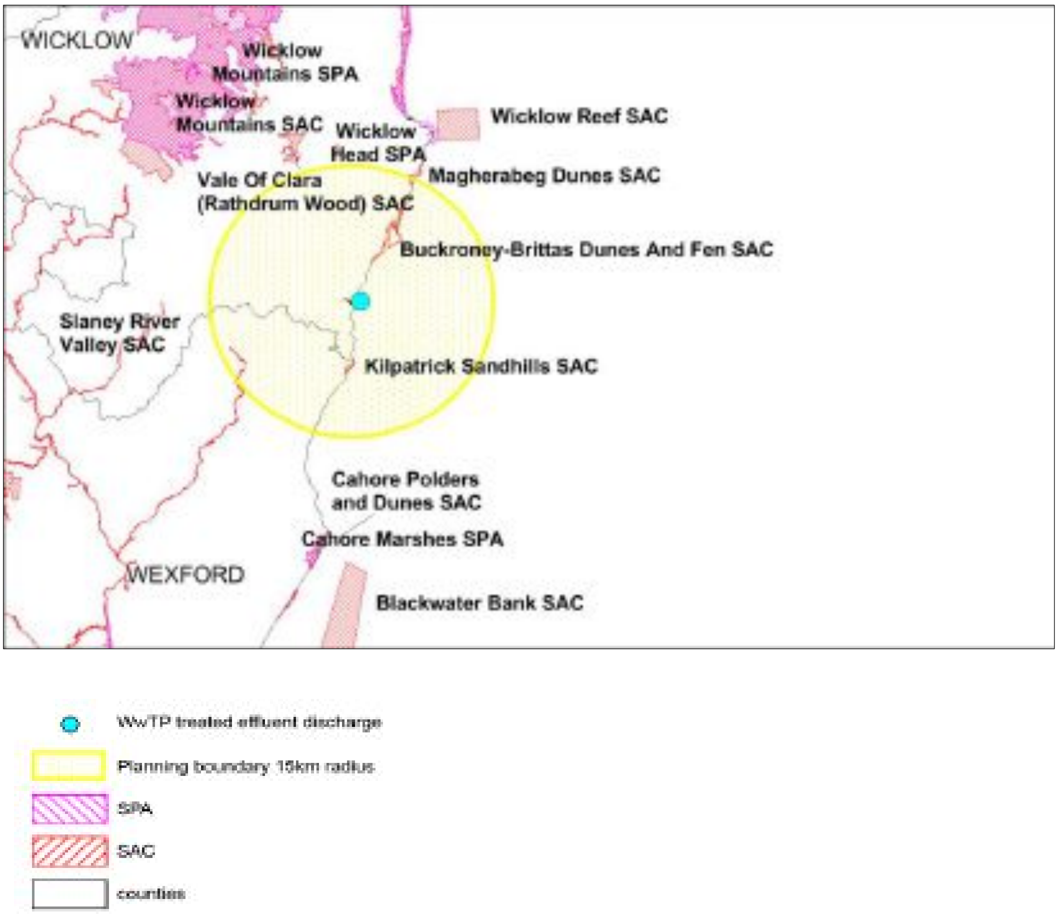


Figure 11: European sites, highlighting sites within a 15km radius of the proposed development

5.2.2 Determination of the Zone of Influence of the proposed development

This section considers the potential Zone(s) of Influence arising from different activities that constitute the proposed development, and examines the Qualifying Interests and Special Conservation Interests of those European sites identified in Section 5.2.1, in order to establish whether there is any potential for the conservation status of any of those Interests to be affected by the proposed development:

- Buckroney – Brittas Dunes and Fen SAC (Site Code 000729)
- Kilpatrick Sandhills SAC (Site Code 001742)
- Magharabeg Dunes SAC (Site Code 001766)
- Wicklow Reef SAC
- Blackwater Bank SAC
- Wicklow Mountains SAC
- Wicklow Mountains SPA

The Zone of Influence of the proposed development is determined with regard to the individual sensitivities of these Natura 2000 sites, their location in relation to the proposed development, the mobility of any species listed as Qualifying Interests that may give rise to *ex situ* effects, and to the geographic extent of the potential effects of proposed activities during the construction and operational phases.

5.2.2.1 Activities and considerations determining the Zone of Influence during the construction phase

The Zone of Influence of the proposed development is restricted to the planning boundary with regard to the terrestrial habitats listed in Table 4. Construction works in and adjoining the aquatic environment of the Avoca River and its estuary do not have a potential to affect the Avoca River catchment upstream, although mobile species listed as Qualifying Interests (see Table 5) could be affected by *ex situ* effects should they occur within the planning boundary of the proposed development.

Construction works within coastal waters include upgrading of the existing revetment, the construction of the SWO, and the construction of the long sea outfall, as described in Section 4 and in Appendix E. The oceanography in the vicinity of the proposed long sea outfall can be described as energetic with strong tidal currents, brief slack waters, large tidal excursions and good dispersive characteristics (Irish Hydrodata 2018[9]). Flood and ebb tide current strength and direction are described in Irish Hydrodata 2018 Section 2.3.

[9] Irish Hydrodata 2018 - Arklow WWTP Investigation of the impact of Treated Wastewater Discharges to the Irish Sea

Flood tide direction is from South to North, and currents are stronger during flood tide than during the ebb tide. The main longshore drift of sediments in the coastal waters off Arklow moves from South to North (Appendix E).

A desktop assessment of the coastal areas where a change of orientation or a physical barrier such as a headland exist has been carried out and is included in (Appendix E, see Figure 13). These uniform units suggest limited exchange of sediment between them. The uniform units identified in the vicinity of the area of study of coastal processes are as follows:

- Kilmichael Point to Mizen Head; and
- Mizen Head to Wicklow Head.

Each uniform unit incorporates sub-physiographic units, also defined by changes in coastline orientation and local headland features, which also have the effect of limiting sediment exchange.

5.2.2.2 Activities and considerations determining the Zone of Influence during the operational phase

The proposed development includes the upgrading of the existing revetment and the construction of the SWO and long sea outfall. The potential for the presence of these structures to give rise to effects during the operational phase is subject to the considerations included in Section 5.2.2.1.

The Zone of Influence of the treated effluent discharge via the long sea outfall arises during the operational phase of the proposed development.

The WwTP would provide secondary treatment as required under the Urban Wastewater Treatment Regulations 2001 - 2010. The proposed discharge location (900m long sea outfall) meets all compliance requirements.

The proposed long sea outfall would discharge treated effluent into a Coastal waterbody as defined under the Water Framework Directive 2000/60/EC (Water Framework Directive). The proposed discharge via a diffuser on the sea bed c. 900m offshore has a maximum design dissolved inorganic nitrogen (DIN) concentration of 60mg/l N. A key objective as per the European Communities Environmental Objectives (Surface Waters) Regulations 2009 (SI 272/2009)[10] is to establish the extent of the mixing zone for this discharge. The relevant controlling parameter for coastal waters is the DIN nutrient concentration, the mixing zone boundary is defined by the Coastal waterbody High Status guideline level of DIN (0.17mg/l N). Studies carried out by Irish Hydrodata (2018) predict that the mixing zone envelope, within which DIN levels would be close to but exceed the High Status guideline (0.17mg/l N), extends about 305m to the north of the proposed 900m outfall on the flood tide, and a similar distance to the south on the ebb tide. It would have an overall width of about 100m.

[10] As amended by the European Communities Environmental Objectives (Surface Waters) (Amendment) Regulations 2012 (S.I. No. 327 of 2012); and the European Communities Environmental Objectives (Surface Water) (Amendment) Regulations 2015

Within this mixing zone, DIN levels would be within the target water quality level for Good Status (Irish Hydrodata 2018, Section 4.5 and Figure 4.4.a, and Section 4.7.4). This envelope represents the potential zone of influence of the effluent discharge plume for all stages of the tide. With reference to Figure 11 of this report, the Zone of Influence arising from the treated effluent discharge via the long sea outfall does not extend to any European sites.

5.2.2.3 Qualifying Interests of those Natura 2000 sites identified in Section 5.2.1

This section examines the Qualifying Interests of the SACs and Special Conservation Interests of the SPAs identified in Section 5.2.1, in order to establish whether there is any potential for the conservation status of any of those Interests to be affected by the proposed development:

- Buckroney – Brittas Dunes and Fen SAC (Site Code 000729)
- Kilpatrick Sandhills SAC (Site Code 001742)
- Magharabeg Dunes SAC (Site Code 001766)
- Wicklow Reef SAC
- Blackwater Bank SAC
- Wicklow Mountains SAC
- Wicklow Mountains SPA

Table 5 lists the Qualifying Interests and Special Conservation Interests for each of these sites, all of which are hydrologically linked to the proposed development, and considers whether these habitats and species are water dependent and if so, which water sources they depend on. The final column in Table 5 assesses the potential for the proposed development to affect the habitat or species, and indicates which feature or attribute of each habitat or species may be vulnerable to individual activities associated with the proposed development.

Table 5: Qualifying Interests of SACs and Special Conservation Interests of SPAs that may be within the Zone of Influence of the proposed development.

Note: Main water sources are c: coastal; t: transitional; s: surface; g: ground; and p: precipitation.

Natura 2000 site	Qualifying Interests * indicates a priority habitat under the Habitats Directive	Water dependent	Main water source	Potential for the proposed development to affect the Conservation Objectives
Buckroney – Brittas Dunes and Fen SAC (Site Code 000729)	Annual vegetation of drift lines [1210]	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Perennial vegetation of stony banks [1220]	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Mediterranean salt meadows (Juncetalia maritimi) [1410]	Yes	c, t, s, g	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Embryonic shifting dunes [2110]	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120]	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Atlantic decalcified fixed dunes (Calluno-Ulicetea) [2150]*	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Dunes with Salix repens ssp. argentea (Salicion arenariae) [2170]	Yes	g, c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Humid dune slacks [2190]	Yes	g, c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Alkaline fens [7230]	Yes	g, s	The proposed development does not have a potential to affect the Conservation Objectives of this habitat, which is located away from the coast on the landward side of the sand dune complex
Kilpatrick Sandhills SAC (Site Code 001742)	Annual vegetation of drift lines [1210]	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Embryonic shifting dunes [2110]	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply

Natura 2000 site	Qualifying Interests * indicates a priority habitat under the Habitats Directive	Water dependent	Main water source	Potential for the proposed development to affect the Conservation Objectives
	Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120]	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Atlantic decalcified fixed dunes (Calluno-Ulicetea) [2150]*	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
Magharabeg Dunes SAC (Site Code 001766)	Annual vegetation of drift lines [1210]	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Embryonic shifting dunes [2110]	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120]	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Atlantic decalcified fixed dunes (Calluno-Ulicetea) [2150]*	Yes	c, (t)	Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute Physical structure: functionality and sediment supply
	Petrifying springs with tufa formation (Cratoneurion) [7220]*	Yes	g	The proposed development does not have a potential to affect the Conservation Objectives of this ground water dependent habitat which is located above tidal waters
Wicklow Reef SAC (Site Code 002274)	Reefs [1170]	Yes	c	A single community type, current-swept subtidal reef community complex occurs in this SAC. Currents of up to 6 knots were recorded within this site, with no significant period of slack water. There is no potential for direct or indirect effects on this site, or on the natural processes that support the conservation status of this site, since the proposed development is located c. 20km to the south of this SAC, and in the unlikely event of suspended solids from construction works in marine waters reaching this SAC, no deposition would arise because of the strong currents at the SAC.
Blackwater Bank SAC (Site Code 002953)	Sandbanks which are slightly covered by sea water all the time [1110]	Yes	c, t	Two community types occur in this site, Sand with *Nephtys cirrosa* and *Bathyporeia elegans* community complex at depths of 0 to 30m, and Cobbles with epifauna community at depths of 30 to 40m. Currents of 2 to 10 knots were recorded at this site. There is no potential for direct or indirect effects on this site, or on the natural processes that support the conservation status of this site, since the proposed development is located

Natura 2000 site	Qualifying Interests * indicates a priority habitat under the Habitats Directive	Water dependent	Main water source	Potential for the proposed development to affect the Conservation Objectives
				c. 30km to the north of this SAC, and the direction of longshore drift is northwards towards the proposed development
Wicklow Mountains SAC (Site Code 002122)	Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae) [3110]	Yes	s, g	Located at least 25km upstream of the proposed development in Arklow, there is no pathway or potential for direct or indirect effects to arise to any of the attributes that support the conservation status of this habitat
	Natural dystrophic lakes and ponds [3160]	Yes	s, (g)	Located at least 25km upstream of the proposed development in Arklow, there is no pathway or potential for direct or indirect effects to arise to any of the attributes that support the conservation status of this habitat
	Northern Atlantic wet heaths with Erica tetralix [4010]	Yes	s, p, (g)	Located at least 25km upstream of the proposed development in Arklow, there is no pathway or potential for direct or indirect effects to arise to any of the attributes that support the conservation status of this habitat
Wicklow Mountains SAC (Site Code 002122)	European dry heaths [4030]	No		Located at least 25km upstream of the proposed development in Arklow, there is no pathway or potential for direct or indirect effects to arise to any of the attributes that support the conservation status of this habitat
	Alpine and Boreal heaths [4060]	No		Located at least 25km upstream of the proposed development in Arklow, there is no pathway or potential for direct or indirect effects to arise to any of the attributes that support the conservation status of this habitat
	Calaminarian grasslands of the Violetalia calaminariae [6130]	No		Located at least 25km upstream of the proposed development in Arklow, there is no pathway or potential for direct or indirect effects to arise to any of the attributes that support the conservation status of this habitat
	Species-rich Nardus grasslands, on siliceous substrates in mountain areas (and submountain areas, in Continental Europe) [6230]*	No		Located at least 25km upstream of the proposed development in Arklow, there is no pathway or potential for direct or indirect effects to arise to any of the attributes that support the conservation status of this habitat
	Blanket bogs (* if active bog) [7130]	Yes	p, s, (g)	Located at least 25km upstream of the proposed development in Arklow, there is no pathway or potential for direct or indirect effects to arise to any of the attributes that support the conservation status of this habitat
	Siliceous scree of the montane to snow levels (Androsacetalia alpinae and Galeopsietalia ladani) [8110]	No		Located at least 25km upstream of the proposed development in Arklow, there is no pathway or potential for direct or indirect effects to arise to any of the attributes that support the conservation status of this habitat

Natura 2000 site	Qualifying Interests * indicates a priority habitat under the Habitats Directive	Water dependent	Main water source	Potential for the proposed development to affect the Conservation Objectives
	Calcareous rocky slopes with chasmophytic vegetation [8210]	No		Located at least 25km upstream of the proposed development in Arklow, there is no pathway or potential for direct or indirect effects to arise to any of the attributes that support the conservation status of this habitat
	Siliceous rocky slopes with chasmophytic vegetation [8220]	No		Located at least 25km upstream of the proposed development in Arklow, there is no pathway or potential for direct or indirect effects to arise to any of the attributes that support the conservation status of this habitat
	Old sessile oak woods with Ilex and Blechnum in the British Isles [91A0]	No		Located at least 25km upstream of the proposed development in Arklow, there is no pathway or potential for direct or indirect effects to arise to any of the attributes that support the conservation status of this habitat
Wicklow Mountains SAC (Site Code 002122)	Lutra lutra (Otter) [1355]	Yes	s, t, c	Otters will utilise freshwater habitats from estuary to headwaters. No aquatic habitat severance will arise to Otters moving between the upper Avoca River catchment and coastal waters, since water will continue to flow through the river and estuary during construction works undertaken for the proposed development, and approximately 83% of the width of the river estuary will remain unobstructed at the narrowest point during construction. The operation of plant and machinery, and the presence of workers on the site, will result in some level of disturbance to Otters using the area. Otters are predominantly nocturnal and therefore would not overlap greatly with construction activities. Otters are also quite tolerant of human disturbance and are often recorded in urban areas, so this impact is unlikely to be significant. Otter spraints were recorded within the proposed development planning boundary, but no holts were found and would not be expected within the habitats present along the river bank (Quay walls, amenity grassland, scrub over rubble substrate). No *ex situ* effects will arise
Vale of Clara (Rathdrum Wood) SAC (Site Code 000733)	Old sessile oak woods with Ilex and Blechnum in the British Isles [91A0]	No		Located at least 20km upstream of the proposed development in Arklow, there is no pathway or potential for direct or indirect effects to arise to any of the attributes that support the conservation status of this habitat
	Special Conservation Interest			
Wicklow Mountains SPA (Site Code 004040)	Merlin (Falco columbarius) [A098]	No		Located at least 30km upstream of the proposed development in Arklow, there is no pathway via which direct, indirect, or *ex situ* effects on the population trend or distribution of this bird species could arise
	Peregrine (Falco peregrinus) [A103]	No		Located at least 30km upstream of the proposed development in Arklow, there is no pathway via which direct, indirect, or *ex situ* effects on the population trend or distribution of this bird species could arise

Arising from the information provided in Table 5, three European sites are identified as having a potential to be affected by the proposed development, and therefore they are brought forward to Stage 2 Appropriate Assessment:

- Buckroney – Brittas Dunes and Fen SAC (Site Code 000729)
- Kilpatrick Sandhills SAC (Site Code 001742)
- Magharabeg Dunes SAC (Site Code 001766)

The attributes, measures and targets supporting the maintenance or restoration of favourable conservation status of dune habitats at Buckroney-Brittas Dunes and Fen SAC are listed in Appendix C, and have been taken into account in compiling the information included in Table 5.

6 Stage 2 Appropriate Assessment

6.1 Natura 2000 sites within the Zone of Influence

Annual vegetation of drift lines (1210), Perennial vegetation of stony banks 1220), and sand dune habitats have been grouped as coastal onshore habitats in Mayes and ESBI (2008). These coastal onshore habitats depend on coastal geomorphological and sediment transport processes for their formation and continued existence, and derive their 'water dependent' status, with regard to the Water Framework Directive, from these processes. For this reason, they are considered to be dependent on coastal and transitional water sources (Table 5).

The Buckroney-Brittas Dunes and Fen SAC (Site Code: 729) Conservation objectives supporting document - coastal habitats (NPWS, 2017) states that:

"the location, character and dynamic behaviour of sand dunes are governed by a combination of geographic, climatic, edaphic and anthropogenic factors. Sand dunes are highly complex, dynamic systems, where the habitats occur in a complex and constantly evolving and changing mosaic. They function as systems in terms of geomorphology and hydrology and maintaining the favourable conservation condition of the habitats present depends on allowing these processes to continue unhindered. Maintaining the favourable conservation condition of all of the sand dune habitats in Buckroney-Brittas Dunes and Fen SAC in terms of structure and functions depends on a range of attributes for which targets have been set as outlined below.

Physical structure: functionality and sediment supply

Coastlines naturally undergo a constant cycle of erosion and accretion. There are two main causes of erosion: (a) those resulting from natural causes and (b) those resulting from human interference. Natural causes include the continual tendency towards a state of equilibrium between coasts and environmental forces, climatic change (particularly an increase in the frequency of storms or a shift in storm tracks), relative sea level rise and natural changes in the sediment supply. Human interference is usually associated with changes in the sediment budget, either directly, through the removal of beach or inshore sediment, or indirectly, by impeding or altering sediment movement. It is important to recognise that the process of coastal erosion is part of a natural tendency towards equilibrium. Natural shorelines attempt to absorb the energy entering the coastal zone by redistributing sediment.

Dunes are naturally dynamic systems that require continuous supply and circulation of sand. Sediment supply is especially important in the embryonic dunes and mobile dunes, as well as the strandline communities where accumulation of organic matter in tidal litter is essential for trapping sand and initiating dune formation. The construction of physical barriers such as sea defences can interrupt longshore drift, leading to beach starvation and increased rates of erosion. Sediment circulation and erosion also has a role to play in the more stabilised dune habitats.

Cycles of erosion and stabilisation are part of a naturally functioning dune system, where the creation of new bare areas allows pioneer species and vegetation communities to develop, thus increasing biodiversity. The construction of physical barriers can interfere with the sediment circulation by cutting the dunes off from the beach resulting in fossilisation or over-stabilisation of dunes."

Attribute	**Measure**	**Target**
Physical structure: functionality and sediment supply	Presence/absence of physical barriers	Maintain the natural circulation of sediment and organic matter, without any physical obstructions

Appendix C lists all of the attributes that support the conservation status of the dune habitats identified in Table 5 and Table 6: Potential effects of the works in coastal waters on coastal processes will be considered further with regard to the attribute "Physical structure: functionality and sediment supply". With reference to Appendix C, and to Table 6, no attribute other than "Physical structure: functionality and sediment supply" has a potential to be affected by *ex situ*, indirect effects associated with the proposed development. The question that arises is whether the works within coastal habitats within the planning boundary, i.e. the upgrading of the existing revetment, and the construction of the SWO and of the long sea outfall, would impede longshore drift, or impede and alter sediment movement, to the extent of affecting the Conservation Status of these habitats at Buckroney – Brittas Dunes and Fen SAC (Site Code 000729) with regard to the attribute Physical structure: functionality and sediment supply. A further assessment is given in Section 7.

The same considerations apply to the attribute Physical structure: functionality and sediment supply of sand dune habitats listed as Qualifying Interests for Magherabeg Dunes SAC and Kilpatrick Sandhills SAC, in which the same habitats occur as Qualifying Interests (Table 6). The NPWS Site Synopses for the three coastal SACs are reproduced in **Appendix B**.

The immediate hinterland of sand dune systems often includes low-lying areas of other water dependent habitats. At Buckroney – Brittas Dunes and Fen SAC, these include the fen habitat Alkaline fen (7230) located to the west of the R750, inland and above tidal influence, and a small area of the saltmarsh habitat Mediterranean salt meadow. Annex 1 listed saltmarsh habitats (1330, 1410 and 1420) develop in sheltered areas in estuaries and to the lee of islands and other coastal barriers and spits, where muddy sediments can accumulate. They occur on the upper shore, and tend to form zones or habitat mosaics of halophytic and salt tolerant plant species in relation to the extent of tidal submergence and salinity. Mediterranean salt meadow generally occupies the upper zone of the saltmarsh, adjacent to the boundary with terrestrial habitats, with minimal inundation on spring tide high water. At Buckroney-Brittas, a small area of Mediterranean salt meadow has been described, associated with the Buckroney River (McCorry and Ryle, 2009), but has been reclassified as a fixed dune/humid dune slack mosaic by the Sand Dunes Monitoring Project (Delaney et al., 2013), as discussed in NPWS (2017). Sand dune systems may include the wetland habitats Humid dune slacks (2190), and Dunes with *Salix repens* ssp. *argentea* (*Salicion arenariae*) (2170), which occur in topographic depressions within dune systems and are mainly ground water dependent, generally with a lens of fresh water overlying more saline water.

Both of these habitats occur at Buckroney-Brittas Dunes and Fen SAC. The same question regarding the attribute Physical structure: functionality and sediment supply arises with regard to these habitats (see Table 6), and are considered in Section 7 of this report.

Table 6: Qualifying Interests of the Natura 2000 sites potentially affected by changes in coastal processes that may result from works in coastal areas within the planning boundary of the proposed development

Natura 2000 site	**Buckroney – Brittas Dunes and Fen SAC (Site Code 000729)**	**Kilpatrick Sandhills SAC (Site Code 001742)**	**Magharabeg Dunes SAC (Site Code 001766)**
Relevant Qualifying Interest * indicates a priority habitat under the Habitats Directive	Annual vegetation of drift lines [1210]	Annual vegetation of drift lines [1210]	Annual vegetation of drift lines [1210]
	Perennial vegetation of stony banks [1220]		
	Mediterranean salt meadows (Juncetalia maritimi) [1410]		
	Embryonic shifting dunes [2110]	Embryonic shifting dunes [2110]	Embryonic shifting dunes [2110]
	Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120]	Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120]	Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120]
	Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*	Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*	Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*
	Atlantic decalcified fixed dunes (Calluno-Ulicetea) [2150]*	Atlantic decalcified fixed dunes (Calluno-Ulicetea) [2150]*	Atlantic decalcified fixed dunes (Calluno-Ulicetea) [2150]*
	Dunes with Salix repens ssp. argentea (Salicion arenariae) [2170]		
	Humid dune slacks [2190]		

6.2 Habitats Directive Annex II listed species

6.2.1 Marine mammals

Habitats Directive Annex II listed marine mammals occur in coastal and marine waters off Arklow. All cetacean species (whales, dolphins and porpoises) are listed in Annex IVa of the Habitats Directive as animal species requiring strict protection in their natural range. The proposed treated effluent long sea outfall, and the SWO at the WwTP site, lie within 10km square T27 (Figure 12a). Harbour Porpoise (Common Porpoise) *Phocoena phocoena* and Bottle-nosed Dolphin *Tursiops truncatus* have been recorded in 10km square T27. Records held by the National Biodiversity Data Centre include several databases compiled by the Irish Whale and Dolphin Group: IWDG Cetacean Strandings Database, IWDG Casual Cetacean Sightings, and IWDG Ferry Survey sightings Data.

Records for coastal and offshore 10km squares to the north and south of Arklow T26, T27, T36, T37, T38, T39, T46, T47, T48 and T49 include the following additional cetacean species: Common Dolphin *Delphinus delphis*, Striped Dolphin *Stenella caeruleoalba*, Risso's Dolphin *Grampus griseus*, and Minke Whale *Balaenoptera acutorostrata*[11] .

The Harbour Porpoise *Phocoena phocoena* is the smallest cetacean species that occurs in Irish waters, and is the most frequently reported and widespread cetacean species. It occurs throughout the year in continental shelf waters, and is frequently recorded in shallow bays, estuaries and tidal channels, in waters less than 20m deep. Line transect cetacean surveys in the Irish Sea in 2011 recorded a total of 57 sightings in Block A in the northern Irish Sea (Figure 12b); 51 Harbour Porpoise sightings and six sightings of individual Minke Whales. In Block B in the southern Irish Sea (Figure 12b), 14 cetacean sightings were recorded, all Harbour Porpoise sightings. This provided sighting rates of Harbour Porpoise of 0.29 sightings per km or 5.24 sightings per hour in Block A, and 0.10 Harbour Porpoise per km or 1.91 sightings per hour in Block B (Berrow *et al*, 2011[12]). There are three marine coastal areas where high numbers of Harbour Porpoise have been recorded (Figure 13), one off Co. Dublin on the east coast, and two off the south west coast of Ireland. Three SACs include Harbour Porpoise as a Qualifying Interest: Rockabill to Dalkey Island SAC off the east coast (more than 50km to the north of Arklow), and Blasket Islands SAC and Roaringwater Bay and Islands SAC in the south west of Ireland.

[11] (Data from the Irish Whale and Dolphin Group held by the National Biodiversity Data Centre www.biodiversityireland.ie (downloaded from Biodiversity Maps on 26.04.2016 and 31 May 2018).

[12] Berrow, Simon, Joanne O'Brien, Conor Ryan, Enda McKeogh and Ian O'Connor (2011) Inshore Boat-based Surveys for Cetaceans – Irish Sea. Report to the National Parks and Wildlife Service. Irish Whale and Dolphin Group.

Figure 12a: Coastal and offshore 10km grid squares in the Arklow area. SACs are also shown in orange (refer to Figure 2).

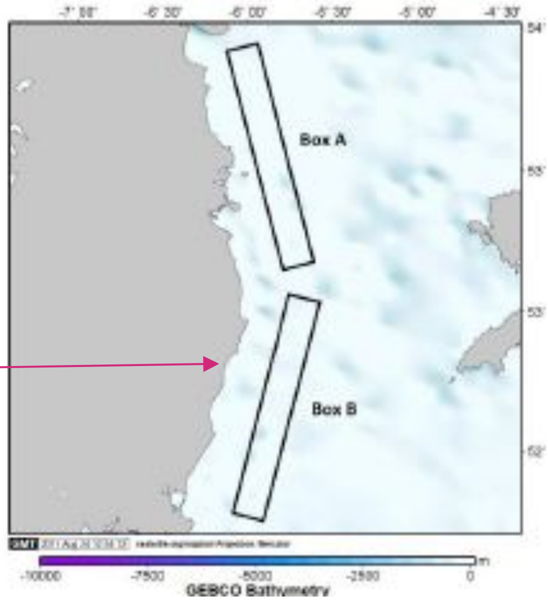


Figure 12.b: The locations of survey blocks in the Irish Sea surveyed for cetaceans in 2011. Reproduced from Berrow *et al*, 2011.

Bottle-nosed Dolphins have been seen in all Irish waters, particularly along the west coast, where three distinct populations are now recognised: the offshore, inshore and Shannon Estuary populations (see Figure 13). One of the most important resident populations in Europe is the group of 120-140 Bottle-nosed Dolphins living year round in the Shannon; the species is included as a Qualifying Interest of the Lower River Shannon SAC. Bottle-nosed Dolphin is the Qualifying Interest of West Connacht Coast SAC, in Galway and Mayo. Since 2010, the Irish Whale and Dolphin Group (IWDG) has recorded an increase in sightings along the Irish east coast extending into the North Irish Sea and Ulster coast.

Common Dolphins are the most frequently recorded dolphin species in Irish waters. They are recorded in their largest concentrations over the continental shelf and in deeper waters, but are also frequently observed in shallow inshore waters off the south and southwest coasts of Ireland and around the Aran Islands, and in the southern Irish Sea (NPWS 2013[13], Ryan et al 2010[14]).

Risso's Dolphins are fairly abundant with a world-wide distribution in tropical and temperate seas, but do not generally penetrate far into high latitudes.

[13] NPWS (2013) *The Status of EU Protected Habitats and Species in Ireland.* Species Assessments Volume 3, Version 1.0. Unpublished Report, National Parks & Wildlife Services. Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

[14] Ryan, Conor, Simon Berrow, Alessandro Pierini, Joanne O'Brien, Ian O'Connor and David McGrath (2010) *Inshore Boat-based Surveys for Cetaceans*. Report to the National Parks and Wildlife Service. Irish Whale and Dolphin Group. pp.33.

They are sighted regularly around the Irish coast, with sightings and strandings concentrated on the south-west and west coast of Ireland, with occasional sightings in the Irish Sea. Risso's Dolphins appear to prefer deep offshore waters but on occasion can be seen close inshore around the Irish coast (http://www.iwdg.ie/).

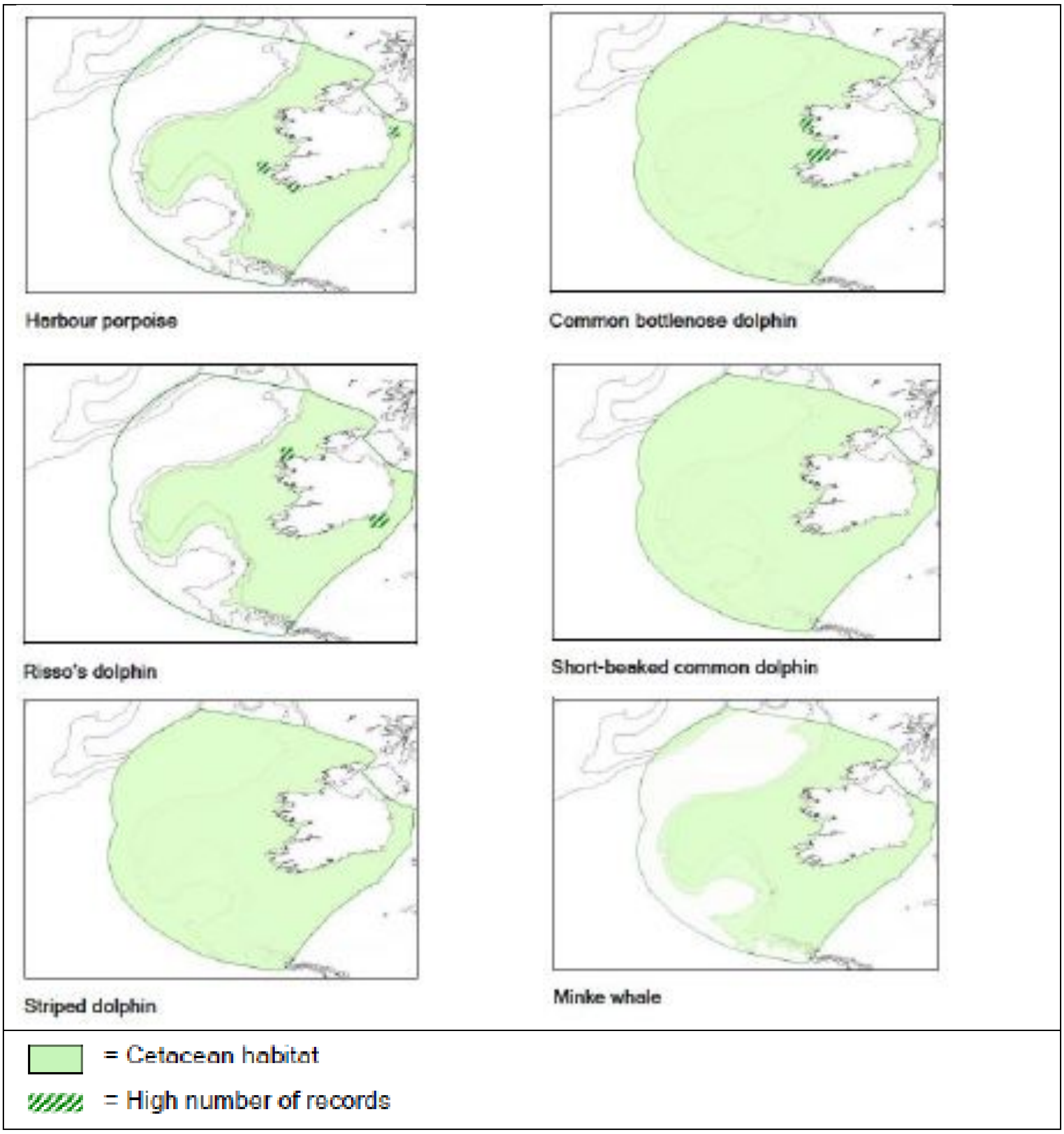


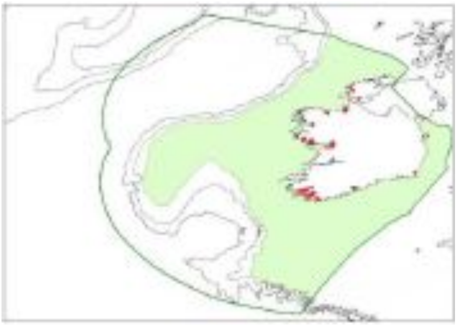
Figure 13: Generalised distribution of cetacean species that have been recorded in coastal waters in the Arklow area. Figures reproduced from Department of Arts, Heritage and the Gaeltacht (January 2014); Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters

Striped Dolphins are not common in Irish waters, occurring mainly further south in warmer waters. They are recorded annually, mainly off the south west coast of Ireland (NPWS, 2013).

Evidence from multi-annual surveillance programmes indicate that Minke Whales occur widely in Irish continental shelf and slope waters, and may do so throughout the year. They have also been recorded in the Celtic Sea and the Irish Sea (NPWS, 2013; Berrow *et al* 2011).

Information on cetacean distribution, movements and seasonal occurrence in Irish and international waters is relatively recent, and currently important concentrations of individual species have been identified in Irish waters only for Harbour Porpoise and Bottle-nosed Dolphin (Figure 13).

Grey Seal *Halichoerus grypus* and Harbour (Common) Seal *Phoca vitulina vitulina* have both been recorded in small numbers in inshore coastal waters in the Arklow area. Both species are listed in Annex II of the Habitats Directive. Important sites for these species are shown in Figure 14. Grey Seals are listed as a Qualifying Interest in ten SACs, of which two are on the east/south east coast: Lambay Island SAC, and Saltee Islands SAC. Harbour Seals are listed as a Qualifying Interest in thirteen SACs of which two are on the east/south east coast: Lambay Island SAC, and Slaney River Valley SAC. These SACs are located at distances in excess of 50km from Arklow.



Harbour Seal; generalised distribution and key breeding and non-breeding haul-out locations

Grey Seal; generalised distribution and key breeding and non-breeding haul-out locations

Figure 14: Generalised distribution and key breeding and non-breeding haul-out locations for Harbour Seal (left) and Grey Seal (right). Figures reproduced from Department of Arts, Heritage and the Gaeltacht (January 2014); Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters

There is a small Grey Seal breeding site at Wicklow Head (Ó Cadhla *et al*, 2008[15]), with seals using small beaches and caves; there are no recent published census data for this colony.

[15] Ó Cadhla, O., Keena, T., Strong, D., Duck, C. and Hiby, L. (2013) Monitoring of the breeding population of grey seals in Ireland, 2009 - 2012. Irish Wildlife Manuals, No. 74. National Parks and Wildlife Service, Department of the Arts, Heritage and the Gaeltacht, Dublin, Ireland.

Marine mammals recorded during baseline surveys

Site investigation works have been carried out in the Avoca River estuary and in Arklow Bay, to inform the proposed development. The contractor's conditions of engagement specified that a qualified Marine Mammal Observer (MMO) would be appointed to monitor for marine mammals and to log all relevant events during the intrusive ground investigations. A total of 30 MMO watches, with a total duration of 268 hours of observations, were carried out during the 30 minutes prior to, and during site investigation works[16]. No marine mammals were recorded.

There were three sightings of seals during bird surveys of coastal waters in Arklow Bay (Table 7).

Table 7: Seal records in coastal waters in Arklow Bay during baseline bird surveys

Species/ count date	24.11.16	8.12.16	28.01.17	24.02.17	29.11.17	13.02.18
Harbour Seal			1			
Grey Seal				1	5	

6.2.2 Annex 2 listed fish species

Despite the negative impacts on the Avoca River from the acid mine drainage and the release of untreated wastewater, the river and estuary continue to support a diverse fish population. Surveys of the Avoca River Estuary carried out under the WFD classed this waterbody as 'Moderate' status for the fish populations in both the 2008 and 2010 sampling periods (Kelly et al, 2009[17], Kelly et al, 2011[18]). The Avoca River Estuary was classified as 'Good' status for fish populations in 2015 (Ryan et al, 2015). The overall WFD status of the Avoca Estuary for the period 2010 to 2015 is 'Moderate' (EPA data, Site Code IE_EA_150_0100).

A number of the species recorded in the WFD Avoca River Estuary sampling are particularly notable, in that they are listed under Annex II of the Habitats Directive, namely Atlantic Salmon and River Lamprey, while the European Eel is listed as Critically Endangered. Though not recorded in the course of the IFI surveys, Sea Lamprey (*Petromyzon marinus*) are also known from the Avoca River, and are also listed under Annex II of the Habitats Directive.

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[16] Department of Arts, Heritage and the Gaeltacht (January 2014); *Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters*, implemented during site investigation works for the proposed development

[17] Kelly, F., Harrison, A., Connor, L., Wightman, G., Matson, R., Morrissey, E., O'Callaghan, R., Feeney, R., Hanna, G., Lordan, M. and Rocks, K. (2009). *Sampling Fish for the Water Framework Directive – Transitional Waters 2008. Avoca Estuary*. The Central and Regional Fisheries Boards.

[18] Kelly, F., Harrison, A., Connor, L., Matson, R., Morrissey, E., O'Callaghan, R., Feeney, R., Wögerbauer, C., Hanna, G., Gallagher, K. and Rocks, K. (2011). *Sampling Fish for the Water Framework Directive – Transitional Waters 2010.* Avoca Estuary. Inland Fisheries Ireland.

It should be noted that the estuary upstream of Arklow Bridge is described by IFI as riverine in nature, although some tidal fluctuation in water levels is evident.

The deep and slow flowing nature of the Avoca River immediately upstream, and the estuarine area within the planning boundary of the proposed development do not provide suitable spawning habitat for salmon or lamprey species, which require shallower, faster flowing water over suitable spawning gravels. The presence of lamprey ammocoetes just upstream of the M11 Bridge, suggests they may also be present downstream of the bridge. After hatching, ammocoetes inhabit silt beds for a number of years, feeding by filtering organic particles out of the water column, before transforming into an adult migrating to the river estuary or to sea (Maitland, 2003[19]). Very slow-flowing or still areas of the Avoca River may support such habitat. Such areas occur within the works area of the proposed Arklow Flood Relief Scheme, for which potential in combination effects are discussed in Section 6.3.

Salmon require passage through the estuary and lower reaches of the Avoca River and estuary to reach spawning grounds further up the system and the area may also support smolts and adults for a period of time on their way to sea or upriver, respectively. The Avoca River supports a spring and summer salmon run, with adults returning from sea, passing through the estuary and moving upstream during this period. Following hatching, salmon develop through a number of stages over the course of a number of years before undergoing physiological change (smoltification) to become smolts and be ready to go to sea. There are a range of factors that determine the exact timing of the movement of smolts to sea, including water temperature and photoperiod (McCormick *et al*., 1998[20], Byrne *et al*., 2004[21]); however, the seaward migration takes places over the spring to summer period.

Following metamorphosis to adults, River Lamprey migrate to estuaries and the sea, where they spend one to two years feeding.

[19] Maitland, P.S. (2003) Ecology of the River, Brook and Sea Lamprey. *Conserving Natura 2000 Rivers Ecology Series No. 5*. English Nature, Peterborough.

[20] McCormick, S.D., Hansen, L.P., Quinn, T.P. and Saunders, R.L (1998) Movement, migration, and smolting of Atlantic salmon (*Salmo salar*). *Canadian Journal of Fisheries and Aquatic Sciences* ***55(suppl. 1)***: 77-92.

[21] Byrne, C.J., Poole, R., Dillane, M., Rogan, G. and Whelan, K.F (2004) Temporal and environmental influences on the variation in sea trout (*Salmo trutta* L.) smolt migration in the Burrishoole system in the west of Ireland from 1971 to 2000. *Fisheries Research* **66(1)**: 85-94.

In Ireland, migration of adults back upstream for spawning takes place over a protracted period from late summer to autumn (Kelly & King, 2001[22]), while downstream movement of newly metamorphosed adults peaks in March-April (Hardisty *et al*., 1970[23]).

Sea Lamprey migrate into rivers for spawning in spring (Maitland, 2003), while the seaward movement of newly metamorphosed adults takes place in autumn and into winter (Kelly & King, 2001).

Annex II listed fish species Atlantic Salmon, River Lamprey, and Sea Lamprey occur in the Avoca River catchment and Estuary, but are not listed as Qualifying Interests in upstream European sites, the Wicklow Mountains SAC (Site Code 002122), and the Vale of Clara (Rathdrum Wood) SAC (Site Code 000733) (see Table 5).

[22] Kelly, F.L. and King, J.J. (2001) A review of the ecology and distribution of three lamprey species, *Lampetra fluviatilis* (L.), *Lampetra planeri* (Bloch) and *Petromyzon marinus* (L.): a context for conservation and biodiversity considerations in Ireland. *Biology and Environment: Proceedings of the Royal Irish Academy* **101B(3)**: 165 – 185.

[23] Hardisty, M.W., Potter, I.C. and Sturge, R. (1970) A comparison of the metamorphosing and macroph-thalmia stages of the lampreys, *Lampetra fluviatilis* and *Lampetra planeri*. *Journal of Zoology (London)* **162**: 383–400.

7 Potential Effects on Natura 2000 Sites

7.1 Potential effects of the proposed development on Natura 2000 sites

The question that arises is whether the works within coastal areas within the planning boundary, as shown in **Drawing No.'s 247825-00-M-R-1002** and **247825-00-M-0-1001** in **Appendix A**), i.e. the upgrading of the existing revetment, and the construction of the long sea outfall and SWO at the WwTP, would impede longshore drift, or impede and alter sediment movement, to the extent of affecting the Conservation Status of the Qualifying Interests listed in Table 6 (copied below for reference) for the three coastal SACs that are located at least 4km distant from the proposed development, with regard to the single relevant attribute Physical structure: functionality and sediment supply.

Table 6: Qualifying Interests of the Natura 2000 sites potentially affected by changes in coastal processes that may result from works in coastal areas within the planning boundary of the proposed development

Natura 2000 site	**Buckroney – Brittas Dunes and Fen SAC (Site Code 000729)**	**Kilpatrick Sandhills SAC (Site Code 001742)**	**Magharabeg Dunes SAC (Site Code 001766)**
Relevant Qualifying Interest * indicates a priority habitat under the Habitats Directive	Annual vegetation of drift lines [1210]	Annual vegetation of drift lines [1210]	Annual vegetation of drift lines [1210]
	Perennial vegetation of stony banks [1220]		
	Mediterranean salt meadows (Juncetalia maritimi) [1410]		
	Embryonic shifting dunes [2110]	Embryonic shifting dunes [2110]	Embryonic shifting dunes [2110]
	Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120]	Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120]	Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120]
	Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*	Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*	Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*
	Atlantic decalcified fixed dunes (Calluno-Ulicetea) [2150]*	Atlantic decalcified fixed dunes (Calluno-Ulicetea) [2150]*	Atlantic decalcified fixed dunes (Calluno-Ulicetea) [2150]*
	Dunes with Salix repens ssp. argentea (Salicion arenariae) [2170]		
	Humid dune slacks [2190]		

A desktop assessment of the coastal areas where a change of orientation or a physical barrier such as a headland exist has been carried out and is included in Appendix E, Section 5, see Figure 13. These uniform units suggest limited exchange of sediment between them. The uniform units identified in the vicinity of the area of study of coastal processes are as follows:

- Kilmichael Point to Mizen Head; and
- Mizen Head to Wicklow Head.

Each uniform unit incorporates smaller sub-physiographic units, also defined by changes in coastline orientation and local headland features, which also have the effect of limiting sediment exchange between adjoining units. In effect, because the direction of longshore drift along the Wexford and Wicklow coasts is from South to North, uniform units and their constituent physiographic sub-units along sandy shores tend towards sediment starvation and erosion at their southern end, and towards sediment accretion at their northern end. This effect is noted in the Buckroney-Brittas Dunes and Fen SAC (site code: 000729) Conservation Objectives supporting document - Coastal habitats (NPWS 2017).

A smaller sub-pysiographic unit is identified within the Kilmichael Point to Mizen Head uniform unit, in the stretch of coastline that is limited to the South by the breakwaters and piers which guard the entrance to Arklow Harbour, and to the North by the headland at Seabank, located at the North end of the Arklow North Beach. The extent and features of this sub-physiographic unit are shown in Appendix E Section 5, Figure 14. This sub-physiographic unit is referred to in Appendix E as the area of interest, and is defined by the coastline orientation and its physical boundaries which limit the coastal processes within this area, and limit sediment exchange with adjoining sub-physiographic units. For clarity, this feature is referred to as the Arklow North sub-physiographic area of interest in this NIS.

7.1.1 Coastal processes affected by the upgraded revetment

7.1.1.1 Construction phase

The existing 2.2km shoreline revetment starts at the northern pier at the harbour mouth and continues in a northerly direction, and then in a north-easterly direction as far as Arklow North Beach. The section of the revetment that is proposed to be upgraded is located near the existing revetment's southern end, immediately adjacent to the WwTP site. The extent of the proposed upgrade revetment is approximately 350m, and is described in detail in Section 4 (see Figure 10 and Appendix A) and Appendix E of this Report. Construction along the existing revetment will involve excavation in coastal waters along the toe of the existing revetment and removal of existing rock armour, and is expected to mobilise sand and silt. Mobilised sand and silt is expected to be naturally deposited within the Arklow North sub-physiographic area of interest, and generally limited by both the harbour entrance at the south and the natural headland at the northern end of the Arklow North sub-physiographic area of interest at Seabank (Appendix E, Section 5.4.1.1).

Excavated sediment obtained during excavation of the existing seabed in front of the existing revetment may either be reinstated at the toe location or disposed of at a suitably licensed facility off-site.

It is noted that elevated concentrations of metals and other contaminants are present in the general area, and are likely to be associated with sediments from the Avoca mines which were washed down to the estuary of the Avoca River (EIAR Chapter 14, Land and Soils). This is consistent with the findings of the estuarine and marine benthic ecology surveys, which recorded existing depauperate benthic communities.

It is not expected that the Conservation Status of Qualifying Interests of Kilpatrick Sandhills SAC (Site Code 001742) will be affected by the dispersion of mobilised sand and silt, because the direction of longshore drift is from South to North, and this SAC is located more than 6km South of the revetment upgrade works. In addition, the sand dune habitats for which this SAC is listed are located to the South of Kilmichael Point, i.e. South of and outside the Kilmichael Point to Mizen head uniform unit identified in Appendix E. Effects on the Conservation Objectives of this SAC are assessed as neutral (i.e. no effects or effects that are imperceptible, within normal bounds of variation or within the margin of forecasting error (EPA, 2017).

Buckroney – Brittas Dunes and Fen SAC (Site Code 000729) lies more than 4km to the north at its closest point. Mizen Head lies within this SAC, and is the boundary between the adjoining uniform units Kilmichael Point to Mizen Head and Mizen Head to Wicklow Head, referred to in Section 6.1 and in Appendix E. Pennycomequick Dunes and Buckroney Dunes, included in the SAC, lie to the South of Mizen Head, while Brittas Dunes lie to the North of Mizen Head. Appendix E Section 5.4.1.2 assesses the likely effect of dispersing material as not significant in relation to coastal processes in the northern part of the Kilmichael Point to Mizen Head uniform unit during construction of the revetment upgrade.

In this regard, it is noted that the Buckroney-Brittas Dunes and Fen SAC (Site Code: 000729) Conservation objectives supporting document - Coastal habitats (NPWS 2017) Appendix 3, describing Brittas Bay dunes, assesses the impacts of existing coastal protection (Impact Code J02.12.01) outside the SAC site as neutral. No assessment of the impacts of existing coastal protection outside the SAC is available currently for the dune systems at Buckroney and at Pennycomequick, located to the South of Mizen Head. The existing revetment at Arklow is the only coastal protection located outside the SAC and within the Kilmichael Point to Mizen Head uniform unit.

Ecologically, the likely effects of the construction of the revetment upgrade on

- Buckroney – Brittas Dunes and Fen SAC (site code: 000729), and
- Magharabeg Dunes SAC (Site Code 001766)

are assessed as neutral, with regard to the Conservation Objectives of both Buckroney – Brittas Dunes and Fen SAC (site code: 000729), and of Magharabeg Dunes SAC (Site Code 001766) which is located to the North of Mizen Head in a more northerly uniform unit (Mizen Head to Wicklow Head), because mobilised sand and silt is expected to be naturally deposited within the Arklow North sub-physiographic area of interest, and generally limited by both the harbour entrance at the south and the natural headland at the north at Seabank.

7.1.1.2 Operational phase

The upgraded revetment, being parallel to the coastline, would not impose a barrier to sediment movement, or an obstruction to any longshore sediment transportation. No change in sediment transport within the normal bounds of variation is expected with the upgraded revetment in place from that which exists currently. The assessment provided in Section 7.1.1.1 therefore applies during the operational phase. Ecologically, the likely effect of the revetment upgrade during the operational phase on

- Kilpatrick Sandhills SAC (Site Code 001742) located to the South of Arklow, is assessed as neutral, with regard to the Conservation Objectives for this European site;
- Buckroney – Brittas Dunes and Fen SAC (site code: 000729) located to the North of Arklow, is assessed as neutral, with regard to the Conservation Objectives for this European site; and on
- Magharabeg Dunes SAC (Site Code 001766) which is located to the North of Mizen Head in a more northerly uniform unit (Mizen Head to Wicklow Head), is assessed as neutral, with regard to the Conservation Objectives for this European site.

7.1.2 Coastal processes affected by the SWO at the WwTP

7.1.2.1 Construction phase and Operational phase

A temporary sheetpile cofferdam would be constructed within the existing revetment to facilitate the excavation and construction of the SWO (**Drawing No.'s 247825-00-M-O-1001, 247825-00-M-O-2001** and **247825-00-M-O-2101** in **Appendix A)**. The SWO would terminate and discharge at the coastal edge of the upgraded revetment. A precast concrete culvert would be constructed over the SWO through the revetment to protect the pipeline in this location. Appropriate scour protection will also be provided at the discharge point. Since these works will take place within a cofferdam within the existing revetment, no impacts on coastal processes are envisaged, either within the Arklow North sub-physiographic area of interest, or within the Kilmichael Point to Mizen Head uniform unit.

Ecologically, the likely effect of the SWO during the construction phase and the operational phase on:

- Kilpatrick Sandhills SAC (Site Code 001742) located to the South of Arklow, is assessed as neutral, with regard to the Conservation Objectives for this European site;
- Buckroney – Brittas Dunes and Fen SAC (site code: 000729) located to the North of Arklow, is assessed as neutral, with regard to the Conservation Objectives for this European site; and on

- Magharabeg Dunes SAC (Site Code 001766) which is located to the North of Mizen Head in a more northerly uniform unit (Mizen Head to Wicklow Head), is assessed as neutral, with regard to the Conservation Objectives for this European site.

7.1.3 Coastal processes affected by the long sea outfall

As described in Section 4 and Appendix E of this report, there are several methods by which the long sea outfall can be constructed and the contractor's methodology would ultimately depend on their available plant and equipment as well as their previous experience with laying marine outfalls. The contractor would be responsible for determining which method is most appropriate, as described in Section 4.4.2.

The likely methods that can be undertaken to construct the long sea outfall, based on current practice and site restraints/characteristics, are:

- Horizontal directional drilling method;
- Flood and float method; and
- Bottom-pull method.

The Horizontal directional drilling method of construction of the long sea outfall would be carried out by the use of a drilling rig located in either the WwTP site or on a barge or jack-up platform near the seaward end of the outfall. The float and flood method, and the bottom-pull method, both require open cut construction, i.e. a trench is excavated in the sea bed, into which the outfall is placed.

Diffuser assembly

As described in Section 4.4.5.4, once the long sea outfall has been laid, by whichever method (HDD, float and flood or bottom-pull), the diffuser would be assembled on the seaward end of the outfall. The diffuser arrangement is likely to include up to 6 diffusers of approximately 0.16m diameter at a spacing of c. 10m intervals (see **Drawing No. 247825-00-M-O-4001** in **Appendix A)**.

The diffuser would be prefabricated on land and placed on the seabed by barge as one complete unit. The exact procedure and depths of backfill required would depend on the equipment available from the contractor along with programme and cost considerations, however it is anticipated that this would be undertaken from the barges and it will likely require open excavation of the seabed, along the length of the diffusers.

The extent of excavation would be approximately 60m long and 6m wide, in a water depth of approximately 11m. The likely indirect effects of the diffuser assembly during the construction phase on:

- Kilpatrick Sandhills SAC (Site Code 001742)
- Buckroney – Brittas Dunes and Fen SAC (site code: 000729), and
- Magharabeg Dunes SAC (Site Code 001766),

are assessed as neutral, because of the small scale of the works involved. Following the precautionary principle, mitigation is provided to ensure this outcome. No direct effects arise.

7.1.3.1 Coastal processes associated with the horizontal directional drilling method of construction of the long sea outfall : Construction phase and Operational phase

The horizontal directional drilling method of construction of the long sea outfall would be carried out by the use of a drilling rig located in either the WwTP site or on a barge or jack-up platform near the seaward end of the outfall. The likely significant effects associated with the horizontal directional drilling method would not involve any change in the seabed geometry during construction or operation, as illustrated in Figure 6, therefore this method is not considered to result in any potential to cause significant effects on coastal processes.

Ecologically, because the long sea outfall is drilled below the sea bed as shown in Figure 6, the likely effect of the horizontal directional drilling method during the construction phase is assessed as neutral, with regard to the Conservation Objectives of Kilpatrick Sandhills SAC (Site Code 001742) located to the South of Arklow. To the North of Arklow, the likely effect of the construction phase of the long sea outfall is assessed as neutral, with regard to the Conservation Objectives of both Buckroney – Brittas Dunes and Fen SAC (site code: 000729), and Magharabeg Dunes SAC (Site Code 001766) which is located to the North of Mizen Head.

No residual effects of construction on coastal processes arise from the horizontal directional drilling method during the operational phase, thus operational phase effects are assessed as neutral, with regard to the Conservation Objectives of Kilpatrick Sandhills SAC (Site Code 001742) located to the South of Arklow. To the North of Arklow, the likely effect of the operational phase of the long sea outfall is assessed as neutral, with regard to the Conservation Objectives of both Buckroney – Brittas Dunes and Fen SAC (site code: 000729), and Magharabeg Dunes SAC (Site Code 001766) which is located to the North of Mizen Head.

7.1.3.2 Coastal processes associated with the float and flood method, and the bottom-pull method: Construction phase

It is estimated that approximately 18,000 m^3 of sea bed material would be excavated to form a trench into which the long sea outfall would be laid (**Drawing No.'s 247825-00-M-O-3001** and **247825-00-M-O-3101** in **Appendix A**). Appendix E Section 5.6.2.1 details the factors taken into account in consideration of the likely significant effects on coastal processes arising as a result of the open cut construction of the long sea outfall (i.e. construction by means of the float and flood method or the bottom-pull method which requires a trench to be excavated).

The Coastal Processes Assessment Report (Appendix E, Section 5.6.2.1), considers that the construction of the outfall pipeline could result in an increased rate of sediment dispersion, with the dredged sediments being completely moved from their original position near the trench. Local currents could suspend the limited volume of sands causing its dispersion by waves and currents. This could have an effect on coastal processes, and in turn on sensitive ecological receptors, such as marine species and European sites, and notes that there are a number of factors which will reduce the significance of effect in this regard.

Since the long sea outfall will be approximately 900m long (from the shore), approximately 50% of the excavated trench length will be within the Arklow North sub-physiographic area of interest (Appendix E Figure 14), and approximately 50% of the excavated trench length will be within the wider area of the Kilmichael Point to Mizen Head uniform unit (Appendix E Figure 13). Appendix E, Section 5.6.2.1 assesses local sediment movement as not significant in relation to coastal processes, within the Arklow North sub-physiographic area of interest, and outside the the Arklow North sub-physiographic area of interest (i.e. within the wider area of the Kilmichael Point to Mizen Head uniform unit), during construction.

Based on the considerations summarised above, and detailed in Appendix E, ecologically, the potential effect of the float and flood method, and the bottom-pull method during the construction phase is assessed as neutral, with regard to the Conservation Objectives of Kilpatrick Sandhills SAC (Site Code 001742) located to the South of Arklow. To the North of Arklow, the likely effect of the float and flood method, and the bottom-pull method during the construction phase is assessed as neutral, with regard to the Conservation Objectives of both Buckroney – Brittas Dunes and Fen SAC (site code: 000729), and Magharabeg Dunes SAC (Site Code 001766) which is located c. 15km to the North of the proposed development in the Mizen Head to Wicklow Head uniform unit (Appendix E Figure 13).

This ecological assessment of potential neutral effects is made in the context of the normal bounds of variation that operate currently (EPA, 2017, Table 3.3). These would include gales and storm conditions originating from the North East to South East, due to the orientation of the coastline at and near the study area, and during which large volumes of marine and coastal sediments can be mobilised. Arising from this, however, there is a potential for the construction phase of the long sea outfall to interact with a strong gale, storm or extreme weather event. If such an event were to occur during construction, an element of uncertainty arises with regard to the likely extent, significance and duration of potential impacts on the Conservation Objectives of Buckroney – Brittas Dunes and Fen SAC (site code: 000729). The marine environment is dynamic and there is a continuous process of sedimentation/deposition which naturally occurs, in which context the volumes of excavated material from the long sea outfall trench is relatively small. Existing and emerging baseline trends include coastal erosion (Irish Coastal Protection Strategy Study (2010[24]).

[24] Irish Coastal Protection Strategy Study (2010) Phase 2 - South East Coast

Applying the precautionary principle, potential effects on the Conservation Objectives of Buckroney – Brittas Dunes and Fen SAC (site code: 000729) could be slight or moderate temporary adverse, because of the location of Pennycomequick dunes and Buckroney dunes (see Appendix C) within the Kilmichael Point to Mizen Head uniform unit, within which adverse effects on existing coastal processes could have a potential to occur during construction in the event of the construction phase of the long sea outfall interacting with a strong gale, storm or extreme weather event, in the absence of mitigation applied in accordance with the precautionary principle.

7.1.3.3 Coastal processes associated with the Flood and float method, and the Bottom-pull method: Operational phase

The c. 900m long sea outfall pipe will require scour protection measures to protect the pipe during the operational phase (**Drawing No. 247825-00-M-O-3101** in **Appendix A**). The scour protection will be placed during the construction phase and would be likely to consist of a 300mm thick concrete mattress that would be 6m wide, and designed to match the seabed level. This scour protection will be sized so it is stable and prevents any scour of the seabed against wave action nearshore, and currents.

The scour protection will be designed to match the seabed level to avoid the creation of a sediment transport barrier. The scour protection will also stabilise and prevent the movement of seabed material in the local area of the outfall.

In the event that seabed levels in the area close to the scour protection reduce, the concrete mattresses would accommodate to the new geometry. It is important to note that the outfall and associated scour protection will be designed against this outcome, but it is assessed as a reasonable worst case scenario. This potential lowering of the seabed will not impose a barrier to sediment transport, based on the considerations given in Appendix E Section 5.6.3.1. Thus, the likely effect of the outfall is considered to be not significant in relation to coastal processes within the Arklow North sub-physiographic area of interest, and within the wider area of the Kilmichael Point to Mizen Head uniform unit, during the operation of the proposed development.

Ecologically, the hard substrate associated with the scour protection concrete mattress proposed to be designed to match existing sea bed level would have a potential to be colonised by marine organisms. Colonisation of the scour protection would be by a range of subtidal marine algae and sessile animals, such as kelps and other seaweeds, molluscs such as mussels, crustaceans such as barnacles, bryozoa and sponges, as well as mobile invertebrates. The colonisation would begin as soon as the scour protection is in place, with a succession of species taking advantage of the unoccupied surface until it reaches an equilibrium over a number of years. The scour protection and the associated algae and sessile species would also provide cover and foraging for larger mobile species such as fish, crabs and lobsters. The scour protection would thus be likely to result in the creation of a linear artificial reef. This could be c. 6m wide and c. 900m long.

Taking the above considerations into account, the likely effect of the float and flood method, and the bottom-pull method during the operational phase is assessed as neutral, with regard to the Conservation Objectives of Kilpatrick Sandhills SAC (Site Code 001742) located to the South of Arklow.

To the North of Arklow, the likely effect of the float and flood method, and the bottom-pull method during the operational phase is assessed as neutral, with regard to the Conservation Objectives of Buckroney – Brittas Dunes and Fen SAC (site code: 000729), with regard to the relevant attribute Physical structure: functionality and sediment supply, for which the target is to maintain the natural circulation of sediment and organic matter throughout the entire dune system, without any physical obstructions.

Further north, within the Mizen Head to Wicklow Head uniform unit, the likely effect of the float and flood method, and the bottom-pull method during the operational phase is assessed as neutral, with regard to the Conservation Objectives of Magharabeg Dunes SAC (Site Code 001766).

7.2 Potential in combination and cumulative effects on European sites

The proposed Arklow Flood Relief Scheme design is being developed currently by the OPW and hydrological investigations are in progress to inform the final design. This is the only project that has been identified as having a potential to give rise to in combination effects.

The proposed Arklow Flood Relief Scheme will likely comprise the construction of direct flood defences, including flood defence walls, embankments and gates within Arklow town to improve resilience to flooding, as well as conveyance improvements in the Avoca River:

- Arklow Bridge would be underpinned (at the bridge piers and abutments) and re-pointed to improve structural integrity and the floor of the bridge would be lowered by one metre;
- Scour protection would be provided at Arklow Bridge to prevent any impacts on the riverbed due to the force of water;
- The downstream river channel would be widened by the slipway on South Quay to improve sediment transport and reduce the need for maintenance dredging;
- Dredging of the river channel would be undertaken upstream and downstream of Arklow Bridge to improve conveyance in the river channel;
- Construction of a debris trap in an accessible location upstream of Arklow Bridge to reduce the risk of blockage of the bridge during flood events; and
- Construction of a gravel trap in an accessible location upstream of Arklow Bridge to reduce the requirement for maintenance dredging.

As currently envisaged, dredging will take place within the estuary (Transitional waterbody) in Arklow, both upstream and downstream of Arklow Bridge, and may extend into the Surface waters of the Avoca River also. The debris trap and gravel trap are likely to be constructed in the Avoca River, subject to the final design details. It is not envisaged that any works would be proposed in coastal waters.

With reference to Table 5 of this report, Otter *Lutra lutra* is listed as a Qualifying Interest for Wicklow Mountains SAC (Site Code 002122). Otters will utilise freshwater habitats from estuary to headwaters. No aquatic habitat severance will arise to Otters moving between the upper Avoca River catchment and coastal waters, since water will continue to flow through the river and estuary during construction works undertaken for the proposed development, and approximately 83% of the width of the river estuary will remain unobstructed at the narrowest point during construction. The operation of plant and machinery, and the presence of workers on the site, will result in some level of disturbance to Otters using the area. Otters are predominantly nocturnal and therefore would not overlap greatly with construction activities. Otters are also quite tolerant of human disturbance and are often recorded in urban areas, so this impact is unlikely to be significant.

No *ex situ* effects are expected to arise, therefore likely cumulative effects on Otter from the carrying out of the proposed development in combination with the proposed Arklow Flood Relief Scheme (even if they are carried out concurrently) are assessed as neutral.

On the basis of the information currently available, it is not considered likely that the proposed Arklow Flood Relief Scheme would interact with the proposed development as regards potential impacts on European sites:

- Buckroney – Brittas Dunes and Fen SAC (Site Code 000729)
- Kilpatrick Sandhills SAC (Site Code 001742)
- Magharabeg Dunes SAC (Site Code 001766).

Potential cumulative effects are therefore assessed as neutral.

Habitats Directive Annex II listed fish species Atlantic Salmon *Salmo salar,* River Lamprey *Lampetra fluviatilis*, and Sea Lamprey (*Petromyzon marinus*) occur in the Avoca River catchment and estuary. The estuary area has been highly modified by human activity through the construction of estuarine retaining walls, harbour breakwaters, and a stretch of coastal rock armour revetment, with the river impacted by acid mine drainage from the Avoca Mines upstream and the estuary also influenced by the input of untreated wastewater. While the estuarine habitats of the study area are of depressed species richness and low ecological value, the estuary does continue to support a fish community and provides a corridor for fish including the following Habitats Directive Annex II listed species: Atlantic Salmon *Salmo salar,* River Lamprey *Lampetra fluviatilis*, and Sea Lamprey (*Petromyzon marinus*). Since these species are not listed as Qualifying Interests for any upstream Natura 2000 sites, no cumulative *ex situ* effects arise.

However, with reference to the Opinion of Advocate General Kokott of 7 August 2018, mitigation measures to protect water quality and fish species in estuarine and river waters during construction, for the protection of these and other typical species, will be required for each project. Mitigation measures for aquatic biodiversity including fish area included in Chapter 11 of the EIAR.

Habitats Directive Annex IV listed bat species have been recorded within the proposed development and the proposed FRS combined works areas, and individual Bat Derogation Licences will be required for each project in respect of works at Arklow Bridge. A Derogation Licence No. DER/BAT 2018 – 73 has been issued in respect of the proposed Arklow WwTP development.

8 Assessment conclusion

Arising from the considerations detailed in Sections 7.1.3.2, it is concluded that it is necessary to proceed to Stage 2 of the Appropriate Assessment process in respect of the float and flood method, and the bottom-pull method, either of which may be used to construct the long sea outfall element of the proposed development, in order to consider mitigation measures that arise, following the precautionary principle, for the European site Buckroney – Brittas Dunes and Fen SAC (site code: 000729). Mitigation arises with regard to the single relevant attribute that can modified by *ex situ* as well as *in situ* effects, that supports the maintenance or restoration of favourable conservation status of the following habitats listed as Qualifying Interests for Buckroney-Brittas Dunes and Fen SAC:

- Annual vegetation of drift lines [1210]
- Perennial vegetation of stony banks [1220]
- Mediterranean salt meadows (Juncetalia maritimi) [1410]
- Embryonic shifting dunes [2110]
- Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120]
- Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*
- Atlantic decalcified fixed dunes (Calluno-Ulicetea) [2150]*
- Dunes with Salix repens ssp. argentea (Salicion arenariae) [2170]
- Humid dune slacks [2190],

for which the following attribute can modified by *ex situ* as well as *in situ* effects:

Attribute	**Measure**	**Target**
Physical structure: functionality and sediment supply	Presence/absence of physical barriers	Maintain the natural circulation of sediment and organic matter, without any physical obstructions

9 Mitigation

9.1 Mitigation measures identified in respect of the long sea outfall, Construction Phase

The following mitigation measure has been identified for the float and flood and the bottom-pull methods of construction of the long sea outfall in Appendix E Section 5.6.4:

- Construction of the long sea outfall will generally be restricted to the period May to September, with the period between November-February generally avoided. In this manner, the months with likely worst wave and wind conditions, which lead to higher levels of sediment suspension and transport, are avoided.

Following the precautionary principle, the installation of the diffuser, required for all methods of construction of the long sea outfall, will be scheduled to be carried out by the contractor during a period of calm weather. The contractor will have regard to weather forecasting, wave and tidal conditions.

9.2 Marine mammals

The lack of observations of marine mammals by MMO during site investigation works indicates that risk is low, and arises with regard to the noise generating activities associated with particular works that are part of the proposed development. The Arklow area is not identified as a sensitive area for marine mammals, and the Arklow coastal area is not known to be used by important concentrations of marine mammals. However, since marine mammals do occur in the area, it is not possible to rule out a risk of injury or a disturbance/behavioural response to protected marine mammals.

The Contractor's Standard Management Conditions will include a requirement to consider alternative construction methodologies during the Contractor Detailed Design Phase, including confirmation of the sound generation characteristics (in air and in water) of all methodologies and all the equipment (see Appendix D.1) intended to be used in coastal and marine environments (i.e. in all areas east of Arklow Harbour at South Quay). The contractor will apply all of the appropriate risk minimisation measures to manage the risk to marine mammals from man-made sound sources in Irish waters. These risk minimisation measures include the following list of measures (listed on page 18 of the Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters (NPWS 2014).

The contractor will apply the following list of measures (listed on page 18 of the Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters):

A6.1. Minimise the duration over which the sound-producing activity is intended to take place;

A6.2. Minimise the individual and cumulative sound pressure and exposure levels delivered into the environment by the activity. If necessary the use of alternative, lower impact equipment and methods could be explored (e.g., vibratory hammer, gravity base piles).

A6.3. Incorporate the use of clear “ramp-up” (i.e., “soft-start”) procedures, whereby sound energy input to the marine environment is gradually or incrementally increased from levels unlikely to cause significant behavioural impact on marine mammals to the full output necessary for completion of the activity.

A6.4. Incorporate the use of fully enclosing or confined bubble curtains, encircling absorptive barriers (e.g., isolation casings, cofferdams) or other demonstrably effective noise reduction methods at the immediate works site, in order to reduce underwater sound propagation from on-site operations. Studies have shown that such methods can provide a significant reduction in sound input to the wider aquatic environment in the order of 10-30 dB.

A6.5. Use trained and experienced marine mammal observers (MMOs) to provide effective means of detecting marine mammals in the vicinity of coastal and marine works. Associated operational considerations must also be taken into account (see section 4.2 of the Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters).

10 Conclusions and Natura Impact Statement

This Natura Impact Statement has been prepared to consider the mitigation measures that have been included, following the precautionary principle, for the European site Buckroney – Brittas Dunes and Fen SAC (site code: 000729), with regard to a single attribute supporting the maintenance or restoration of favourable conservation status of the following habitats listed as Qualifying Interests for Buckroney-Brittas Dunes and Fen SAC:

- Annual vegetation of drift lines [1210]
- Perennial vegetation of stony banks [1220]
- Mediterranean salt meadows (Juncetalia maritimi) [1410]
- Embryonic shifting dunes [2110]
- Shifting dunes along the shoreline with Ammophila arenaria (white dunes) [2120]
- Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]*
- Atlantic decalcified fixed dunes (Calluno-Ulicetea) [2150]*
- Dunes with Salix repens ssp. argentea (Salicion arenariae) [2170]
- Humid dune slacks [2190],

for which the following attribute can modified by *ex situ* as well as *in situ* effects:

Attribute	**Measure**	**Target**
Physical structure: functionality and sediment supply	Presence/absence of physical barriers	Maintain the natural circulation of sediment and organic matter, without any physical obstructions

With the implementation of mitigation measures included in Section 9.1 and 9.2, the proposed Arklow WwTP development will not result in direct, indirect or cumulative impacts on the European site Buckroney – Brittas Dunes and Fen SAC (site code: 000729), in respect of the Qualifying Interests listed above.

As noted in Table 5, the Qualifying Interest for Buckroney – Brittas Dunes and Fen SAC Alkaline fens [7230], does not have a potential to be adversely affected by the proposed development.

Arising from the considerations included in Section 7.1, the following European sites can be excluded from the Zone of Influence of the proposed development, and no impacts direct, indirect or cumulative will arise on:

- Kilpatrick Sandhills SAC (Site Code 001742)
- Magharabeg Dunes SAC (Site Code 001766).

With the implementation of mitigation measures included in Section 9.2, the proposed Arklow WwTP development will not have direct, indirect, or cumulative effects on cetaceans.

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Appendix A

Relevant scheme drawings

NOTES:

1. ALL DIMENSIONS IN M UNLESS OTHERWISE NOTED.
2. ALL LEVELS IN METRES RELATIVE TO ORDNANCE DATUM MALIN.
3. A MARKER BUOY CONSISTING OF A YELLOW CAN SHAPED LIGHTED BUOY, EXHIBITING A FL.Y.2.5S LIGHT (OR AS REQUIRED) SHALL BE INSTALLED TO MARK THE LOCATION OF THE OUTFALL.
4. ANCHORING OF THE BUOY SHALL BE SEPARATE FROM THE OUTFALL STRUCTURE AND LOCATED AT AN APPROPRIATE DISTANCE BEYOND THE END OF THE OUTFALL, SUCH THAT IT HAS NO IMPACT ON THE OUTFALL STRUCTURE

LEGEND

- PROPOSED PLANNING BOUNDARY
- PROPOSED FINAL WWTP SITE BOUNDARY
- PROPOSED OUTFALL \ STORMWATER OUTLET

OSi Sheet numbers:
4428-A, 4428-07, 4428-11, 4428-12, 4428-16 & 4428-17

P1	03/09/18	TD	AC	EMcA
Issue	Date	By	Chkd	Appd

Client: UISCE ÉIREANN : IRISH WATER

Job Title: ARKLOW WASTWATER TREATMENT PLANT PROJECT

Scale at A1: 1:2000

Discipline: Infrastructure

ARUP BYRNELOOBY

CLANCY MOORE ARCHITECTS

Drawing Title: ARKLOW WwTP OUTFALLS - PROPOSED CONTIGUOUS LAYOUT PLAN

Drawing Status: **PLANNING**

Job No	Drawing No	Issue
247825-00	**M-O-1001**	**P1**

Do not scale

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OSi Sheet numbers:
4428-A, 4428-07, 4428-11, 4428-12, 4428-16 & 4428-17

P1	03/09/18	TD	AC	EMcA
Issue	Date	By	Chkd	Appd

Client

Job Title
ARKLOW WASTEWATER TREATMENT PLANT PROJECT

Scale at A1 1:125

Discipline Infrastructure

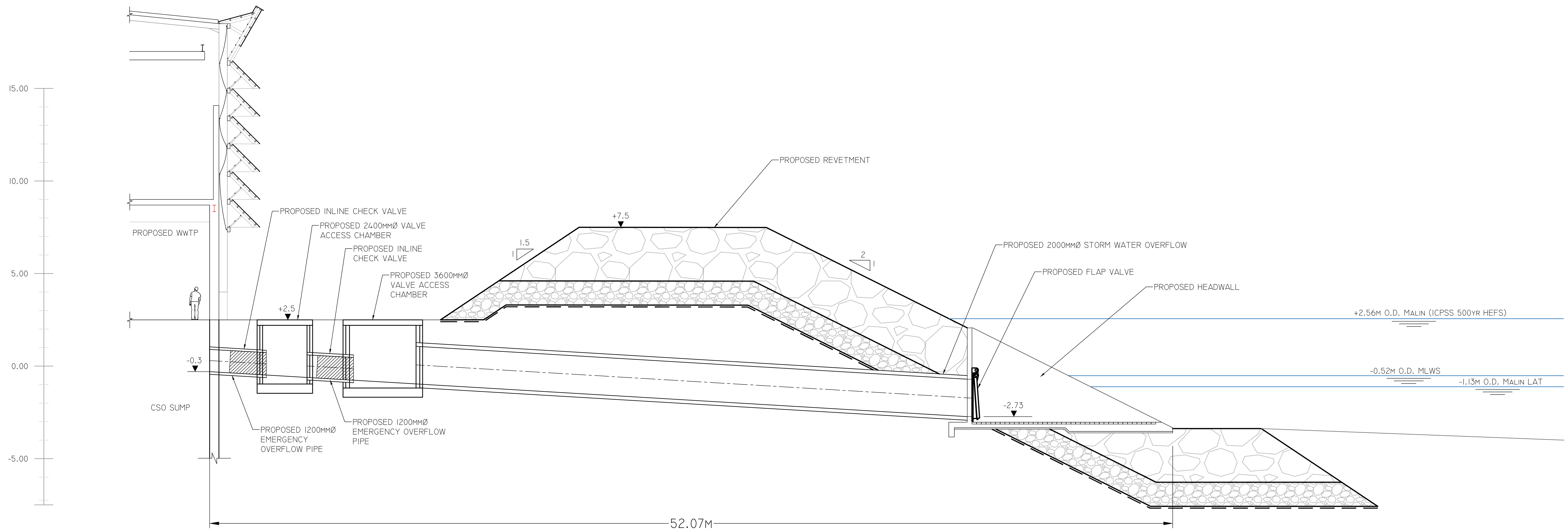
CLANCY MOORE ARCHITECTS

Drawing Title
ARKLOW WwTP - STORM WATER OVERFLOW (SWO) AT WwTP SITE PLAN

Drawing Status
PLANNING

Job No	Drawing No	Issue
247825-00	M-O-2001	P1

Do not scale



P1	03/09/18	TD	AC	EMcA
Issue	Date	By	Chkd	Appd

Client: UISCE ÉIREANN : IRISH WATER

Job Title
ARKLOW WASTEWATER TREATMENT PLANT PROJECT

Scale at A1: 1:125
Discipline: Infrastructure

ARUP BYRNELOOBY
CLANCY MOORE ARCHITECTS

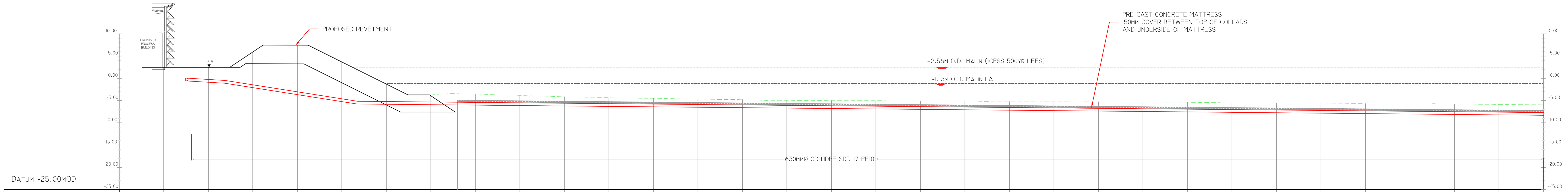
Drawing Title
ARKLOW WwTP - STORM WATER OVERFLOW (SWO) AT WwTP SITE LONGITUDINAL SECTION

Drawing Status
PLANNING

Job No	Drawing No	Issue
247825-00	M-O-2101	P1

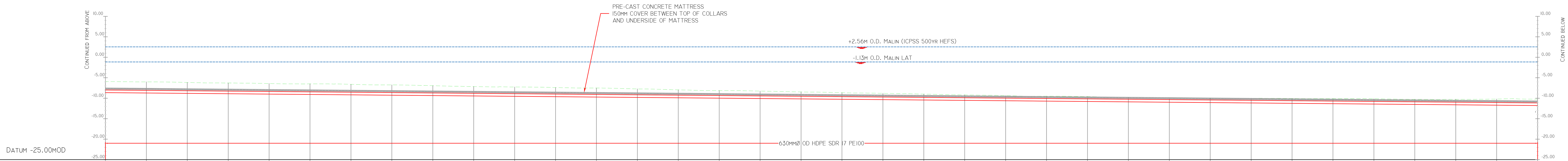
Do not scale

A1



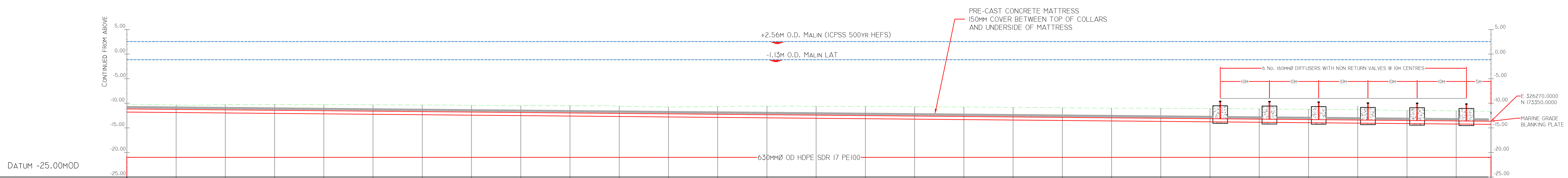
GROUND \ BED LEVELS (MOD)	2.500	2.500	5.920	7.500	3.697	-2.554	-3.674	-3.541	-3.840	-4.143	-4.340	-4.501	-4.679	-4.794	-4.998	-4.994	-5.001	-5.090	-5.095	-5.250	-5.250	-5.281	-5.353	-5.390	-5.489	-5.518	-5.564	-5.707	-5.750	-5.754	-5.866	-5.931
CHAINAGE	-10.000	00.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	180.000	190.000	200.000	210.000	220.000	230.000	240.000	250.000	260.000	270.000	280.000	290.000	300.000
PIPE INVERT LEVEL								-6.032	-6.127	-6.222	-6.317	-6.413	-6.508	-6.603	-6.698	-6.793	-6.889	-6.984	-7.079	-7.174	-7.270	-7.365	-7.460	-7.555	-7.650	-7.746	-7.841	-7.936	-8.031	-8.126	-8.222	-8.317
CONSTRUCTION								PRE-CAST CONCRETE MATTRESS & PRE-CAST CONCRETE WEIGHT COLLARS AT 3M CENTRES																								

LONG SEA OUTFALL - LONG SECTION
SCALE: H 1:500,V 1:500. DATUM: -15.000



GROUND \ BED LEVELS (MOD)	-5.931	-6.000	-6.145	-6.278	-6.409	-6.501	-6.607	-6.750	-6.936	-7.151	-7.249	-7.385	-7.507	-7.726	-7.958	-8.122	-8.250	-8.464	-8.661	-8.805	-9.000	-9.183	-9.366	-9.501	-9.591	-9.747	-9.895	-9.997	-9.977	-10.043	-10.085	-10.113	-10.249	-10.251	-10.201	-10.230
CHAINAGE	300.000	310.000	320.000	330.000	340.000	350.000	360.000	370.000	380.000	390.000	400.000	410.000	420.000	430.000	440.000	450.000	460.000	470.000	480.000	490.000	500.000	510.000	520.000	530.000	540.000	550.000	560.000	570.000	580.000	590.000	600.000	610.000	620.000	630.000	640.000	650.000
PIPE INVERT LEVEL	-8.317	-8.412	-8.507	-8.602	-8.698	-8.793	-8.888	-8.983	-9.079	-9.174	-9.269	-9.364	-9.460	-9.555	-9.650	-9.745	-9.840	-9.936	-10.031	-10.126	-10.221	-10.317	-10.412	-10.507	-10.602	-10.697	-10.793	-10.888	-10.983	-11.078	-11.174	-11.269	-11.364	-11.459	-11.554	-11.650
CONSTRUCTION	PRE-CAST CONCRETE MATTRESS & PRE-CAST CONCRETE WEIGHT COLLARS AT 3M CENTRES																																			

LONG SEA OUTFALL - LONG SECTION
SCALE: H 1:500,V 1:500. DATUM: -15.000



GROUND \ BED LEVELS (MOD)	-10.230	-10.352	-10.256	-10.254	-10.294	-10.305	-10.345	-10.417	-10.500	-10.501	-10.573	-10.750	-10.664	-10.580	-10.634	-10.628	-10.706	-10.750	-10.835	-10.913	-11.000	-11.023	-11.065	-11.128	-11.242	-11.308	-11.479	-11.545	-11.655
CHAINAGE	650.000	660.000	670.000	680.000	690.000	700.000	710.000	720.000	730.000	740.000	750.000	760.000	770.000	780.000	790.000	800.000	810.000	820.000	830.000	840.000	850.000	860.000	870.000	880.000	890.000	900.000	910.000	920.000	927.067
PIPE INVERT LEVEL	-11.650	-11.745	-11.840	-11.935	-12.030	-12.126	-12.221	-12.316	-12.411	-12.507	-12.602	-12.697	-12.792	-12.887	-12.983	-13.078	-13.173	-13.268	-13.364	-13.459	-13.554	-13.649	-13.744	-13.840	-13.935	-14.030	-14.125	-14.221	-14.221
CONSTRUCTION	PRE-CAST CONCRETE MATTRESS & PRE-CAST CONCRETE WEIGHT COLLARS AT 3M CENTRES																												

LONG SEA OUTFALL - LONG SECTION
SCALE: H 1:500,V 1:500. DATUM: -15.000

P1	03/09/18	TD	AC	EMcA
Issue	Date	By	Chkd	Appd

Client
UISCE ÉIREANN : IRISH WATER

Job Title
ARKLOW WASTEWATER TREATMENT PLANT PROJECT

Scale at A1: As Shown
Discipline: Infrastructure

ARUP BYRNELOOBY
CLANCY MOORE ARCHITECTS

Drawing Title
ARKLOW WwTP
LONG SEA OUTFALL - INDICATIVE LONGITUDINAL SECTION

Drawing Status
PLANNING

Job No: 247825-00
Drawing No: M-O-3001
Issue: P1

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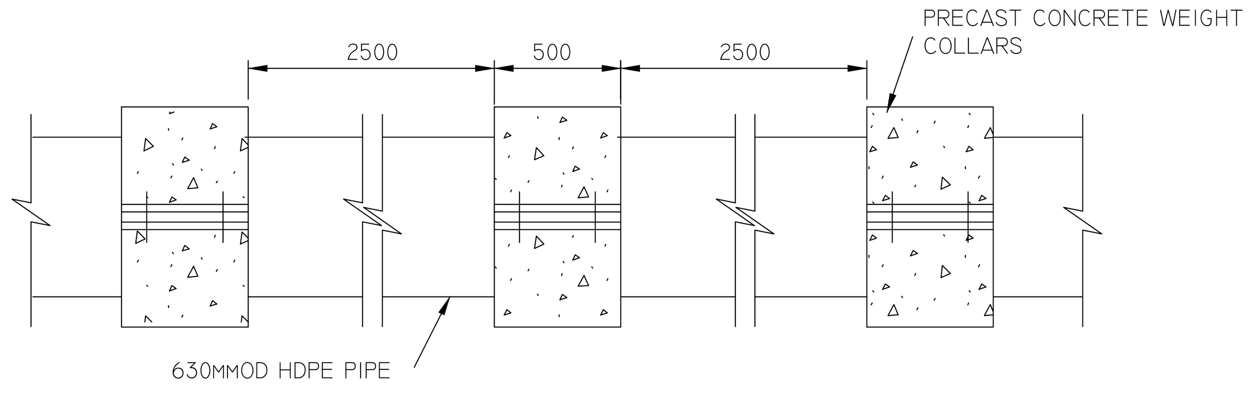
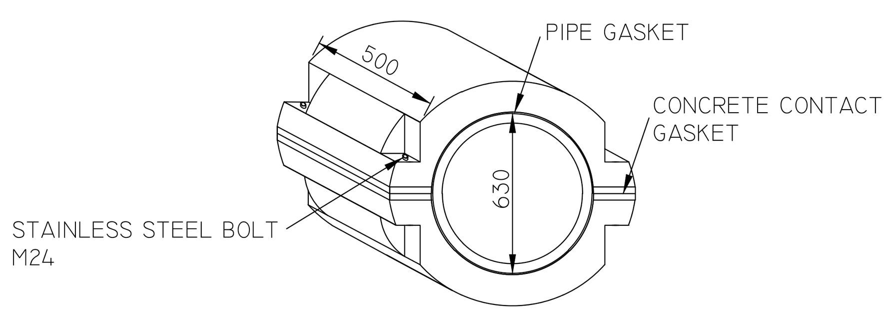
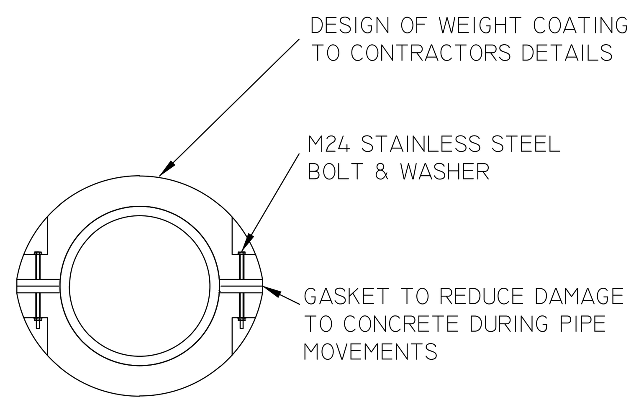


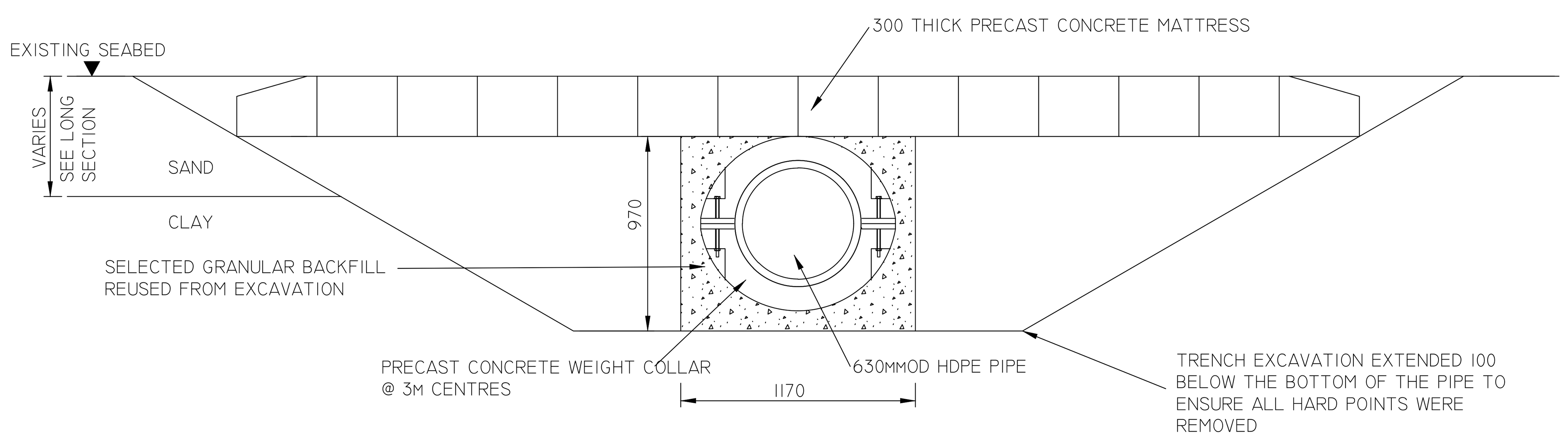
PIPE LONGSECTION (INSTALLATION PHASE)
SCALE 1:25



CONCRETE WEIGHT COATING DETAIL
SCALE 1:25



FIXING DETAIL
SCALE 1:25



TYPICAL TRENCH PROFILE - SEABED
SCALE 1:25

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES. ALL LEVELS ARE IN METRES ABOVE ORDNANCE DATUM UNLESS NOTED OTHERWISE.
2. ALL MANHOLES AND WORKS TO COMPLY WITH IRISH WATER STANDARD DETAILS
3. FOR OUTFALL ROUTE PLAN REFER TO DRAWING No. 247825-00-M-O-1001
4. FOR OUTFALL LONGITUDINAL SECTIONS REFER TO DRAWING No. 247825-00-M-O-3001
5. EXACT SIZE OF CONCRETE COLLAR WEIGHT TO BE DETERMINED BY CONTRACTOR
6. WHERE WEIGHT COLLARS ARE NOT SHOWN, PIPES TO BE SUNK USING SADDLE BAGS TO CONTRACTORS DETAILS
7. LAPS TO GEOTEXTILES 1000MM IN ALL CASES
8. MATTRESS AT CORNER TO HAVE NO VOIDS, LOCAL GROUTING REQUIRED
9. MATTRESS EXTENDED A MINIMUM OF 3M EITHER SIDE OF THE PIPE CENTRE LINE AT ALL LOCATIONS
10. PIPES TO BE LAID ON A BED OF MATERIAL WHICH PROVIDES EVEN AND CONTINUOUS SUPPORT. BED TO BE CHECKED FOR HARD POINTS WHICH ARE TO BE REMOVED.
11. ALL STAINLESS STEEL IS TO BS 1.4462 TO EN 10088

Issue	Date	By	Chkd	Appd
P1	03/09/18	TD	AC	EMcA

Client
UISCE ÉIREANN : IRISH WATER

Job Title
ARKLOW WASTEWATER TREATMENT PLANT PROJECT

Scale at A1: As shown
Discipline: Infrastructure

ARUP BYRNELOOBY
CLANCY MOORE ARCHITECTS

Drawing Title
ARKLOW WwTP
LONG SEA OUTFALL
TYPICAL CROSS SECTION

Drawing Status
PLANNING

Job No	Drawing No	Issue
247825-00	M-O-3101	P1

Do not scale

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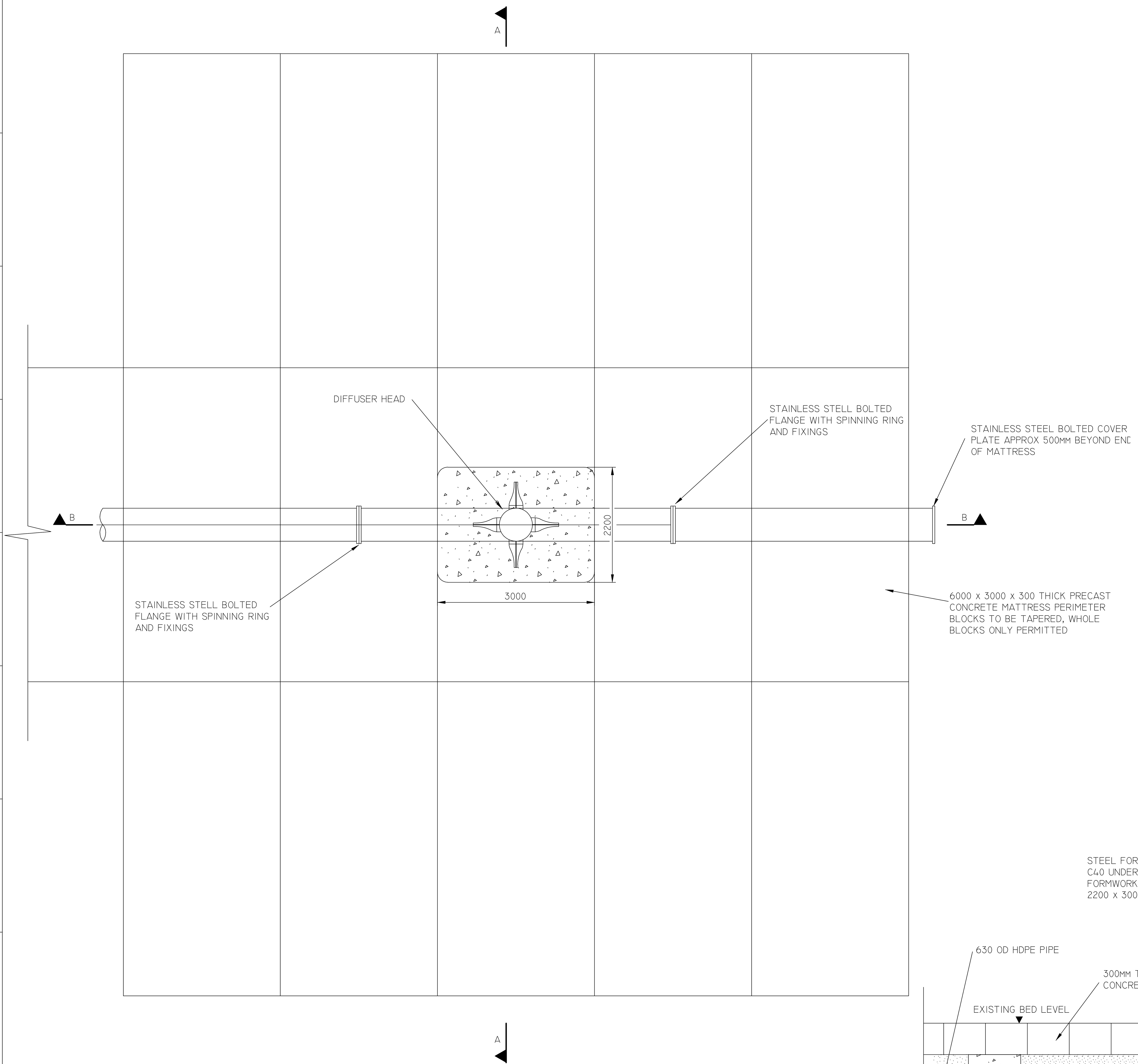
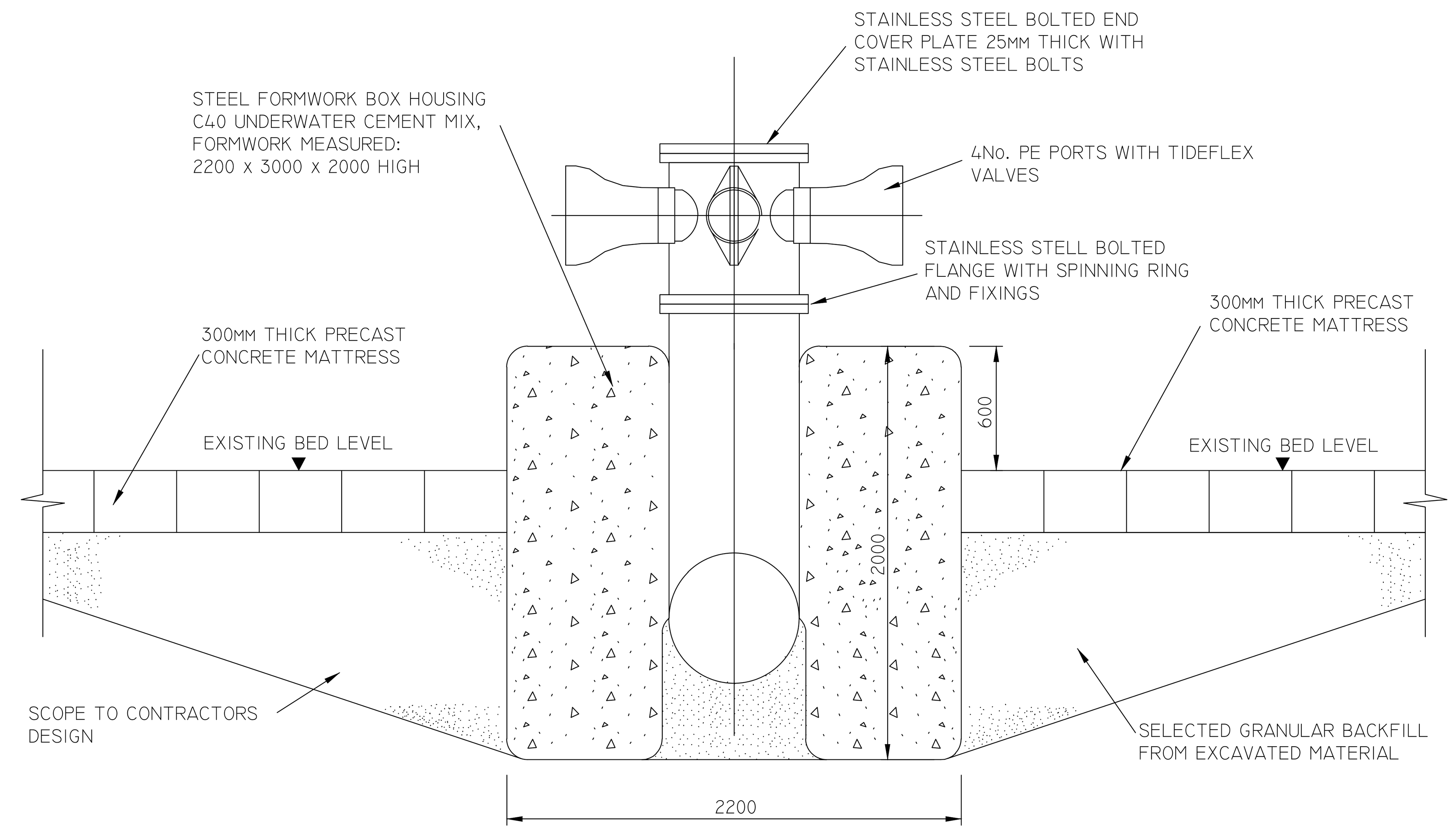
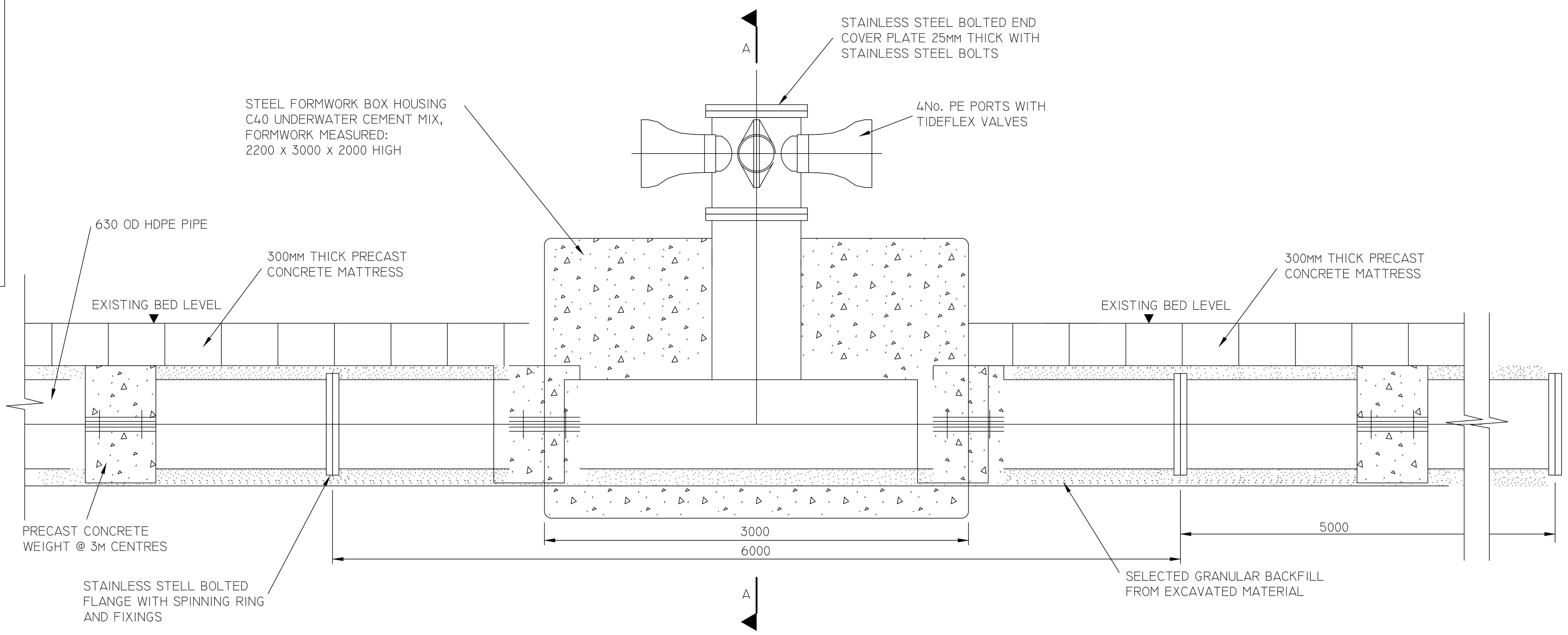


PLAN OF OUTFALL
SCALE 1:50



CROSS SECTION A-A
SCALE 1:25



SECTION B-B
SCALE 1:25

Issue	Date	By	Chkd	Appd
P1	03/09/18	TD	AC	EMcA

Client
UISCE ÉIREANN : IRISH WATER

Job Title
ARKLOW WASTEWATER TREATMENT PLANT PROJECT

Scale at A1: As Shown
Discipline: Infrastructure

ARUP BYRNELOOBY
CLANCY MOORE ARCHITECTS

Drawing Title
ARKLOW WwTP
LONG SEA OUTFALL
TYPICAL DIFFUSER DETAILS

Drawing Status
PLANNING

Job No	Drawing No	Issue
247825-00	M-O-4001	P1

Do not scale

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NOTES
1. ALL DIMENSIONS IN M UNLESS OTHERWISE NOTED.
2. ALL LEVELS IN METRES RELATIVE TO ORDNANCE DATUM MALIN.
3. TOP LAYER OF EXISTING REVETMENT TO BE REMOVED TO A MINIMUM OF 2.5mODM OR 2M THICKNESS, WHICHEVER IS GREATER.
4. TIE-IN DETAIL OF SOUTHERN END OF REVETMENT TO BE CONFIRMED BASED ON LOCATION OF EXISTING GE CABLE
5. DENSITY OF ROCK ARMOUR ASSUMED TO BE 2600KG/M^3
6. HISTORIC HIGH WATER MARK TAKEN FROM THE EXTENT OF FORESHORE SHOWN ON THE 1888-1913 OSi 25 INCH MAPS

LEGEND
PROPOSED PLANNING BOUNDARY
PROPOSED FINAL WWTP SITE BOUNDARY


KEY PLAN

OSi Sheet numbers:
4428-A, 4428-07, 4428-11, 4428-12, 4428-16 & 4428-17

FOR SECTIONS REFER TO DRGS 247825-00-M-R-2001 TO M-R-2003

P1	03/09/18	PW	IA	IA
Issue	Date	By	Chkd	Appd

Client: UISCE ÉIREANN : IRISH WATER

Job Title: ARKLOW WASTEWATER TREATMENT PLANT PROJECT

Scale at A1: 1:500

Discipline: Infrastructure

ARUP BYRNELOOBY
CLANCY MOORE ARCHITECTS

Drawing Title: ARKLOW WwTP REVETMENT UPGRADE EXISTING LAYOUT PLAN

Drawing Status: PLANNING

Job No: 247825-00 | Drawing No: M-R-1001 | Issue: P1

Do not scale

NOTES

1. ALL DIMENSIONS IN M UNLESS OTHERWISE NOTED.
2. ALL LEVELS IN METRES RELATIVE TO ORDNANCE DATUM MALIN.
3. TOP LAYER OF EXISTING REVETMENT TO BE REMOVED TO A MINIMUM OF 2.5mODM OR 2M THICKNESS, WHICHEVER IS GREATER.
4. TIE-IN DETAIL OF SOUTHERN END OF REVETMENT TO BE CONFIRMED BASED ON LOCATION OF EXISTING GE CABLE
5. DENSITY OF ROCK ARMOUR ASSUMED TO BE 2600KG/M^3
6. HISTORIC HIGH WATER MARK TAKEN FROM THE EXTENT OF FORESHORE SHOWN ON THE 1888-1913 OSI 25 INCH MAPS

LEGEND

- PROPOSED PLANNING BOUNDARY
- PROPOSED FINAL WWTP SITE BOUNDARY
- PROPOSED OUTFALL \ SWO

OSi Sheet numbers:
4428-A, 4428-07, 4428-11, 4428-12, 4428-16 & 4428-17

FOR SECTIONS REFER TO DRGS
247825-00-M-R-2001 TO M-R-2003

P1	03/09/18	PW	IA	IA
Issue	Date	By	Chkd	Appd

Client: UISCE ÉIREANN : IRISH WATER

Job Title
ARKLOW WASTEWATER TREATMENT PLANT PROJECT

Scale at A1: 1:500
Discipline: Infrastructure

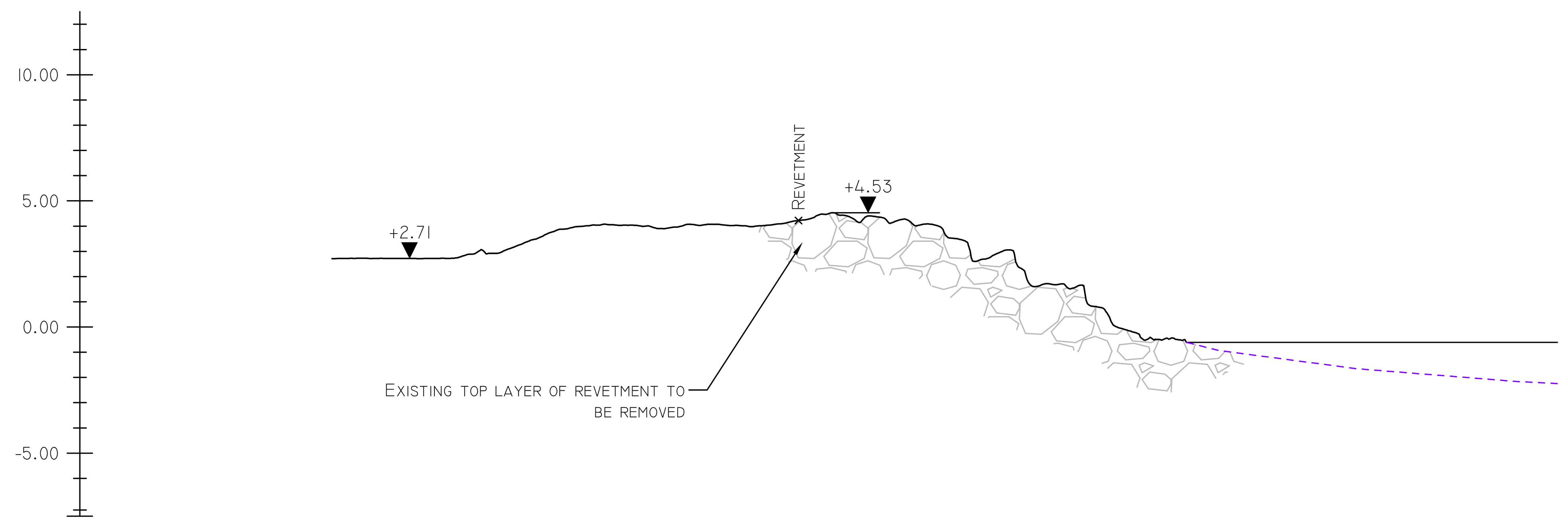
ARUP BYRNELOOBY
CLANCY MOORE ARCHITECTS

Drawing Title
ARKLOW WwTP
REVETMENT UPGRADE
PROPOSED LAYOUT PLAN

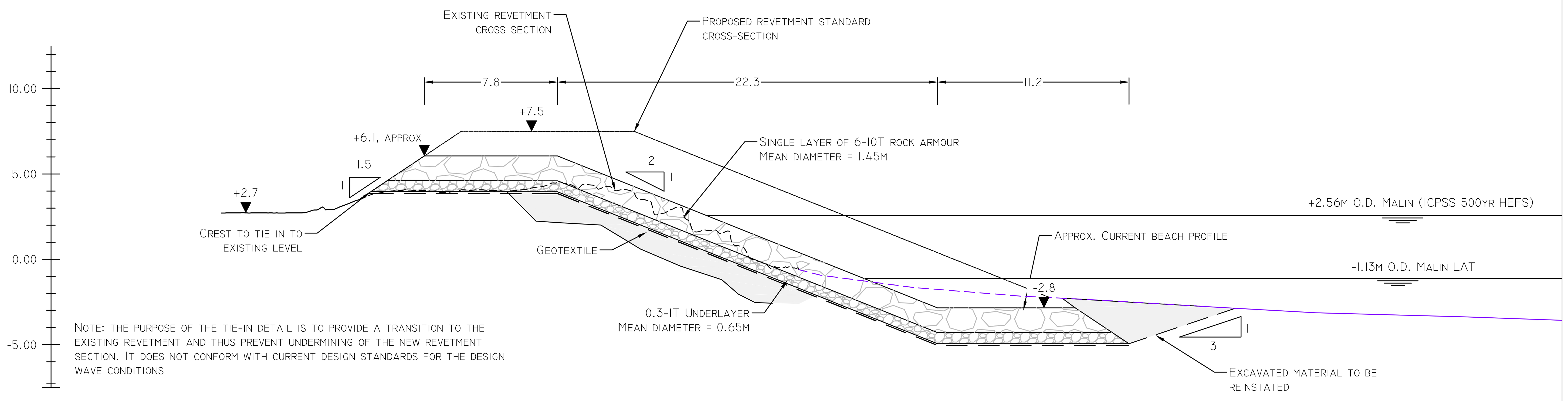
Drawing Status
PLANNING

Job No	Drawing No	Issue
247825-00	M-R-1002	P1

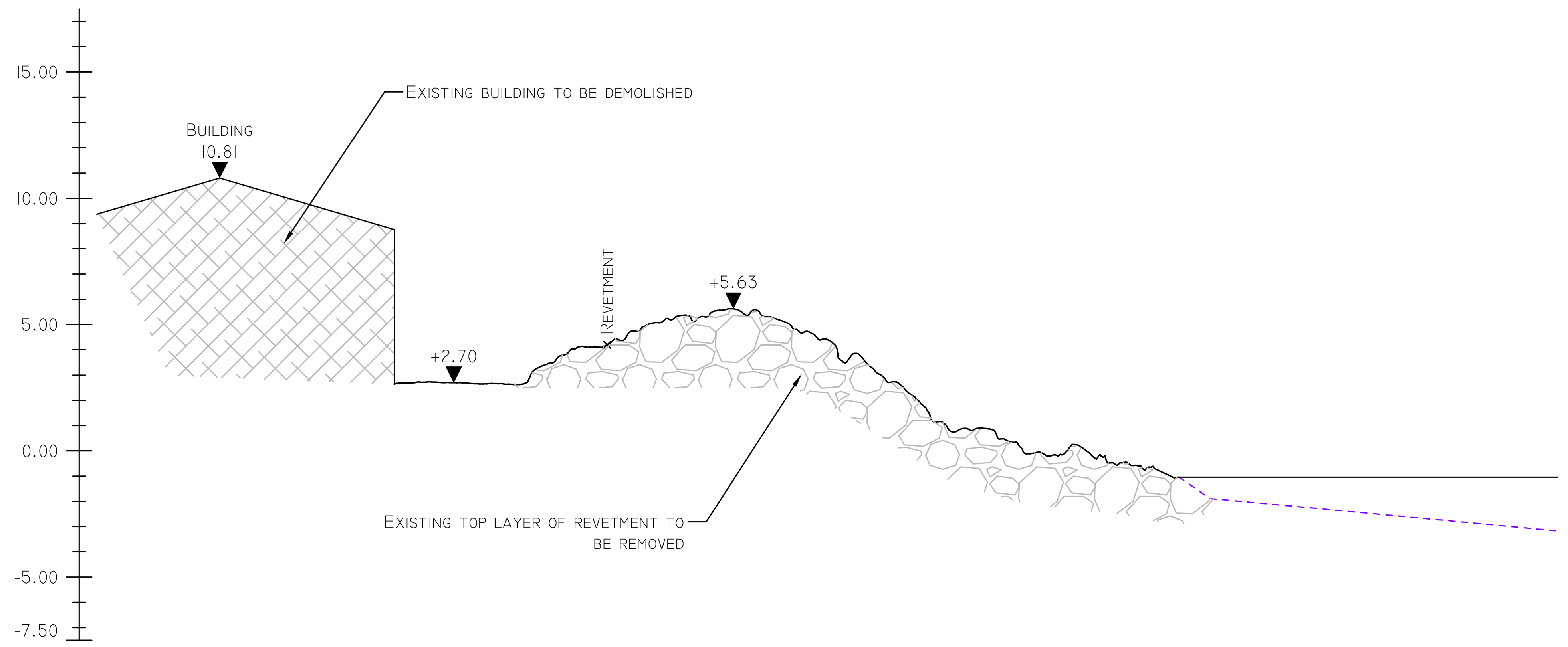
Do not scale



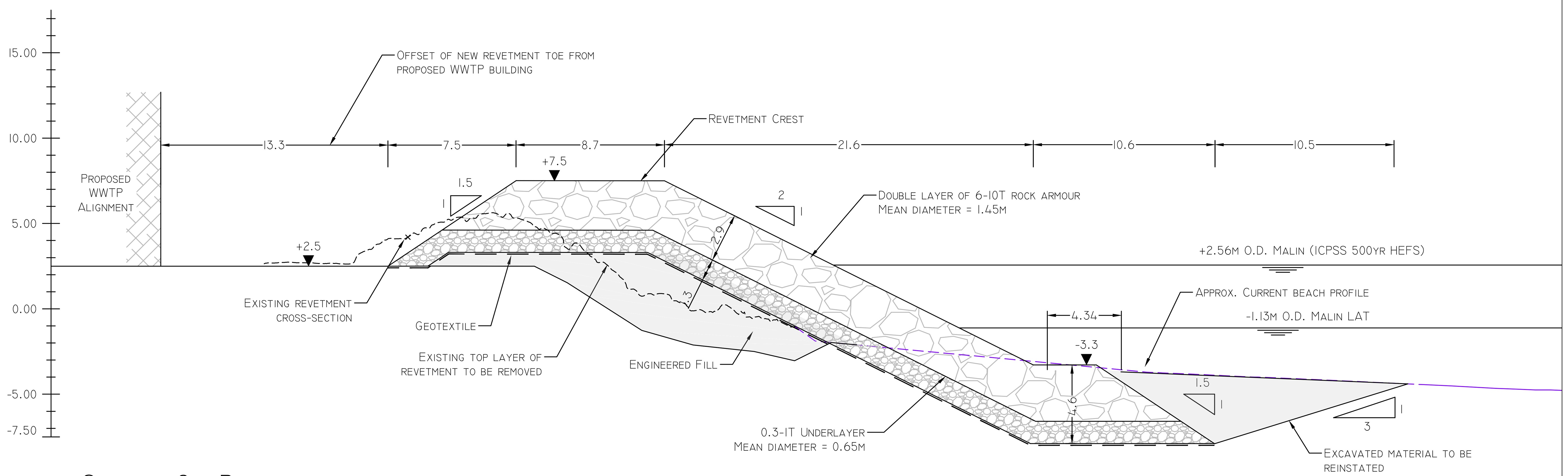
Section 1 - Existing



Section 1 - Proposed: Tie in to existing revetment, South



Section 2 - Existing



Section 2 - Proposed

Notes

1. All dimensions in m unless otherwise noted.
2. All levels in metres relative to Ordnance Datum Malin.
3. Top layer of existing revetment to be removed to a minimum of 2.5mODM or 2m thickness, whichever is greater.
4. Tie-in detail of southern end of revetment to be confirmed based on location of existing GE cable
5. Density of rock armour assumed to be 2600kg/m³
6. Historic high water mark taken from the extent of foreshore shown on the 1888-1913 OSi 25 inch maps

For section locations refer to DRGS 247825-00-M-R-1001 & M-R-1002

Issue	Date	By	Chkd	Appd
P1	03/09/18	PW	IA	IA

Client: UISCE ÉIREANN : IRISH WATER

Job Title: ARKLOW WASTEWATER TREATMENT PLANT PROJECT

Scale at A1: 1:200

Discipline: Infrastructure

ARUP BYRNELOOBY

CLANCY MOORE ARCHITECTS

Drawing Title: ARKLOW WWTP REVETMENT UPGRADE CROSS SECTION - SHEET 1 OF 3

Drawing Status: PLANNING

Job No	Drawing No	Issue
247825-00	M-R-2001	P1

Do not scale

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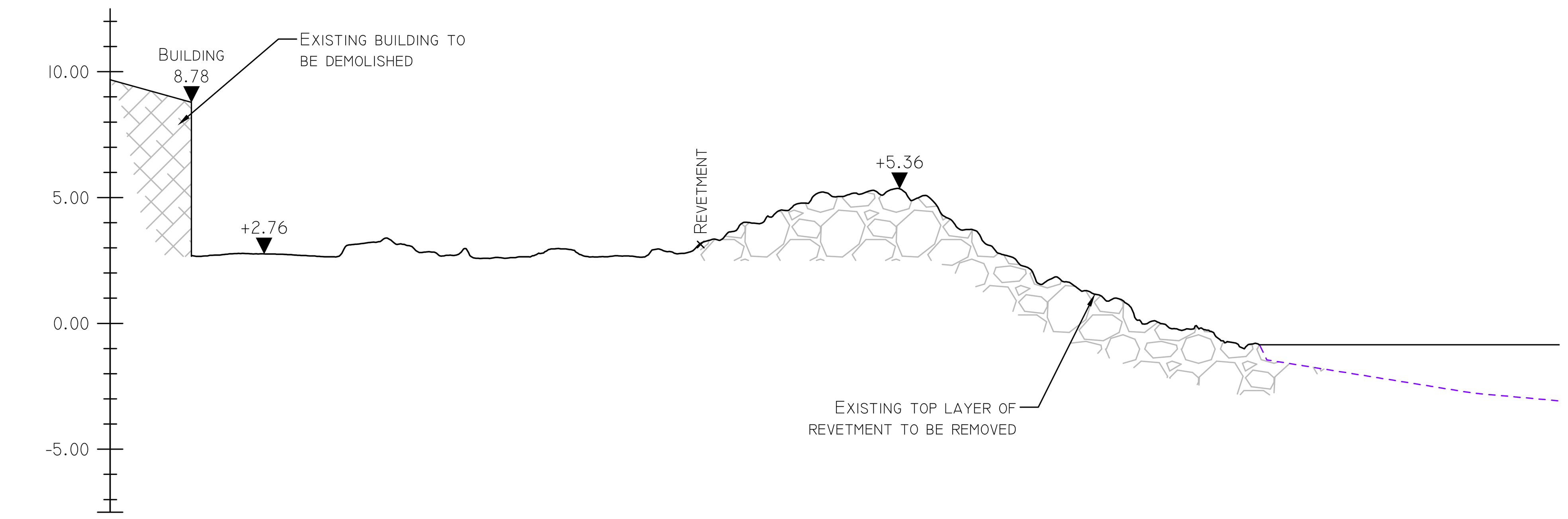
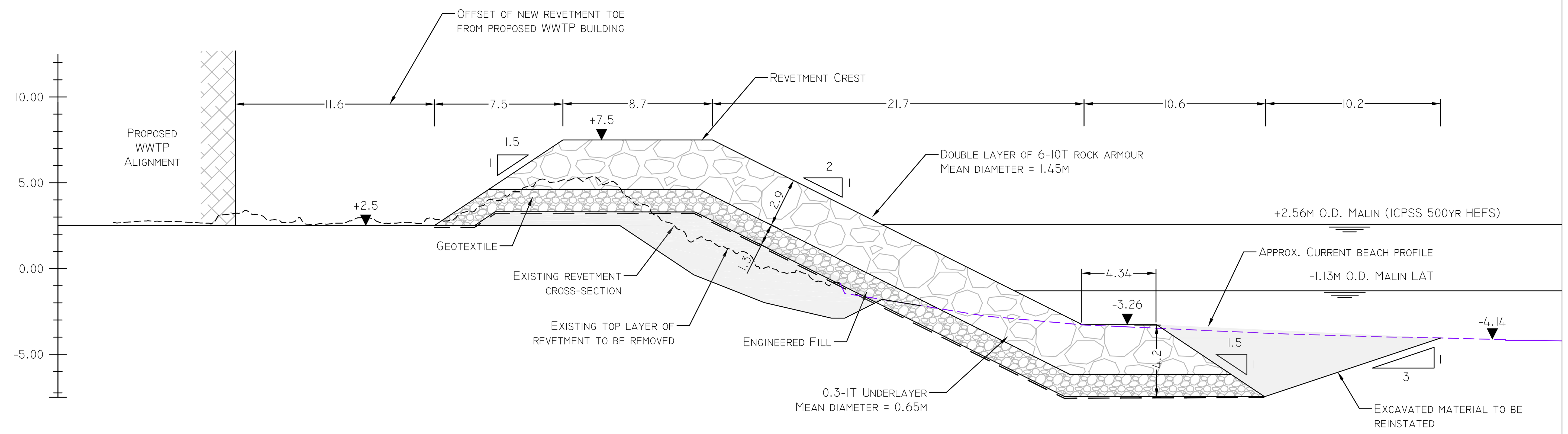
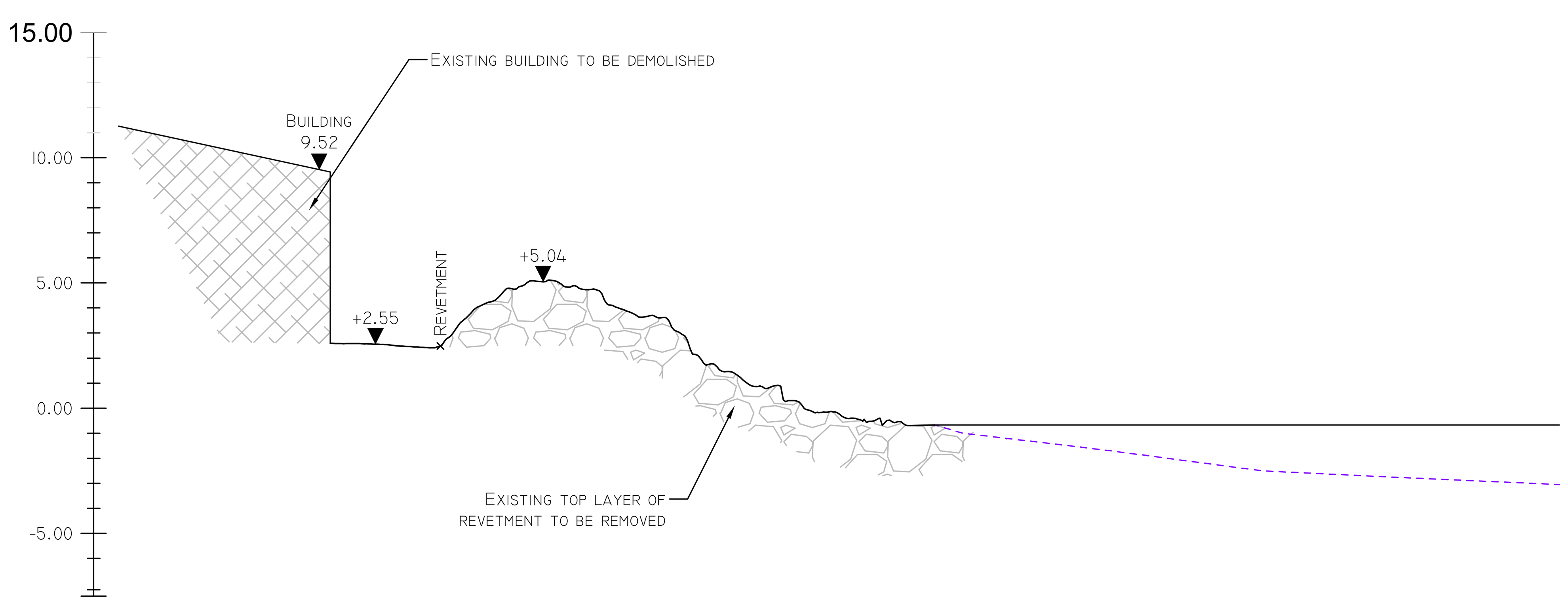


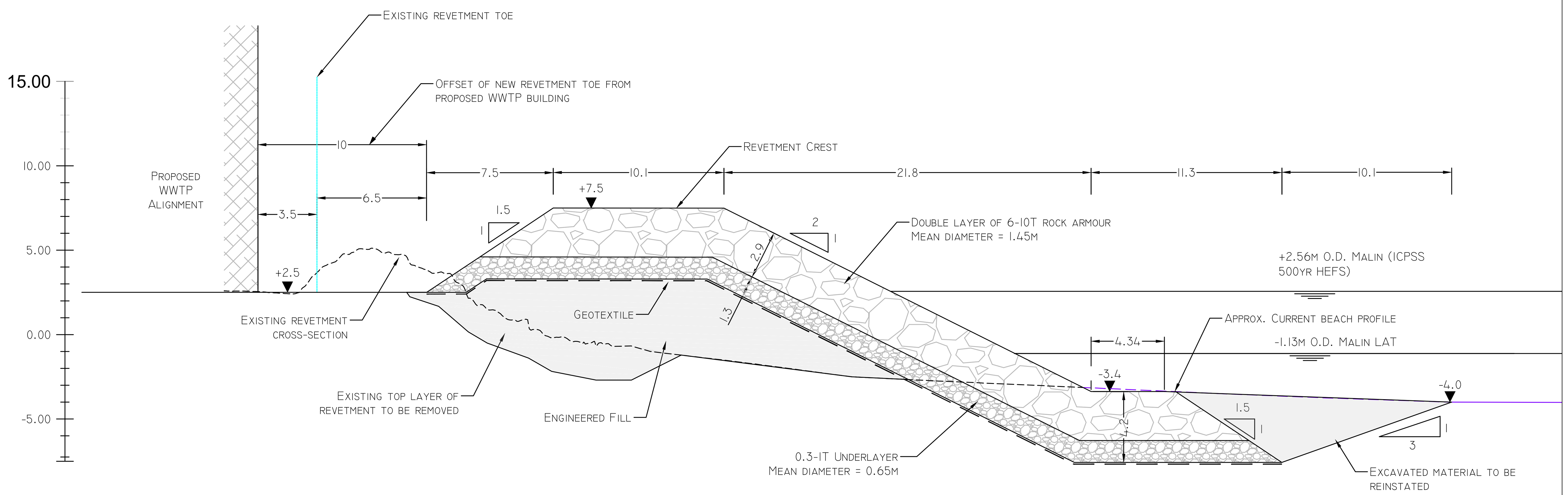
Section 3 - Existing



Section 3 - Proposed



Section 4 - Existing



Section 4 - Proposed

Notes

1. All dimensions in m unless otherwise noted.
2. All levels in metres relative to Ordnance Datum Malin.
3. Top layer of existing revetment to be removed to a minimum of 2.5mODM or 2m thickness, whichever is greater.
4. Tie-in detail of southern end of revetment to be confirmed based on location of existing GE cable
5. Density of rock armour assumed to be 2600kg/m^3
6. Historic high water mark taken from the extent of foreshore shown on the 1888-1913 OSi 25 inch maps

FOR SECTION LOCATIONS REFER TO DRGS 247825-00-M-R-1001 & M-R-1002

Issue	Date	By	Chkd	Appd
P1	03/09/18	PW	IA	IA

Client: UISCE ÉIREANN : IRISH WATER

Job Title: ARKLOW WASTEWATER TREATMENT PLANT PROJECT

Scale at A1: 1:200

Discipline: Infrastructure

ARUP BYRNELOOBY

CLANCY MOORE ARCHITECTS

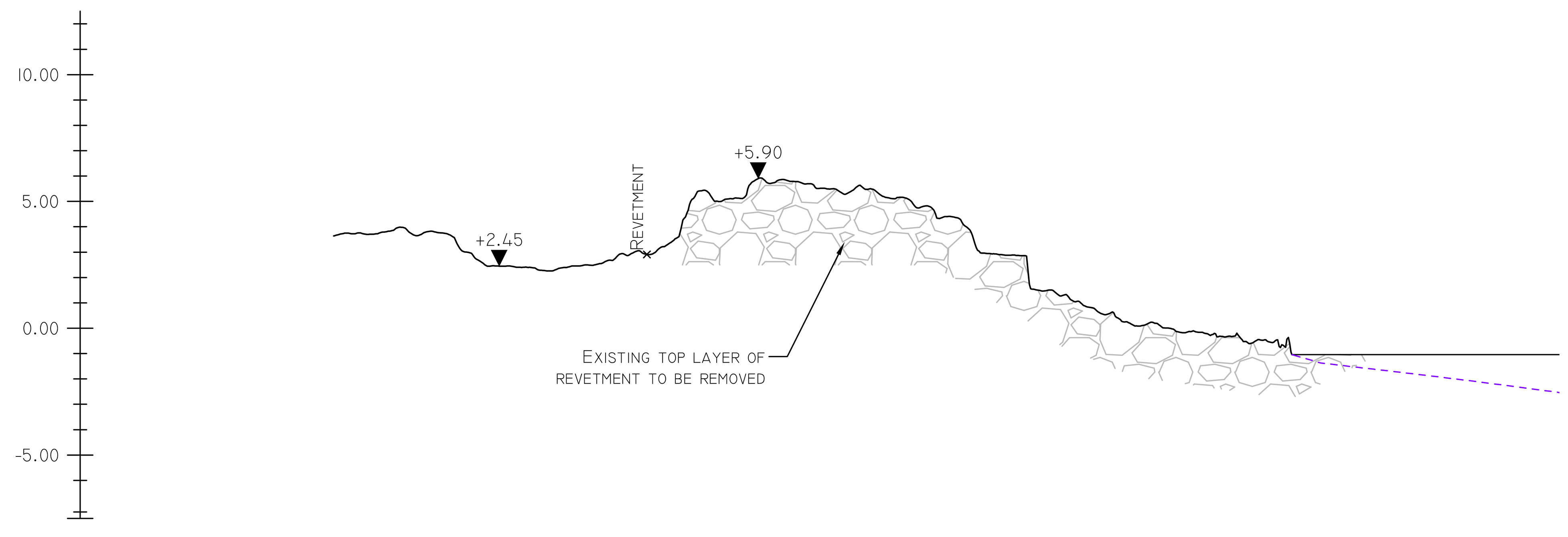
Drawing Title: Arklow WWTP REVETMENT UPGRADE CROSS SECTION - SHEET 2 OF 3

Drawing Status: PLANNING

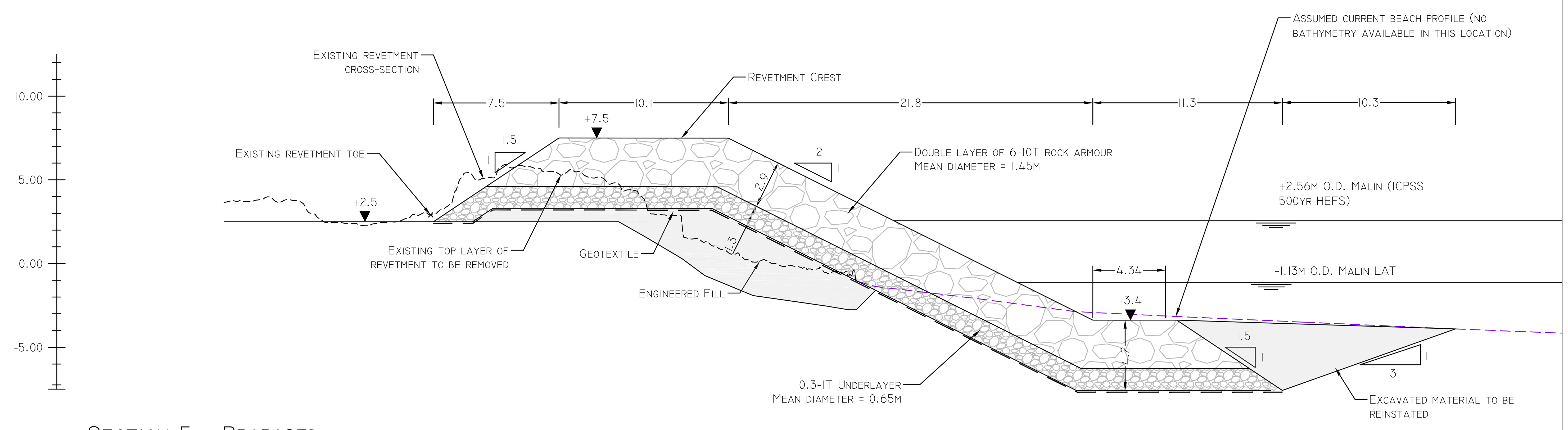
Job No: 247825-00 | Drawing No: M-R-2002 | Issue: P1

Do not scale

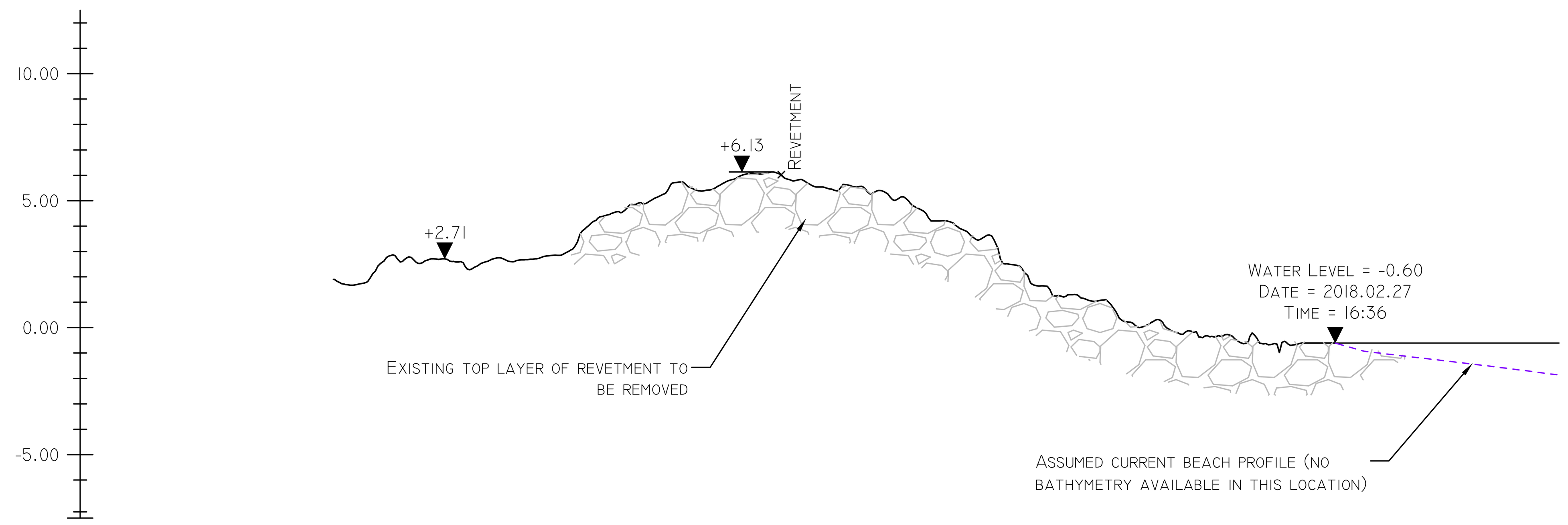
J:\247000\247825-00\4. Internal\4-02 Drawings\4-02-11 Planning\247825-00-M-R-2001.dwg



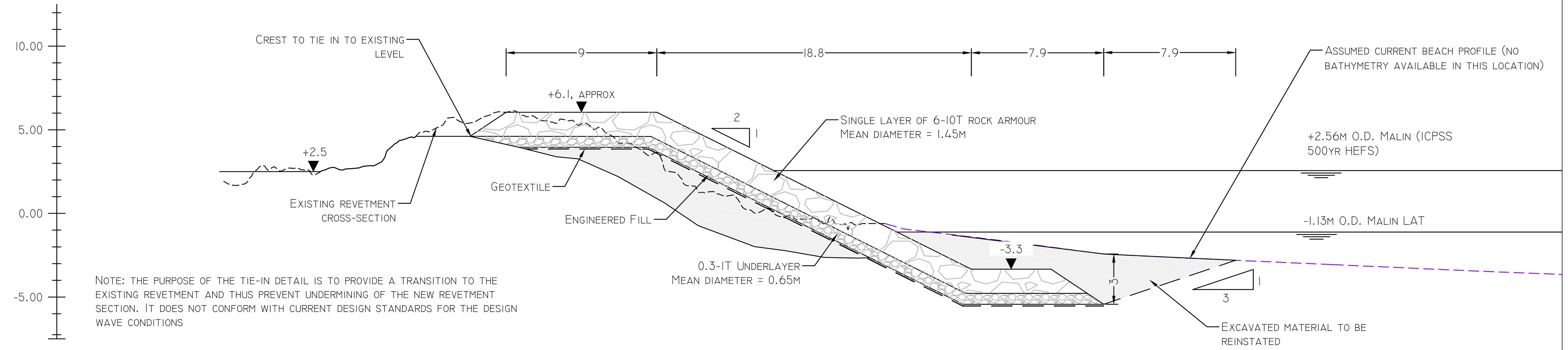
SECTION 5 - EXISTING



SECTION 5 - PROPOSED



SECTION 6 - EXISTING



SECTION 6 - PROPOSED: TIE IN TO EXISTING REVETMENT, NORTH

Notes

1. All dimensions in m unless otherwise noted.
2. All levels in metres relative to Ordnance Datum Malin.
3. Top layer of existing revetment to be removed to a minimum of 2.5mODM or 2m thickness, whichever is greater.
4. Tie-in detail of southern end of revetment to be confirmed based on location of existing GE cable
5. Density of rock armour assumed to be 2600kg/m^3
6. Historic high water mark taken from the extent of foreshore shown on the 1888-1913 OSi 25 inch maps

FOR SECTION LOCATIONS REFER TO DRGS 247825-00-M-R-1001 & M-R-1002

Issue	Date	By	Chkd	Appd
P1	03/09/18	PW	IA	IA

Client: UISCE ÉIREANN : IRISH WATER

Job Title: ARKLOW WASTEWATER TREATMENT PLANT PROJECT

Scale at A1: 1:200

Discipline: Infrastructure

ARUP BYRNELOOBY CLANCY MOORE ARCHITECTS

Drawing Title: ARKLOW WWTP REVETMENT UPGRADE CROSS SECTION - SHEET 3 OF 3

Drawing Status: PLANNING

Job No	Drawing No	Issue
247825-00	M-R-2003	P1

Do not scale

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Appendix B

Attributes, measures and targets supporting the maintenance or restoration of favourable conservation status of dune habitats at Buckroney-Brittas Dunes and Fen SAC (taken from NPWS 2017

B1 Buckroney-Brittas Dunes and Fen SAC

Site Code: 000729

Version date: 23.09.2013

Buckroney-Brittas Dunes and Fen is a complex of coastal habitats located about 10 km south of Wicklow town. It comprises two main sand dune systems, Brittas Bay and Buckroney Dunes, connected on the coast by the rocky headland of Mizen Head. The dunes have cut off the outflow of a small river at Mizen Head and a fen, Buckroney Fen, has developed. A further small sand dune system occurs south of Pennycomequick Bridge.

The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I / II of the E.U. Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

- [1210] Annual Vegetation of Drift Lines
- [1220] Perennial Vegetation of Stony Banks
- [1410] Mediterranean Salt Meadows
- [2110] Embryonic Shifting Dunes
- [2120] Marram Dunes (White Dunes)
- [2130] Fixed Dunes (Grey Dunes)*
- [2150] Decalcified Dune Heath*
- [2170] Dunes with Creeping Willow
- [2190] Humid Dune Slacks
- [7230] Alkaline Fens

Along much of the higher parts of the beach at this site, typical annual strandline vegetation occurs. Species such as Sea Rocket (*Cakile maritima*), Prickly Saltwort (*Salsola kali*) and Spear-leaved Orache (*Atriplex prostrata*) are frequent in this zone, with the scarcer Yellow Horned-poppy (*Glaucium flavum*) present in places.

A shingle ridge occurs along the Buckroney dune system. The amount of exposed shingle is low, but it is likely that shingle underlies much of the sandy areas also. The vegetation on the shingle is similar in composition to that which occurs as part of the drift line and embryonic dune habitats. Sea Sandwort (*Honkenya peploides*) is characteristic, and other species include Sand Couch (*Elymus farctus*), Sand Sedge (*Carex arenaria*), Sea Rocket and Yellow Horned-Poppy.

An area of saline vegetation which conforms to 'Mediterranean salt meadows' occurs in the Buckroney dune system south of the inlet stream to the fen, and possibly in small areas elsewhere within the site. It is typically dominated by rushes (*Juncus* spp.), and of note is the presence of Sharp Rush (*J. acutus*). Sea Club-rush (*Scirpus maritimus*) also occurs. The area is inundated by the tide only occasionally via the narrow inlet leading to Buckroney Fen.

Embryonic dune development occurs at the southern part of Brittas and more widely at Buckroney and Pennycomequick. Typical species are couch grasses (*Elymus* sp.), Sand Sedge and Sea Sandwort. The main dune ridges are dominated by Marram (*Ammophila arenaria*), with herbaceous species such Sea Spurge (*Euphorbia paralias*), Sea-holly (*Eryngium maritimum*) and Common Restharrow (*Ononis repens*) occurring throughout. The main dune ridges are well developed, reaching heights of 10 m at Brittas. The northern end of the Brittas system has fine examples of parabolic dunes.

Stable fixed dunes are well developed at Brittas and Buckroney. Marram is less frequent in these areas and is replaced by Red Fescue (*Festuca rubra*) as the most common grass species. A rich flora occurs, especially in the more open areas. Common species include Pyramidal Orchid (*Anacamptis pyramidalis*), Common Milkwort (*Polygala vulgaris*), Wild Pansy (*Viola tricolor subsp. curtisii*), Carline Thistle (*Carlina vulgaris*), Biting Stonecrop (*Sedum acre*), Wild Thyme (*Thymus praecox*) and Common Bird's-foot-trefoil (*Lotus corniculatus*). The mature areas of fixed dune also contain Burnet Rose (*Rosa pimpinellifolia*), Bracken (*Pteridium aquilinum*), Wood Sage (*Teucrium scordonia*) and Common Sorrel (*Rumex acetosa*). Mosses such as *Tortula ruralis subsp. ruraliformis*, *Rhytidiadelphus triquetris*, and *Homalothecium lutescens* are frequent, along with lichens (*Cladonia* spp., *Peltigera canina*).

This is one of the few Irish east coast sites to possess good examples of wet dune slacks and dunes with Creeping Willow (*Salix repens*). These areas of the dunes have a rich and varied flora, including species such as Creeping Willow, Water Mint (*Mentha aquatica*), Silverweed (*Potentilla anserina*), Meadowsweet (*Filipendula ulmaria*) and Meadow Thistle (*Cirsium dissectum*). The slacks are notably rich in rushes and sedges. Of particular interest is the presence of Sharp Rush (*Juncus acutus*), a scarce species in eastern Ireland and one that is indicative of a saline influence.

The site is also notable for the presence, at the back of the dunes, of areas of decalcified dune heath, a rare habitat type, and one which is listed with priority status in the E.U. Habitats Directive. Heath species present include Heather (*Calluna vulgaris*), Bell Heather (*Erica cinerea*) and Gorse (*Ulex europaeus*).

Buckroney Fen lies west of Mizen Head. It is backed to the west by a dense swamp of Common Reed (*Phragmites australis*). The fen is dominated by Tussock Sedge (*Carex paniculata*), with Water Mint, Purple Loosestrife (*Lythrum salicaria*), Marsh Pennywort (*Hydrocotyle vulgaris*), Greater Bird's-foot-trefoil (*Lotus uliginosus*), Water Horsetail (*Equisetum fluviatile*), small sedges (*Carex spp.*) and other flowering plants. An extensive stand of Blunt-flowered Rush (*Juncus subnodulosus*) is of note. Throughout this area the rare Marsh Fern (*Thelypteris palustris*) is frequent. There are also extensive areas of Rusty Willow (*Salix cinerea subsp. oleifolia*) scrub.

This site contains two rare plant species protected under the Flora (Protection) Order, 1999: Wild Asparagus (*Asparagus officinalis* subsp. *prostratus*), in its most northerly Irish station, and Meadow Saxifrage (*Saxifraga granulata*).

Other rare species which occur within the site include Green-flowered Helleborine (*Epipactis phyllanthes*), Bird's-foot (*Ornithopus perpusillus*) and Spring Vetch (*Vicia lathyroides*). All of these are Red Data Book species. The rare sedge hybrid *Carex riparia x C. vesicaria (Carex x csomadensis*) is only known from Mizen Head.

The invertebrate fauna of Buckroney fen has been investigated and some notable species have been recorded, including the beetle *Eurynebria complanata* and the following flies: *Machimus cowini*, *Anasimyia lunulata*, *Parhelophilus consimilis* and *Lejogaster splendia*.

Little Tern, a species listed on Annex I of the E.U. Birds Directive, has bred or attempted to breed at Buckroney strand in recent years. In 1992 between 7 and 10 pairs were present and in 1993 up to 8 pairs. Teal are regular in winter (119), as are Curlew (46), Lapwing (515) and Snipe (87). All figures are average peaks for 1994/95 - 1995/96.

The dune systems and beaches are subject to high amenity usage from day-trippers and several areas around the site have been developed as caravan parks, car parks and golf courses. The marginal areas of the fen have been reclaimed, especially at the south end, though these areas still flood in winter and attract waterfowl.

This site is important as an extensive sand dune/fen system with well developed plant communities. Several coastal habitats listed on the E.U. Habitats Directive, including two priority habitats - fixed dune and decalcified dune heath - are present. The area contains two legally protected plants, as well as a number of other rare or scarce plant species. The site provides habitat for some rare species of invertebrate and for the vulnerable Little Tern. A rich flora and fauna has persisted on this site despite extensive amenity use and adjacent farming. However, future land use practices will need to be managed to ensure the continued survival of this unique mosaic of coastal habitats.

B2 Kilpatrick Sandhills SAC

Site Code: 001742

Version date: 6.11.2013

Kilpatrick Sandhills are located about 8 km south of Arklow town, and just south of the Wicklow/Wexford county boundary. The site is comprised of a mosaic of coastal habitats but primarily a mature sand dune system which extends along 2km of coastline.

The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I / II of the E.U. Habitats Directive

(* = priority; numbers in brackets are Natura 2000 codes):

[1210] Annual Vegetation of Drift Lines

[2110] Embryonic Shifting Dunes

[2120] Marram Dunes (White Dunes)

[2130] Fixed Dunes (Grey Dunes)*

[2150] Decalcified Dune Heath*

Various stages of sand dune formation can be seen at this site, from small fore dunes which are stabilized by Marram (*Ammophila arenaria*), to mature fixed dunes colonised by a species-rich sward of grasses and herbaceous plants.

Embryonic shifting fore dunes occur mainly along the middle and southern sections of the site. Species such as Marram, Sand Couch (*Elymus farctus*) and Sea Sandwort (*Honkenya peploides*) are present. The Marram dunes are dominated by Marram, with species such as Sea Spurge (*Euphorbia paralias*), Sea Bindweed (*Calystegia soldanella*) and Sea-holly (*Eryngium maritimum*) also found.

In the fixed dunes Red Fescue (*Festuca rubra*) is the dominant grass. Other species present include Lady's Bedstraw (*Galium verum*), Kidney Vetch (*Anthyllis vulneraria*), Wild Thyme (*Thymus praecox*) and Sheep's-bit (*Jasione montana*). On the older dunes, there is an abundance of legumes, including Common Bird's-foot-trefoil (*Lotus corniculatus*), White Clover (*Trifolium repens*), Hop Trefoil (*Trifolium campestre*) and Lesser Trefoil (*Trifolium dubium*). Further inland, on the more mature grey dunes, Burnet Rose (*Rosa pimpinellifolia*) is common. The scarce species Lesser Meadow-rue (*Thalictrum minus*) occurs among the vegetation of the more mobile dunes.

Dune heath occurs behind the fixed dunes in the mid and southern sections of the site. This is a very rare vegetation type in Ireland. The heathy scrub is dominated by Gorse (*Ulex europaeus*), and other species recorded in this area include Blackthorn (*Prunus spinosa*), Bracken (*Pteridium aquilinum*), Cleavers (*Galium aparine*), Common Sorrel (*Rumex acetosa*), Common Ragwort (*Senecio jacobaea*), Burnet Rose, Tormentil (*Potentilla erecta*) and Bramble.

On the landward side of the dunes, in the middle of the site, there is a low-lying marsh which is dominated by Bulrush (Typha latifolia), with Branched Bur-reed (Sparganium erectum), Yellow Iris (*Iris pseudacorus*), Tubular Water-dropwort (*Oenanthe fistulosa*), Wild Angelica (*Angelica sylvestris*) and sedges (*Carex* spp.). To the west of the marsh is an area of wet scrub woodland. The canopy is formed of Alder (*Alnus glutinosa*) and willows (*Salix* spp.), with Bramble (*Rubus fruticosus agg*.), Honeysuckle (*Lonicera periclymenum*), Great Horsetail (*Equisetum telmateia*), Wood Dock (*Rumex sanguineus*) and Narrow Buckler-fern (*Dryopteris carthusiana*) among the ground flora.

At the northern end of the site is a rocky headland, Kilmichael Point, which affords fine views along the coastline. Rock outcrops occur where the overlying clay drift has eroded, exposing cliffs which rise in steps to about 10 m. The headland supports a species-rich coastal grassland and cliff vegetation, including the scarce species, Rock Sea-lavender (*Limonium binervosum*).

The Red Data Book species, Sea Stock (*Matthiola sinuata*), has been observed among rocky crevices here in the past, but has not been recorded recently. The species is now thought to be extinct in Ireland.

At the southern end of the site, the sand dunes and beach are used by visitors for amenity purposes. Parts of the site are also used for grazing cattle. Grazing is a critical factor in coastal systems: the correct grazing pressure maintains species-rich open swards and curtails scrub encroachment. Over-exposure to grazing and amenity usage can cause damage to dune vegetation and exacerbate dune erosion.

The site is ecologically important as a good example of a mature and fairly intact sand dune system which shows the developmental stages of dunes from fore dunes to mature grey dunes. A good diversity of habitats and species are present. Fixed dunes and dune heath are priority habitats under Annex I of the E.U. Habitats Directive.

B3 Magherabeg Dunes SAC

Site Code: 001766

Version date: 13.11.2013

Magherabeg Dunes SAC is a sand dune system situated at Ardmore Point, about 5 km south of Wicklow Head in Co. Wicklow. The Three Mile Water River enters the sea through the dunes. The site is fairly intact, though some areas are being naturally eroded by wind and sea, in particular at the southern end, where bedrock has been exposed.

The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I / II of the E.U. Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

- [1210] Annual Vegetation of Drift Lines
- [2110] Embryonic Shifting Dunes
- [2120] Marram Dunes (White Dunes)
- [2130] Fixed Dunes (Grey Dunes)*
- [2150] Decalcified Dune Heath*
- [7220] Petrifying Springs*

Despite its small size, the dune system at Magherabeg shows most of the developmental stages, with embryonic dunes, white dunes, grey fixed dunes and decalcified fixed dunes all represented. The embryo dunes occur mainly in the northern sector, in association with a good example of drift line vegetation. Species present include Sea Couch (*Elymus farctus*), Marram (*Ammophila arenaria*) and Sea Sandwort (*Honkenya peploides*). A narrow band of shifting marram dunes then occur, these having been largely washed away by erosion in the southern sector. Stable fixed dunes are well represented, with such species as Red Fescue (*Festuca rubra*), Common Restharrow (*Ononis repens*), Common Bird's-foot-trefoil (*Lotus corniculatus*), Wild Pansy (*Viola tricolor*), Wild Thyme (*Thymus praecox*) and White Clover (*Trifolium repens*). Burnet Rose (*Rosa pimpinellifolia*) is present on the older fixed dunes. The fixed dunes merge with dune heath, with species such as Gorse (*Ulex europaeus*) and Bracken (*Pteridium aquilinum*) present. The dune system is backed by drift banks, which are well covered by deciduous woodland and scrub. Other species occurring on these drift banks include Hemp-agrimony (*Eupatorium cannabinum*), Yellow-wort (*Blackstonia perfoliata*) and the scarce species Wood Vetch (*Vicia sylvatica*).

Along the low cliffs at Ardmore Point a line of petrifying springs with tufa formations occurs, and a range of specialised moss species are found.

The Three Mile Water River, which flows through the dunes provides habitat for wetland species such as sedges, including Bladder Sedge (*Carex vesicaria*), Fox Sedge (*C. otrubae*) and Grey Sedge (*C. divulsa*). The very rare hybrid sedge, *Carex* x *grossii* (*C. hirta* x *C. vesicaria*) has also been recorded here. Common Reed (*Phragmites australis*) is also found along the river.

The site is of conservation importance because it is a fine example of a dune system which is fairly intact and which has a well-developed flora. The lack of easy public access to this site has undoubtedly helped in preventing damage and erosion from amenity activities. The presence of wetland vegetation on the site is of additional interest.

B4 Wicklow Reef SAC

Site Code: 002274

Version date: 4.01.2014

Wicklow Reef is situated just to the north of Wicklow Head on the east coast of Ireland in Co. Wicklow. The substrate is a mixture of cobbles, bedrock and sand and is subject to strong tidal streams.

The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I / II of the E.U. Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

[1170] Reefs

Wicklow Reef is an example of a subtidal reef constructed by the honeycomb worm *Sabellaria alveolata*. In Irish waters this worm normally constructs reefs on intertidal rocks, in areas subject to some sand scour. Such reefs are widespread but uncommon. *Sabellaria alveolata* subtidal reefs are known to occur in the Mediterranean but this example is an extremely unusual feature and may be the first record for Britain and Ireland.

The reef occurs at a depth of 12-30 m and reaches a thickness of at least 0.3-0.5 m. It is composed of consolidated sand grains formed into a honeycomb structure by the activities of the worm. There is a good diversity of species associated with the reef, including hydroids (e.g. *Hydrallmania falcata*), a variety of polychaete worms, the snail *Calliostoma zizyphinum*, the bivalves *Musculus discor* and *Mytilus edulis*, other molluscs, bryzoans, barnacles, amphipods, crabs, starfish, brittlestars and sea squirts. Three of the species associated with this biogenic reef are rare in Irish waters. The bryozoan *Phaeostachys spinifera* is only known from five locations, with the majority on the west coast and no records in the Irish sea south of Co. Antrim. The polychaete *Eulalia ornata* and the amphipod *Unciola crenatipalma* are only known from one and two sites respectively in Ireland.

Wicklow Reef is of high conservation value as it is the only documented example in Ireland of a biogenic reef. Further, it supports a number of uncommon species.

B5 Blackwater Bank SAC

Site Code: 002953

Version date: 10.02.2014

Blackwater Bank SAC consists of a series of sandbanks running roughly parallel to the coastline of Co. Wexford. The total area of this site is approximately 12,407 ha. This designation includes the Lucifer Bank, Blackwater Bank and Moneyweights Bank. These features are at the southern end of a series of offshore sandbanks that run along the eastern seaboard of Ireland as far north as Co. Dublin.

The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I / II of the E.U. Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

[1110] Sandbanks

The sandbanks in this site form a series of banks from Cahore Point, in the north, extending almost as far southwards as Rosslare, Co. Wexford. These features range from 2-4 km from the shoreline. Offshore sandbanks are generally formed from varying sediment fractions that range from cobbles to fine sand. The sediment surface is often rippled, through the action of currents and storms, and builds up into sand waves that may measure more than 1 m in height and several metres in width.

Some of the banks shoal during low tide but are generally between 4-8 m below the sea surface at low tide. These banks are characterised predominantly by fine sand to medium sand with smaller percentages of very fine sand. Previous surveys indicated an area of high hydrodynamic activity with strong, tidally induced current speeds operating. Such currents do not allow for the settling out of finer particles of organic and inorganic matter. This type of current regime also tends to make the sediments quite mobile, with material being transported over some distance during strong phases of the tidal cycle. Such areas are characterised by low species densities. Low species numbers and densities in such habitat are probably due to the inhospitable nature of the environment, i.e. mobile sands, which demand specialised lifestyles for animals to either cope with, or escape from, sand abrasion.

The species recorded from the area are typical of sandy coastal habitats. A total of 35 species, from four phyla were collected. The most abundant species were crustaceans (*Bathyporeia elegans*, *Pontocrates altamarinus*, *Portumnus latipes* and *Urothoe elegans*), segmented worms (*Spio armata*, *Scolelepis squamata*, *Nephtys longosetosa*, *Nephtys cirrosa*, *Magelona mirabilis*, *Spiophanes bombyx*, *Magelona johnstoni*, *Gastrosaccus spinifer* and *Levinsenia gracilis*) and the mollusc *Parvicardium minimum*. Analysis of the species has split the various faunal communities into two distinct assemblages: ‘infralittoral mobile clean sand with sparse fauna’ and ‘*Bathyporeia* spp. in infralittoral sand’.

The site is of conservation importance for its submerged sandbanks, a habitat that is listed on Annex I of the E.U. Habitats Directive.

B6 Site Name: Wicklow Mountains SAC

Site Code: 002122

Version date: 31.05.2017

Wicklow Mountains SAC is a complex of upland areas in Counties Wicklow and Dublin, flanked by the Blessington reservoir to the west and Vartry reservoir in the east, Cruagh Mountain in the north and Lybagh Mountain in the south. Most of the site is over 300 m, with much ground over 600 m. The highest peak is 925 m at Lugnaquilla. The Wicklow uplands comprise a core of granites flanked by Ordovician schists, mudstones and volcanics. The form of the Wicklow Glens is due to glacial erosion. The topography is typical of a mountain chain, showing the effects of more than one cycle of erosion. The massive granite has weathered characteristically into broad domes. Most of the western part of the site consists of an elevated moorland, covered by peat. The surrounding schists have assumed more diverse outlines, forming prominent peaks and rocky foothills with deep glens. The dominant topographical features are the products of glaciation. High corrie lakes, deep valleys and moraines are common features of this area. The substrate over much of the area is peat, usually less than 2 m deep. Poor mineral soil covers the slopes, and rock outcrops are frequent. The Wicklow Mountains are drained by several major rivers including the Dargle, Liffey, Dodder, Slaney and Avonmore. The river water in the mountain areas is often peaty, especially during floods.

The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I / II of the E.U. Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

- [3110] Oligotrophic Waters containing very few minerals
- [3160] Dystrophic Lakes
- [4010] Wet Heath
- [4030] Dry Heath
- [4060] Alpine and Subalpine Heaths
- [6130] Calaminarian Grassland
- [6230] Species-rich *Nardus* Grassland*
- [7130] Blanket Bogs (Active)*
- [8110] Siliceous Scree
- [8210] Calcareous Rocky Slopes
- [8220] Siliceous Rocky Slopes
- [91A0] Old Oak Woodlands
- [1355] Otter (*Lutra lutra*)

The vegetation over most of Wicklow Mountains SAC is a mosaic of heath, blanket bog and upland grassland (mostly on peaty soil, though some on mineral soil), stands of dense Bracken (*Pteridium aquilinum*), and small woodlands mainly along the rivers. Mountain loughs and corrie lakes are scattered throughout the site.

The two dominant vegetation communities in the area are heath and blanket bog. Heath vegetation, with both wet and dry heath well represented, occurs in association with blanket bog, upland acid grassland and rocky habitats. The wet heath is characterised by species such as Heather (*Calluna vulgaris*), Cross-leaved Heath (*Erica tetralix*), cottongrasses (*Eriophorum* spp.), Tormentil (*Potentilla erecta*), Mat-grass (*Nardus stricta*), bent grasses (*Agrostis* spp.) and bog mosses (*Sphagnum* spp.). In places the wet heath occurs in conjunction with flush communities and streamside vegetation, and here species such as Heath Rush (*Juncus squarrosus*) and sedges (*Carex* spp.) are found. Dry heath at this site is confined to shallow peaty soils on steep slopes where drainage is better and particularly in sheltered conditions. It is characterised by species such as Heather, gorse (*Ulex* spp.), Bell Heather (*Erica cinerea*), Bilberry (*Vaccinium myrtillus*), Purple Moor-grass (*Molinia caerulea*) and lichens (*Cladonia* spp.). In places the heath grades into upland grassland on mineral soil.

Blanket bog is usually dominated by cottongrasses, Heather and bog mosses. On steeper slopes there is some flushing and here Purple Moor-grass, Heath Rush and certain *Sphagnum* species become more common. The Liffey Head blanket bog is among the best of its kind in eastern Ireland, with deep peat formations and an extensive system of dystrophic pools developed among the hummocks and hollows on the bog surface. The vegetation is largely dominated by Heather and Cross-leaved Heath, with cottongrasses (*Eriophorum vaginatum* and *E. angustifolium*), Deergrass (*Scirpus cespitosus*) and Bog Asphodel (*Narthecium ossifragum*). In drier areas, Bilberry and Cowberry (*Vaccinium vitis-idaea*) are common, while the scarce Bog-rosemary (*Andromeda polifolia*) is also found. Blanket bog occurs over extensive areas of deeper peat on the plateau and also on gentle slopes at high altitudes.

Due to the underlying rock strata, the water of the rivers and streams is acid rather than alkaline. The water is generally oligotrophic and free from enrichment. The lakes within the area range from the high altitude lakes of Lough Firrib and Three Lakes, to the lower pater-noster lakes of Glendalough, Lough Tay and Lough Dan. Spectacular corrie lakes, such as Loughs Bray (Upper and Lower), Ouler, Cleevaun, Arts, Kellys and Nahanagan, exhibit fine sequences of moraine stages. The deep lakes are characteristically species-poor, but hold some interesting plants including an unusual form of Quillwort (*Isoetes lacustris* var. *morei*), a stonewort (*Nitella* sp.) and Floating Bur-reed (*Sparganium angustifolium*).

Alpine vegetation occurs on some of the mountain tops, notably in the Lugnaquilla area, and also on exposed cliffs and scree slopes elsewhere in the site. Here alpine heath vegetation is represented with heath species such as Crowberry (*Empetrum nigrum*) and Cowberry, and others such as Dwarf Willow (*Salix herbacea*), the grey-green moss *Racomitrium lanuginosum,* and scarce species such as Mountain Clubmoss (*Diphasiastrum alpinum*), Firmoss (*Huperzia selago*), and Starry Saxifrage (*Saxifraga stellaris*). Some rare arctic-alpine species have been recorded, including Alpine Lady's-mantle (*Alchemilla alpina*) and Alpine Saw-wort (*Saussurea alpina*).

Old lead mine workings at Glendasan support an estimated 3.6 hectares of Calaminarian Grassland, with a suite of rare metallophyte (metal-loving) bryophytes, including the moss *Ditrichum plumbicola* and the liverworts *Cephaloziella massalongi* and *C. nicholsonii*.

Small areas of old oakwood (Blechno-Quercetum petraeae type) occur on the slopes of Glendalough and Glenmalure, near Lough Tay and Lough Dan, with native Sessile Oak (*Quercus petraea*) trees, many of which are 100-120 years old. On wetter areas, wet broadleaved semi-natural woodlands occur which are dominated by Downy Birch (*Betula pubescens*). Mixed woodland with non-native tree species also occurs.

The site supports a range of rare plant species. Parsley Fern (*Cryptogramma crispa*), Marsh Clubmoss (*Lycopodiella inundata*), Lanceolate Spleenwort (*Asplenium billotii*), Small-white Orchid (*Pseudorchis albida*) and Bog Orchid (*Hammarbya paludosa*) are all legally protected under the Flora (Protection) Order, 2015. Greater Broomrape (*Orobanche rapum-genistae*), Alpine Saw-wort and Alpine Lady's-mantle are listed in the Irish Red Data Book. The rare Myxomycete fungus *Echinostelium colliculosum* has been recorded from the Military Road.

The Red Data Book fish species Arctic Char has been recorded from Lough Dan, but this population may now have died out.

Mammals and birds which occur are typical of the uplands. Deer are abundant, mainly hybrids between Red and Sika Deer. Other mammals include Hare, Badger and Otter, the latter being a species listed on Annex II of the E.U. Habitats Directive. Pine Marten has recently been confirmed as occurring within the site. Among the birds, Meadow Pipit, Skylark, Raven and Red Grouse are resident throughout the site. Wheatear, Whinchat and the scarce Ring Ouzel are summer visitors. Wood Warbler and Redstarts are rare breeding species of the woodlands. Dipper and Grey Wagtail are typical riparian species. Merlin and Peregrine, both Annex I species of the E.U. Birds Directive, breed within the site. Recently, Goosander has become established as a breeding species.

Large areas of the site are owned by the National Parks and Wildlife Service (NPWS) and are managed for nature conservation based on traditional land uses of upland areas. The most common land use is traditional sheep grazing, but others include turf cutting, mostly hand-cutting but some machine-cutting also occurs. These activities are largely confined to the Military Road, where there is easy access. Large areas which had been previously hand-cut and are now abandoned are regenerating.

In the last 40 years, forestry has become an important land use in the uplands, and has affected both the wildlife and the hydrology of the area. Amenity use is very high, with Dublin city close to the site. Peat erosion is frequent on the peaks. This may be a natural process, but is likely to be accelerated by activities such as grazing.

Wicklow Mountains is important as a complex, extensive upland site. It shows great diversity from a geomorphological and a topographical point of view. The vegetation provides examples of the typical upland habitats with heath, blanket bog and upland grassland covering large, relatively undisturbed areas. In all, twelve habitats listed on Annex I of the E.U. Habitats Directive are found within the site. Several rare or protected plant and animal species occur, adding further to its value.

Appendix C

Attributes, measures and targets supporting the maintenance or restoration of favourable conservation status of dune habitats at Buckroney-Brittas Dunes and Fen SAC (taken from NPWS 2017)

1210 Annual vegetation of drift lines		
Attribute	**Measure**	**Target**
Habitat area	Hectares	Area stable or increasing, subject to natural processes, including erosion and succession. For the sub-site mapped: Pennycomequick - 0.48ha.
Habitat distribution	Occurrence	No decline or change in habitat distribution, subject to natural processes.
Physical structure: functionality and sediment supply	Presence/absence of physical barriers	Maintain the natural circulation of sediment and organic matter, without any physical obstructions
Vegetation structure: zonation	Occurrence	Maintain the range of coastal habitats including transitional zones, subject to natural processes including erosion and succession
Vegetation composition: typical species and sub-communities	Percentage cover at a representative number of monitoring stops	Maintain the presence of species-poor communities with typical species: sea rocket (*Cakile maritima*), sea sandwort (*Honckenya peploides*), prickly saltwort (*Salsola kali*) and oraches (*Atriplex* spp.)
Vegetation composition: negative indicator species	Percentage cover	Negative indicator species (including non-native species) to represent less than 5% cover
1220 Perennial vegetation of stony banks		
Attribute	**Measure**	**Target**
Habitat area	Hectares	Area stable or increasing, subject to natural processes, including erosion and succession.
Habitat distribution	Occurrence	No decline or change in habitat distribution, subject to natural processes.
Physical structure: functionality and sediment supply	Presence/absence of physical barriers	Maintain the natural circulation of sediment and organic matter, without any physical obstructions
Vegetation structure: zonation	Occurrence	Maintain the range of coastal habitats including transitional zones, subject to natural processes including erosion and succession
Vegetation composition: typical species and sub-communities	Percentage cover at a representative number of monitoring stops	Maintain the typical vegetated shingle flora including the range of sub-communities within the different zones

Vegetation composition: negative indicator species	Percentage cover	Negative indicator species (including non-native species) to represent less than 5% cover
1410 Mediterranean salt meadows (Juncetalia maritimi)		
Attribute	**Measure**	**Target**
Habitat area	Hectares	Area stable or increasing, subject to natural processes, including erosion and succession.
Habitat distribution	Occurrence	No decline or change in habitat distribution, subject to natural processes.
Physical structure: functionality and sediment supply	Presence/absence of physical barriers	Maintain the natural circulation of sediment and organic matter, without any physical obstructions
Physical structure: creeks and pans	Occurrence	Maintain creek and pan structure, subject to natural processes including erosion and succession
Physical structure: flooding regime	Hectares flooded; frequency	Maintain natural tidal regime
Vegetation structure: zonation	Occurrence	Maintain the range of coastal habitats including transitional zones, subject to natural processes including erosion and succession
Vegetation structure: vegetation height	Centimetres	Maintain structural variation in the sward
Vegetation structure: vegetation cover	Percentage cover at a representative number of monitoring stops	Maintain more than 90% of the area outside of creeks vegetated
Vegetation composition: typical species and sub-communities	Percentage cover at a representative number of monitoring stops	Maintain range of sub-communities with typical species listed in McCorry and Ryle (2009)
Vegetation composition: negative indicator species - *Spartina anglica*	Hectares	There is no record of common cordgrass (*Spartina anglica*) in the SAC and its establishment should be prevented

2110 Embryonic shifting dunes		
Attribute	**Measure**	**Target**
Habitat area	Hectares	Area stable or increasing, subject to natural processes including erosion and succession. For the sub-sites mapped: Brittas Bay - 2.02ha; Mizen Head - 0.22ha; Pennycomequick - 0.35ha.
Habitat distribution	Occurrence	No decline or change in habitat distribution, subject to natural processes.
Physical structure: functionality and sediment supply	Presence/absence of physical barriers	Maintain the natural circulation of sediment and organic matter, without any physical obstructions
Vegetation structure: zonation	Occurrence	Maintain the range of coastal habitats including transitional zones, subject to natural processes including erosion and succession
Vegetation composition: plant health of foredune grasses	Percentage cover	More than 95% of sand couch grass (*Elytrigia juncea*) and/or lyme-grass (*Leymus arenarius*) should be healthy (i.e. green plant parts above ground and flowering heads present)
Vegetation composition: typical species and sub-communities	Percentage cover at a representative number of monitoring stops	Maintain the presence of species-poor communities with typical species: sand couch grass (*Elytrigia juncea*) and/or lyme-grass (*Leymus arenarius*)
Vegetation composition: negative indicator species	Percentage cover	Negative indicator species (including non-native species) to represent less than 5% cover
2120 Shifting dunes along the shoreline with Ammophila arenaria (white dunes)		
Attribute	**Measure**	**Target**
Habitat area	Hectares	Area stable or increasing, subject to natural processes including erosion and succession. For the sub-sites mapped: Brittas Bay - 3.64ha; Pennycomequick - 0.7ha.
Habitat distribution	Occurrence	No decline or change in habitat distribution, subject to natural processes.
Physical structure: functionality and sediment supply	Presence/absence of physical barriers	Maintain the natural circulation of sediment and organic matter, without any physical obstructions

Vegetation structure: zonation	Occurrence	Maintain the range of coastal habitats including transitional zones, subject to natural processes including erosion and succession
Vegetation composition: plant health of dune grasses	Percentage cover	More than 95% of marram grass (*Ammophila arenaria*) and/or lymegrass (*Leymus arenarius*) should be healthy (i.e. green plant parts above ground and flowering heads present)
Vegetation composition: typical species and sub-communities	Percentage cover at a representative number of monitoring stops	Maintain the presence of species-poor communities dominated by marram grass (*Ammophila arenaria*) and/or lymegrass (*Leymus arenarius*)
Vegetation composition: negative indicator species	Percentage cover	Negative indicator species (including non-native species) to represent less than 5% cover
2130 Fixed coastal dunes with herbaceous vegetation (grey dunes)		
Attribute	**Measure**	**Target**
Habitat area	Hectares	Area stable or increasing, subject to natural processes including erosion and succession. For the sub-sites mapped: Brittas Bay - 52.03ha; Mizen Head - 46.4ha; Pennycomequick - 11.15ha.
Habitat distribution	Occurrence	No decline or change in habitat distribution, subject to natural processes.
Physical structure: functionality and sediment supply	Presence/absence of physical barriers	Maintain the natural circulation of sediment and organic matter, without any physical obstructions
Vegetation structure: zonation	Occurrence	Maintain the range of coastal habitats including transitional zones, subject to natural processes including erosion and succession
Vegetation structure: bare ground	Percentage cover	Bare ground should not exceed 10% of fixed dune habitat, subject to natural processes
Vegetation structure: sward height	Centimetres	Maintain structural variation within sward
Vegetation composition: typical species and sub-communities	Percentage cover at a representative number of monitoring stops	Maintain range of sub-communities with typical species listed in Delaney et al. (2013)

Vegetation composition: negative indicator species (including *Hippophae rhamnoides*)	Percentage cover	Negative indicator species (including non-native species) to represent less than 5% cover
Vegetation composition: scrub/trees	Percentage cover	No more than 5% cover or under control
2150 Atlantic decalcified fixed dunes (Calluno-Ulicetea)		
Attribute	**Measure**	**Target**
Habitat area	Hectares	Area stable or increasing, subject to natural processes including erosion and succession. For the sub-site mapped: Brittas Bay - 0.26ha.
Habitat distribution	Occurrence	No decline or change in habitat distribution, subject to natural processes.
Physical structure: functionality and sediment supply	Presence/absence of physical barriers	Maintain the natural circulation of sediment and organic matter, without any physical obstructions
Vegetation structure: zonation	Occurrence	Maintain the range of coastal habitats including transitional zones, subject to natural processes including erosion and succession
Vegetation structure: bare ground	Percentage cover	Bare ground should not exceed 10% of the dune habitat, subject to natural processes
Vegetation structure: sward height	Centimetres	Maintain structural variation within sward
Vegetation composition: typical species and sub-communities	Percentage cover at a representative number of monitoring stops	Maintain range of sub-communities with typical species listed in Delaney et al. (2013)
Vegetation composition: negative indicator species	Percentage cover	Negative indicator species (including non-native species) to represent less than 5% cover
Vegetation composition: scrub/trees	Percentage cover	No more than 5% cover or under control

2170 Dunes with Salix repens ssp. argentea (Salicion arenariae)		
Attribute	**Measure**	**Target**
Habitat area	Hectares	Area stable or increasing, subject to natural processes including erosion and succession. For the sub-sites mapped: Brittas Bay - 0.13ha; Mizen Head - 0.07ha.
Habitat distribution	Occurrence	No decline or change in habitat distribution, subject to natural processes.
Physical structure: functionality and sediment supply	Presence/absence of physical barriers	Maintain the natural circulation of sediment and organic matter, without any physical obstructions
Vegetation structure: zonation	Occurrence	Maintain the range of coastal habitats including transitional zones, subject to natural processes including erosion and succession
Vegetation structure: bare ground	Percentage cover	Bare ground should not exceed 10% of the dune habitat, subject to natural processes
Vegetation structure: sward height	Centimetres	Maintain structural variation within sward
Vegetation composition: typical species and sub-communities	Percentage cover at a representative number of monitoring stops	Maintain range of sub-communities with typical species listed in Delaney et al. (2013)
Vegetation composition: cover and height of *Salix repens*	Percentage cover; centimetres	Maintain more than 10% cover of creeping willow (*Salix repens*); vegetation height should be in the average range of 5-20cm
Vegetation composition: negative indicator species (including *Hippophae rhamnoides*)	Percentage cover at a representative number of monitoring stops	Negative indicator species (including non-native species) to represent less than 5% cover
Vegetation composition: scrub/trees	Percentage cover	For trees and scrub other than creeping willow (*Salix repens*), there should be no more than 5% cover or their presence should be under control

2190 Humid dune slacks		
Attribute	**Measure**	**Target**
Habitat area	Hectares	Area stable or increasing, subject to natural processes including erosion and succession. For the sub-sites mapped: Brittas Bay - 0.34ha; Mizen Head - 4.76ha; Pennycomequick - 0.10ha.
Habitat distribution	Occurrence	No decline or change in habitat distribution, subject to natural processes.
Physical structure: functionality and sediment supply	Presence/absence of physical barriers	Maintain the natural circulation of sediment and organic matter, without any physical obstructions
Physical structure: hydrological and flooding regime	Water table levels; groundwater fluctuations (metres)	Maintain natural hydrological regime
Vegetation structure: zonation	Occurrence	Maintain the range of coastal habitats including transitional zones, subject to natural processes including erosion and succession
Vegetation structure: bare ground	Percentage cover	Bare ground should not exceed 5% of dune slack habitat, with the exception of pioneer slacks which can have up to 20% bare ground
Vegetation structure: sward height	Centimetres	Maintain structural variation within sward
Vegetation composition: typical species and sub-communities	Percentage cover at a representative number of monitoring stops	Maintain range of sub-communities with typical species listed in Delaney et al. (2013)
Vegetation composition: cover of *Salix repens*	Percentage cover	Maintain less than 40% cover of creeping willow (*Salix repens*)
Vegetation composition: negative indicator species	Percentage cover	Negative indicator species (including non-native species) to represent less than 5% cover
Vegetation composition: scrub/trees	Percentage cover	No more than 5% cover or under control

Appendix D

Marine mammal Risk assessment and Marine Mammal Observer records during site investigation works, and sound information and exposure criteria reproduced from Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters (Department of Arts, Heritage and the Gaeltacht, January 2014)

D1 Protected marine mammals risk assessment

Marine mammal sensory systems are adapted to life in the water or, in the case of seals, both in water and on land. The sound receiving systems of marine mammals have become specialised to meet the physical demands of water and to diving to considerable depth, while retaining many of the characteristics of land mammals (e.g., ear canal, air-filled middle ear, spiral cochlea of the inner ear). Marine mammals rely on sound to navigate, to communicate with one another and to sense and interpret their surroundings.

Cetacean species may currently be distinguished by three groupings related to their known auditory ability and functional frequencies. Seal species that occur in Irish waters, and other pinniped species occurring elsewhere, demonstrate differing auditory ability in air and in water, so from a functional point of view they may be subdivided into two groups: (i) pinnipeds in water, and (ii) pinnipeds in air (Table 1). Further information on marine mammal noise exposure criteria for permanent injury and for disturbance/behavioural response is given in Appendix C2.

Cetaceans			Pinnipeds	Pinnipeds
Low frequency	*Mid-frequency*	*High frequency*	*in water*	*in air*
7 Hz-22 kHz	150 Hz-160 kHz	200 Hz-180 kHz	75 Hz-75 kHz	75 Hz-30 kHz
Baleen whales	Most toothed whales, dolphins	Certain toothed whales, porpoises	All species	All species
Species- Ireland Humpback whale Blue whale Fin whale Sei whale Minke whale	*Species- Ireland* Sperm whale Killer whale Long-finned pilot whale Beaked whale species Dolphin species	*Species- Ireland* Pygmy sperm whale Harbour porpoise	*Species- Ireland* Grey seal Harbour seal	*Species- Ireland* Grey seal Harbour seal

Table 1: Functional frequency ranges in Cetacean and Seal species. Reproduced from Department of Arts, Heritage and the Gaeltacht (January 2014); Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters

Due to the concern regarding levels of anthropogenic sound associated with human activities in the marine environment, there is a growing body of literature and metrics describing the sound pressure level (SPL), sound exposure level (SEL) and other acoustic characteristics associated with specific machinery, vessels and operations, examples of which are given in Appendix C, reproduced from the Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters.

With reference to the Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters (Department of Arts, Heritage and the Gaeltacht, January 2014), and to the descriptions of the proposed works described in Section 4 of this report, the proposed development works at Arklow include the works summarised below.

1. Construction of the short sea outfall, within a temporary coffer dam requiring the insertion and removal of sheet piles. A sheet piling method has not been specified, but can be expected to be carried out either by impact hammer or by vibrating head (including low vibration piling). These two piling methods have different sound generating characteristics, with impact hammer pile driving representing a worst case scenario. Pile driving strikes have generally been reported to produce low frequency pulse sounds of several tens of Hz to several thousand Hz (and up to approximately 20 kHz), with some technologies introducing underwater sound at comparatively high sound pressure levels exceeding 220 dB re: 1 μPa (Appendix C 1). This presents the possibility of permanent hearing injury (i.e., PTS), temporary hearing loss (i.e., TTS) or other injury for some marine mammals in close proximity to such operations (Appendix C 2, Department of Arts, Heritage and the Gaeltacht, January 2014).
2. Construction of the long sea outfall would include works from both the land and sea. It is expected that several vessels may be required during the construction of the outfall and that diving support is likely to be required at times. Three possible methodologies have been identified:
   - Horizontal directional drilling method;
   - Flood and float method; and
   - Bottom-pull method,

   of which the latter two methods require dredging of a trench within which the long sea outfall pipe would be laid.

   In addition to the sound from attendant vessels, dredging operations have been reported to produce low frequency omnidirectional sound of several tens of Hz to several thousand Hz (and up to approximately 20 kHz) at sound pressure levels of 135-186 dB re: 1 μPa. Therefore some coastal dredging operations can be detected at received levels (RL) exceeding ambient sound more than 10km from shore3. While sound exposure levels from such operations are thought to be below that expected to cause injury to a marine mammal, they have the potential to cause lower level disturbance, masking or behavioural impacts, for example.

   Drilling is generally acknowledged to produce moderate levels of continuous omnidirectional sound at low frequency (several tens of Hz to several thousand Hz and up to c.10 kHz). Source sound pressure levels have generally been reported to lie within the 145-190 dB re: 1 μPa range. While sound exposure levels from such operations are thought to be below that expected to cause injury to a marine mammal, they have the potential to cause lower level disturbance, masking or behavioural impacts, for example.
3. Upgrading the revetment would require the removal of the existing rock revetment and its subsequent realignment and replacement of the rock armour. Construction of the upgraded revetment would be carried out from toe to crest by using suitable excavators located on the WwTP site. As a worst case scenario, noise levels are expected to be similar to those arising from dredging works.

In addition to the works in marine waters listed above, sheet piling is also likely to be required within the Avoca River estuary.

Occurrence of marine mammals in the vicinity of the proposed works

Harbour Porpoise, Bottle-nosed Dolphin, Harbour Seal and Grey Seal have been recorded in the vicinity of the proposed works occasionally, and in small numbers (see Section XX of this report). This area is not known to hold important concentrations of these species. Identified areas of importance for these species are located at a distance of at least 50km from the proposed works area. A total of 30 MMO watches, with a total duration of 268 hours of observations, were carried out during the 30 minutes prior to, and during site investigation works conducted in respect of the proposed development. No marine mammals were recorded. The risk of cetaceans and seals being present in coastal waters during works is therefore assessed as low.

Additional marine mammal species recorded in coastal and offshore waters near Arklow are Common Dolphin, Striped Dolphin, Risso's Dolphin, and Minke Whale. This area is not known to hold important concentrations of these species. Identified areas of importance for these species are located at a distance of at least 50km from the proposed works area.

In-combination activities include existing boat traffic entering and leaving Arklow Port, and existing activities at the quarry at Arklow Head. The Arklow Flood Relief Scheme works will include dredging works within the Avoca River estuary both upstream and downstream of Arklow Bridge.

D2 Marine Mammal Observer records carried out during site investigation works

MARINE MAMMAL RECORDING FORM - LOCATION AND EFFORT DATA (COASTAL WORKS*)

PROJECT No: 17-0167

CAUSEWAY GEOTECH

Location: ARKLOW BAY

Operated by: Causeway Geotech Limited

Platform type/name: "OCMeo" Jack-Up Barge and OCM Baby Blue

Contracting Body: Byrne Looby ARUP Joint Venture

Please record the following information every day even if no marine mammals are seen.

Date	Observer name	Time you started looking for marine mammals	Time you stopped looking for marine mammals	Length of time of target operations while you were looking for marine mammals (mins)	Wind force and direction (use Beaufort scale)	Sea state (WMO Sea State Code)	Swell Choose from: 0 = no Swell 1 = <1 m 2 = 1-2 m 3 = 2+ m	Visibility Choose from: 1 = < 1 km 2 = 1-5 km 3 = > 5 km	Were marine mammals present in the time before the target operations began and how long before?	If marine mammals were present, what action was taken? (e.g. delay, none)
22/08/17	S. Graydon	13:00	19:00	360 mins	3 SW	1	0	1	No	-
23/08/17	S. Graydon	07:00	17:00	600 mins	2 S	1	0	2	No	-
24/08/17	S. Graydon	07:00	17:30	630 mins	3 SW	1	0	3	No	-
25/08/17	S. Graydon	07:00	19:00	720 mins	3 SSW	1	0	3	No	-
29/08/17	S. Graydon	11:30	19:00	450 mins	2 S	1	0	3	No	-
30/08/17	S. Graydon	07:00	19:00	720 mins	3 SW	1	0	2	No	-
31/08/17	S. Graydon	07:00	18:45	705 mins	2 SE	1	0	3	No	-
01/09/17	S. Graydon	12:30	17:00	270 mins	3 S	1	0	3	No	-
04/09/17	S. Graydon	08:00	19:00	540 mins	2 E	1	0	1	No	-
05/09/17	S. Graydon	07:00	13:00	360 mins	3 SE	1	0	2	No	-
07/09/17	S. Graydon	12:30	19:00	390 mins	3 W	3	2	2	No	-
08/09/17	S. Graydon	07:00	19:00	720 mins	4 NW	1	2	3	No	-
19/09/17	S. Graydon	07:00	19:00	720 mins	3 SSW	1	1	3	No	-
20/09/17	S. Graydon	07:00	9:30	150 mins	3 WSW	2	2	2	No	-
20/09/17	S. Graydon	18:30	19:30	60 mins	3 SW	2	2	2	No	-
21/09/17	S. Graydon	07:00	19:00	720 mins	3 - 4 W	2	1	3	No	-
26/09/17	S. Graydon	07:00	19:00	720 mins	3 – 5 SE	1	1	2	No	-
28/09/17	S. Graydon	07:00	13:00	360 mins	2 – 3 S	3	1	3	No	-
29/09/17	S. Graydon	09:30	10:30	60 mins	5 – 6 NW	3	1	2	No	-
30/09/17	S. Graydon	07:00	19:00	720 mins	3 – 4 SW	2	1	3	No	-
08/10/17	S. Graydon	10:00	19:00	540 mins	1 – 2 W	1	1	3	No	-
09/10/17	S. Graydon	07:00	19:00	720 mins	2 – 3 WSW	1	1	3	No	-
10/10/17	S. Graydon	07:00	17:00	600 mins	3 – 5 SW	2	2	3	No	-
26/10/17	S. Graydon	07:00	19:00	720 mins	3 – 4 W	2	1	1	No	-
27/10/17	S. Graydon	07:00	19:00	720 mins	2 – 4 NE	1	1	3	No	-
28/10/17	S. Graydon	07:00	15:00	480 mins	3 – 5 S	2	2	1	No	-
02/11/17	L. Newland	07:00	17:00	600 mins	1 – 2 W	1	0	3	No	-
03/11/17	L. Newland	07:00	17:00	600 mins	1 – 2 SW	1	0	3	No	-
06/11/17	L. Newland	08:00	20:00	720 mins	2 – 3 SE	1	0	3	No	-
07/11/17	L. Newland	07:00	14:00	420 mins	1 – 2 NW	1	0	3	No	-

*Coastal works are any operations outside of acoustic seafloor surveys where mitigation for potential impacts of marine noise are required for marine mammals e.g. dredging, pile-driving etc.

D3 Examples of general underwater sound information from a range of anthropogenic sources

Appendix 1 - Examples of general underwater sound information from a range of anthropogenic sources, ordered by their potential for introduction of high level sound (based on information in Hildebrand[1]; Richardson *et al.*[3]; OSPAR[45]; Nedwell & Howell[52]).

Source	Sound Pressure Level dB re: 1μPa @1m	Sound Exposure Level dB re: $1\mu Pa^2$-s	Sound Duration seconds	Peak Frequency Hz	Band Width Hz	Direction
Ship Shock Trial (10,000 lbs TNT)	299	302	2 s	Low	Broad	Omni
Explosives (1-100lbs TNT)	272-287	-	0.001-0.01	6-21	2-1,000	Omni
Airgun Array (2000 psi, 8000 in^3)	256	241	0.03 s	50	150	Vertical
Pile-driving (4m diameter monopile)	192-261	210-215	-	-	100-1,000	Omni
Military Sonar (SURTASS/LFA)	235	243	6-100 s	250	30	Horizontal
Multibeam echosounder (hull-mounted)	235	218	0.02 s	12,000	Narrow	Vertical
Super Tanker 337m long @ 18 knots	185	-	constant	23	5-100	Omni
Drilling (Ship/Semi-submersible)	145-191	-	constant	-	1-600	Omni
Dredging (Suction/Hopper dredge)	177	-	constant	80-200	20-8,000	Omni
Acoustic Harassment Device (AHD)	185	185	0.5-2.0 s	10,000	600	Omni
Tug vessel (while towing)	145-170	-	constant	-	37-5,000	Omni
Wind turbine (power output - 1MW)	142-153		constant	16	15-20,000	Omni
Fishing vessel (12m long @ 7 knots)	150		constant	300	250-1000	Omni
Acoustic Deterrent Device (ADD)	132	127	0.3 s	10,000	2000	Omni

Reproduced from Department of Arts, Heritage and the Gaeltacht (January 2014); Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters

D4 Transcription of marine mammal noise exposure criteria

Appendix 3 – Transcription of marine mammal noise exposure criteria given by Southall *et al*.23. Table B includes received levels (RL) from multiple pulse and non-pulse sound events reported to elicit significant behavioural responses* in previous studies. [* w.r.t. Irish-occurring species]

A, Criteria for Permanent Injury - estimated values for PTS-onset.

Cetaceans			Pinnipeds	Pinnipeds
Low frequency	*Mid-frequency*	*High frequency*	*In Water*	*In Air*
7 Hz-22 kHz	150 Hz-160 kHz	200 Hz-180 kHz	75 Hz-75 kHz	75 Hz-30 kHz
Baleen whales	Most toothed whales, dolphins	Certain toothed whales, porpoises	All species	All species
Single Pulse: 230 dB SPL 198 dB SEL	Single Pulse: 230 dB SPL 198 dB SEL	Single Pulse: 230 dB SPL 198 dB SEL	Single Pulse: 218 dB SPL 186 dB SEL	Single Pulse: 149 dB SPL 144 dB SEL
Multiple Pulse: 230 dB SPL 198 dB SEL	Multiple Pulse: 230 dB SPL 198 dB SEL	Multiple Pulse: 230 dB SPL 198 dB SEL	Multiple Pulse: 218 dB SPL 186 dB SEL	Multiple Pulse: 149 dB SPL 144 dB SEL
Non-pulses: 230 dB SPL 215 dB SEL	Non-pulses: 230 dB SPL 215 dB SEL	Non-pulses: 230 dB SPL 215 dB SEL	Non-pulses: 218 dB SPL 203 dB SEL	Non-pulses: 149 dB SPL 144.5 dB SEL

B. Criteria and values for TTS-onset (single pulses only) and Disturbance/Behavioural Response (multiple pulses and non-pulses).

Cetaceans			Pinnipeds	Pinnipeds
Low frequency	*Mid-frequency*	*High frequency*	*In Water*	*In Air*
7 Hz-22 kHz	150 Hz-160 kHz	200 Hz-180 kHz	75 Hz-75 kHz	75 Hz-30 kHz
Baleen whales	Most toothed whales, dolphins	Certain toothed whales, porpoises	All species	All species
Single Pulse: 224 dB SPL 183 dB SEL	Single Pulse: 224 dB SPL 183 dB SEL	Single Pulse: 224 dB SPL 183 dB SEL	Single Pulse: 212 dB SPL 171 dB SEL	Single Pulse: 109 dB SPL 100 dB SEL
Multiple Pulse: 120-180 dB RL Not applicable	Multiple Pulse: 120-180 dB RL Not applicable	Multiple Pulse: Data unavailable Not applicable	Multiple Pulse: 150-200 dB RL Not applicable	Multiple Pulse: Data unavailable Not applicable
Non-pulses: 120-160 dB RL Not applicable	Non-pulses: 90-200 dB RL Not applicable	Non-pulses: 90-170 dB RL Not applicable	Non-pulses: 100+ dB RL Not applicable	Non-pulses: 110-120 dB RL Not applicable

* Units of measurement:
Sound Pressure Level, SPL (in water): measured in dB re: 1 μPa (peak) (flat)
Sound Exposure Level, SEL (in water): measured in dB re: 1 μPa^2-s
Sound Pressure Level, SPL (*in air*): measured in dB re: 20 μPa (peak) (flat)
Sound Exposure Level, SEL (*in air*): measured in dB re: $(20\ \mu Pa)^2$-s

Reproduced from Department of Arts, Heritage and the Gaeltacht (January 2014); Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters

Appendix E

Coastal Processes Report

Irish Water

Arklow Wastewater Treatment Plant Project

Coastal processes assessment

247825-00

Issue | 29 August 2018

Job number 247825-00

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Contents

Appendices

1 Introduction

1.1 Aim

As part of the Arklow Wastewater Treatment Plant Project (the proposed development), Arup has been commissioned to design revetment upgrade works for the length of the rock revetment adjacent to the proposed wastewater treatment plant site (WwTP site) as well as a storm water overflow (SWO) which will discharge at the toe of the revetment and a long sea outfall, discharging treated effluent, extending into the Irish Sea by approximately 900 m.

This report examines the existing coastal processes in the area and assesses the likely significant effects that the proposed revetment, the long sea outfall and the SWO at the WwTP may have on the coastal system either during the construction and/or operation of the proposed development. This report supports the Environmental Impact Assessment Report (EIAR) which has been prepared for the proposed development.

It should be noted that this report examines the effect of the proposed revetment, SWO and sea outfall works included as part of the proposed development on the dynamic coastal system only. The assessment of any other relevant aspects is documented separately in the EIAR [1].

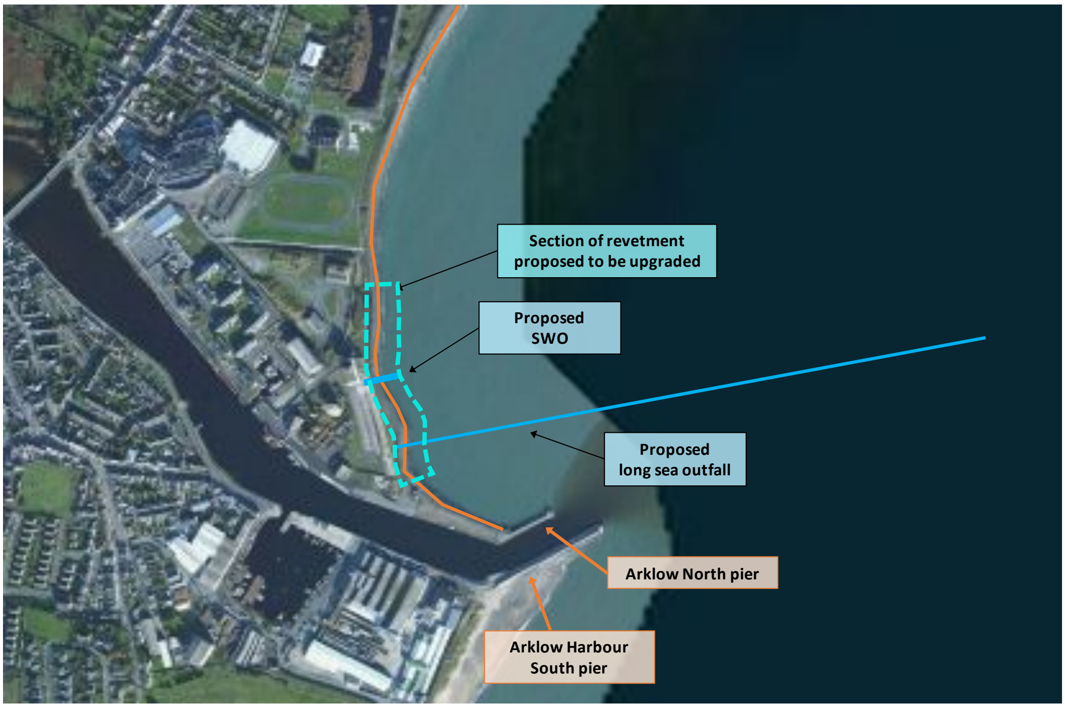
1.2 Site

The WwTP site is located due north of the entrance to Arklow Harbour, which is at the mouth of the Avoca River. The rock revetment that is currently in place runs between the river mouth and Arklow North Beach (see Figure 1).

The section of the existing revetment that is proposed to be upgraded, as well as the approximate location of the proposed outfalls is shown in Figure 2.

Figure 1: Location of the proposed WwTP development (Source: Google Maps - ©2014 Google).

Figure 2: Overview of the proposed revetment, SWO and sea outfall works (Source: Google Maps - ©2014 Google).



2 Proposed development

2.1 Scope of works

The proposed development will include a new Wastewater Treatment Plant and associated infrastructure, including the upgrade of an existing rock revetment, a SWO and a long sea outfall.

This section refers to the elements of the proposed Arklow WwTP development that are relevant for assessing the likely significant effects on the existing coastal processes, i.e. the rock revetment, the SWO and the long sea outfall.

A summary of the reasonable worst case based on the specimen design of these elements as well as the reasonable worst case construction methodology that is envisaged the contractor would follow is presented herein.

2.2 Procurement strategy

Overview

Irish Water intends to procure the detailed design and construction of the proposed development using a Design and Build contract. This form of contract has the benefit of encouraging innovation and value engineering, particularly for a project of this nature and scale, by giving the contractor ownership of both the detailed design and construction phases. Design and Build contracts traditionally also lead to shorter construction programmes. Under this form of contract the successful contractor will ultimately be responsible for the final detailed design of the proposed development, within the constraints as outlined herein.

The contractor is required to comply with all of the performance requirements set out in the tender documentation including the statutory consent approvals which may be granted by An Bord Pleanála, Department of Housing Planning and Local Government, EPA and other statutory stakeholders.

Design

Irish Water has developed a specimen design of the proposed development for assessment within this EIAR. This EIAR has considered the likely significant effects on the environment associated with our specimen design. The contractor will develop this design further, including final dimensions and details of the various elements, in accordance with the proposed mitigation measures, and any conditions that may be prescribed as part of the consent for the proposed development, ensuring that there is no material change in terms of significant effects on the environment.

As such, the assessment herein is considered to be the 'reasonable worst case scenario' in terms of significant environmental effects with regard to the overall planning boundary of the proposed development. The detailed design by the contractor should seek to identify opportunities for reducing further any significant adverse environmental effects where practicable.

Construction

The approach to construction describes the main construction activities that are relevant for the reasonable worst case assessment of likely significant environmental effects. The approach is considered to be the reasonable worst case scenario, given the existing site constraints, the adjacent land uses and the various construction methodologies which could be considered by the contractor. The construction of the proposed development will require a combination of marine, riverine and land-based works.

It will be the responsibility of the contractor (under the obligations of the contract) to ensure compliance with those measures that have been outlined in this EIAR to avoid and/or reduce significant adverse effects that have been identified. Where the contractor diverts from the methodologies and working areas outlined herein and defined in the granted planning consent, it will be the responsibility of the contractor to obtain the relevant licenses, permits and consents for such changes.

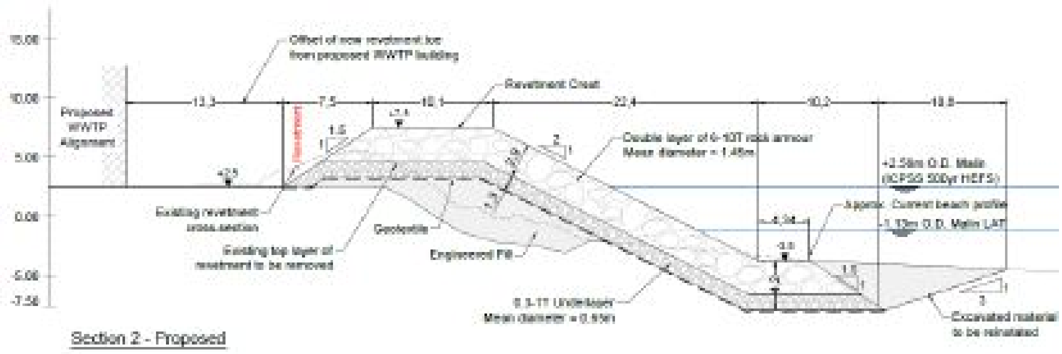
2.3 Revetment

2.3.1 Design

The section of the existing rock armour revetment located adjacent to the site will be upgraded as part of the proposed development. It is proposed that the existing structure will be removed and subsequently replaced along a distance of approximately 350m, as shown in the revetment layout drawings [2] and [3].

The upgraded revetment will consist of a double layer of rock armour of approximately 6 - 10 tonnes (t) with a slope of 1:2 on an underlayer of rock armour of approximately 0.3 - 1t. The designed crest level will be approximately 1 to 3m above the level of the existing revetment crest. Further details on the proposed structure can be found in the revetment cross section drawings [4], [5] and [6] (See Figure 3).

Figure 3: Typical cross section of the proposed revetment.



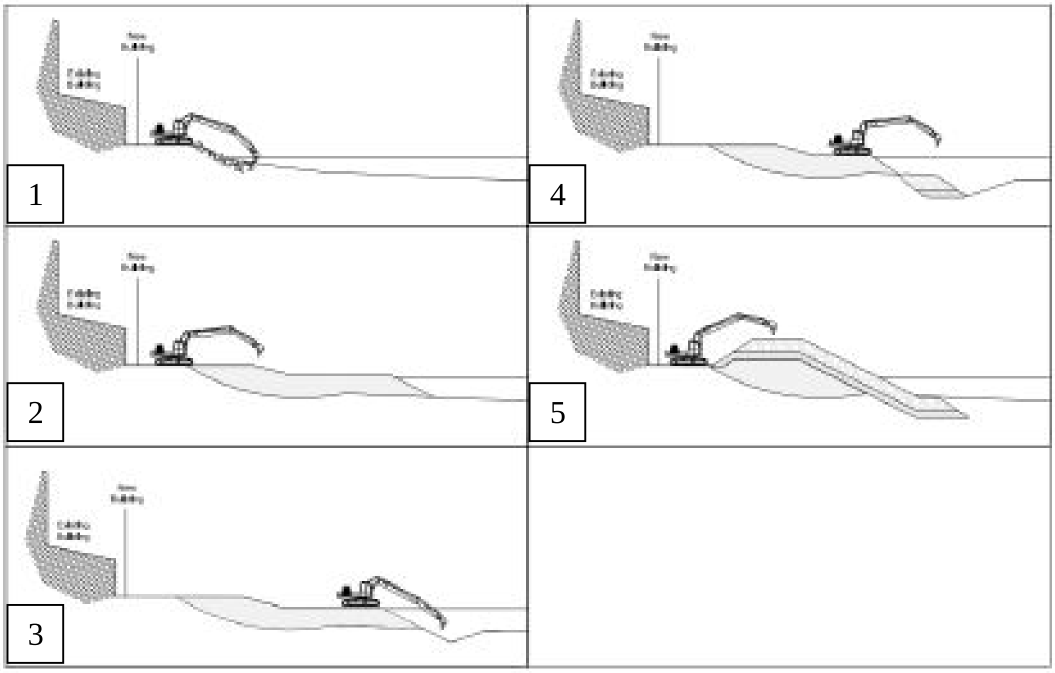
2.3.2 Construction methodology

It is envisaged that the removal of the existing rock revetment and its subsequent upgrade will be carried out in a staged process, in sections of approximately 15 to 25m.

A schematic summary of the envisaged construction methodology for an individual section of revetment is provided in Figure 4. The existing rock armour will be removed from crest to toe, with the installation of the new rock armour carried out from toe to crest to upgrade the revetment. Both construction processes will be carried out by the use of suitable excavators, and a temporary platform may be needed throughout the process.

Suitable fill and rock armour material will be required to upgrade the revetment. It is also envisaged that part of the excavated soil will be reinstated at the toe location, while the rest will be transported to a suitable facility off-site.

Figure 4: Envisaged procedure for the removal and subsequent replacement of the rock revetment.



2.4 SWO and Long Sea Outfall

2.4.1 Design

As part of the proposed development, a Storm Water Overflow (SWO) and a long sea outfall will be provided. These structures will start from the WwTP site, cross through/ underneath the revetment and discharge to the Irish Sea.

While the SWO will discharge excess storm flows in shallow waters, the long sea outfall will continue perpendicular to the revetment for approximately 900 m offshore, discharging the treated effluent at an approximate seabed level of -15m Chart Datum (CD) in relatively deep waters. The proposed locations of the SWO and long sea outfall are shown in Figure 2.

The following sections include a brief description of the proposed SWO and long sea outfall.

2.4.1.1 Storm Water Overflow (SWO)

The SWO pipeline will consist of precast concrete elements with an internal diameter of approximately 2.0m. The pipeline will be routed through the upgraded section of the revetment and the outlet structure will comprise a precast base slab, a headwall and wingwalls installed at the crest of the toe of the revetment. The outlet from the SWO pipe will be fitted with appropriate non-return valves.

2.4.1.2 Long sea outfall

It is expected that the long sea outfall will likely comprise high density polyethylene (HDPE) pipes with an internal diameter of approximately 555mm. Its longitudinal and transversal configuration will be defined based on the construction methodology ultimately followed by the contractor. For the purpose of this coastal assessment, we have considered all relevant construction methods.

2.4.2 Construction methodology

2.4.2.1 Storm Water Overflow (SWO)

The installation of the SWO will take place during the construction of the revetment in the section crossed by this pipeline.

The works will likely require the installation of a temporary sheet pile cofferdam to allow the works to be carried out in the dry. After dewatering, the existing rock armour will be removed and the trench for the SWO which will likely consist of precast concrete elements will be excavated on the landside. This will be followed by the placement of the bedding layer and the laying of the pipeline in the trench. The outlet from the SWO will be installed at the crest of the toe of the revetment. Subsequently, the backfilling and construction of the remaining section of the revetment will be carried out.

During the construction of the cofferdam for the short sea outfall, the depth of excavation will be below the water table. It will therefore be necessary to prevent groundwater and marine water ingress or dewater the water bearing sand and gravel soil likely to be present (based on the ground conditions at the WwTP site). Considering the high permeability of the sand and gravels, groundwater exclusion will be achieved by installing deep temporary sheet pile walls (approximately 15m beneath ground level).

Even with these measures, some dewatering from the areas of excavation may be necessary to remove residual groundwater within the sheet pile wall, manage surface water and to manage any small amounts of seepage through the sheet pile wall. The groundwater encountered may be contaminated due to the historical use of the site (as documented in Chapter 14 of the EIAR) and if this is the case, it will not be possible to discharge directly into the Irish Sea. The strategy for removing contaminated groundwater from the site is likely to comprise either tankering off site to a suitable licenced facility or treatment on site (See section 14.3 of Chapter 14 of the EIAR).

2.4.2.2 Long sea outfall

Introduction

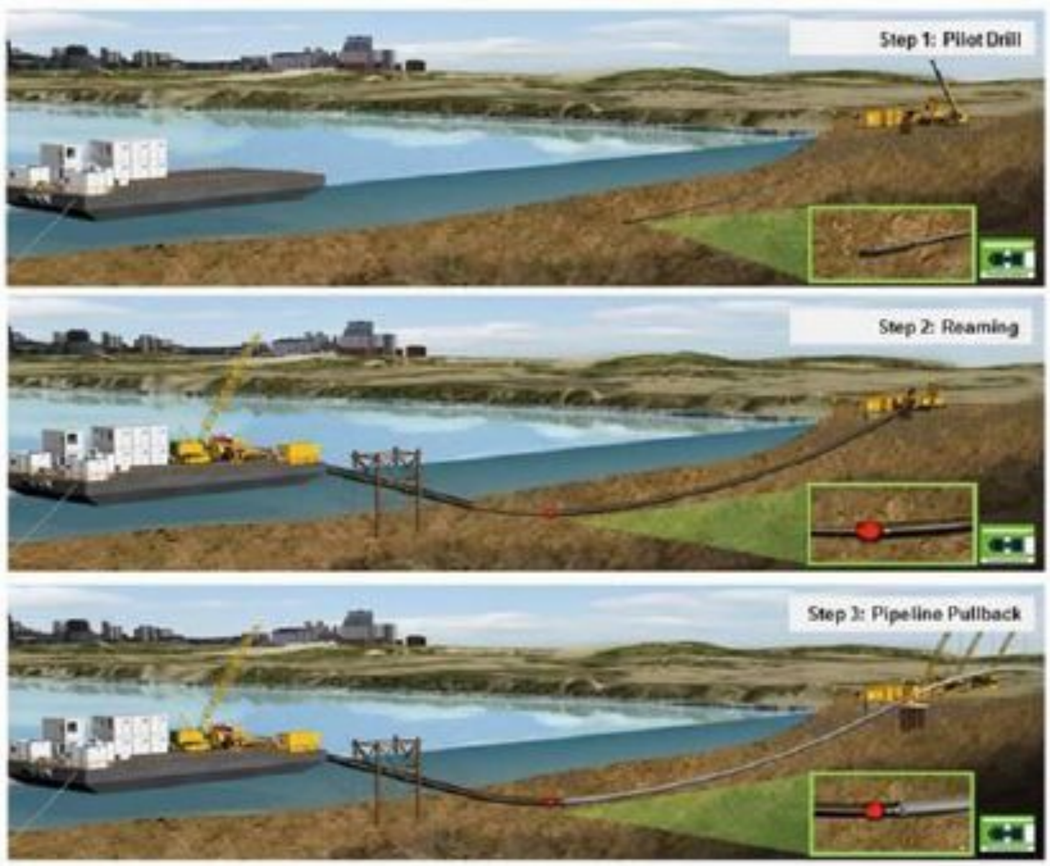
As outlined in Chapter 5 of the EIAR [1], it is envisaged that the contractor will follow one of the following methods for the installation of the long sea outfall:

- Horizontal Directional Drilling (HDD) method;
- Float and flood method; and
- Bottom-pull method.

Horizontal Directional Drilling method

Construction of the outfall would be carried out by the use of a drilling rig located in either the WwTP site or on a barge or jack-up platform near the seaward end of the outfall. The installation would comprise three phases: drilling of a pilot boring, pre-reaming and pipe positioning, illustrated in Figure 5.

Figure 5: Typical HDD process for a sea outfall (Source: Stevens [7]).



First, a drill rig would be positioned at a designated launch point (i.e. within the WwTP site), from which pilot boring would be carried out. The pilot boring would be undertaken to excavate along the alignment of the outfall.

Following the pilot boring, a reamer would be used to enlarge the hole in order to accommodate the outfall. Subsequently, the pipe positioning phase would take place, during which the outfall pipeline would be laid out at the exit point and connected to the previous hollow pipe.

It is noted that there is no need to install scour protection along the route of the outfall in this case.

More details regarding the HDD method can be found in Chapter 5 of the EIAR.

Float and flood method

The use of the float and flood method would require the formation of trenches and the placement of suitable material to support and protect the long sea outfall once it is in position.

Trenching and placement of bedding layer

Like the installation of the SWO, a temporary sheet pile cofferdam would likely be required to facilitate the installation of the outfall at the location of the revetment. This section of the outfall would be routed underneath the upgraded revetment and would consist of a HDPE pipeline laid within a concrete culvert.

The installation will take place prior to the construction of the revetment. The dewatering methodology would follow that for the SWO outlined above.

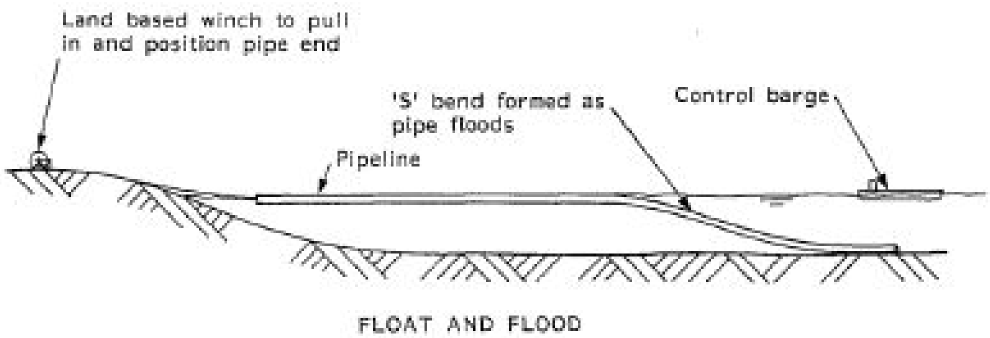
Prior to the installation of the marine section of the pipeline, the trench in which the outfall is to be laid would be excavated along its route. The total volume of seabed material to be removed to form the trench is estimated to be c. 18,000m^3. This excavated/ dredged material will be left to the side of the trench. It is anticipated that approximately 50% of the material would be later reused as fill material whilst the rest may be naturally dispersed. The dredging equipment that will be used will depend on the contractor, but it is envisaged that either backhoe dredgers or grab dredgers will be used.

Once the seabed material has been removed and the trench has been formed, the imported bedding material would be placed along the bottom of the trench to form the bedding layer.

Installation of the outfall pipeline

The float and flood method, also known to as the ‘S-Bend method’ would involve floating and towing the entire marine section of the outfall pipeline into position on the surface of the sea and the subsequent lowering down of the pipe into the trench as illustrated in Figure 6.

Figure 6: Flood and float method of installing the outfall (Source: WRC [8]).



Sections of the outfall pipe would be assembled on land and readied for moving to the water. The pipe and diffuser would be sealed temporarily while full of air, which provides the buoyancy necessary to float.

The pipeline would then be floated into the water using barges, which would tow and manoeuvre the outfall into position. The lowering operation would be achieved by replacing the air with water, which causes the outfall to sink into position. The rate of submergence would be controlled by the rate of air release.

Additional weight would be added where required (e.g. by using concrete ballast collars) in order to provide the negative buoyancy needed to sink the pipeline and place it in the bottom of the trench.

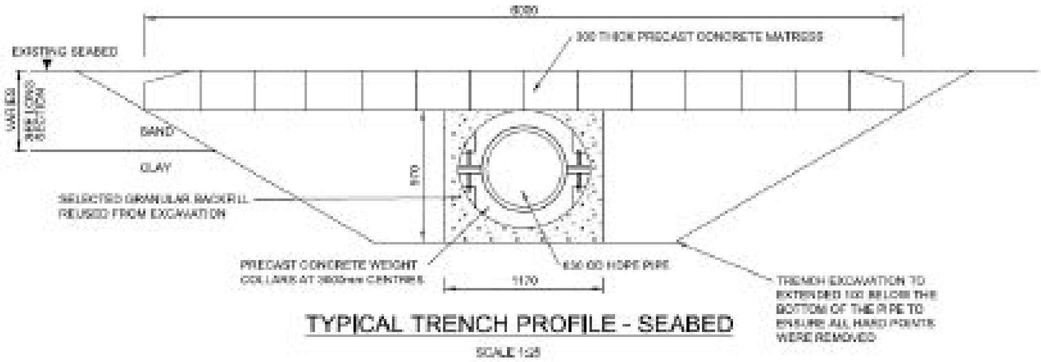
Backfilling the Trench

Once the outfall is laid in place, the fill material and the scour protection would be placed to surround the outfall pipe. Figure 5 below shows an indicative detail for the trench and scour protection.

As previously mentioned, the fill material will be comprised of seabed material as well as imported material. The excavated seabed material, previously placed parallel to the trench, and the imported material, brought by barges, would be placed back into the trench most likely by the use of backhoe or grab dredgers, or similar equipment. Given the nature of the contract, the exact equipment that will be used will be determined by the contractor.

To ensure against potential medium/long term effect from scour, suitable protection of the pipeline is required. A concrete mattress layer of approximately 300mm thickness is proposed for this purpose. The concrete mattress will finish at existing bed level.

Figure 7: Typical detail for scour protection of an outfall.



The total duration of the works is estimated to be 3-4 months (dependent on weather conditions).

Bottom-pull method

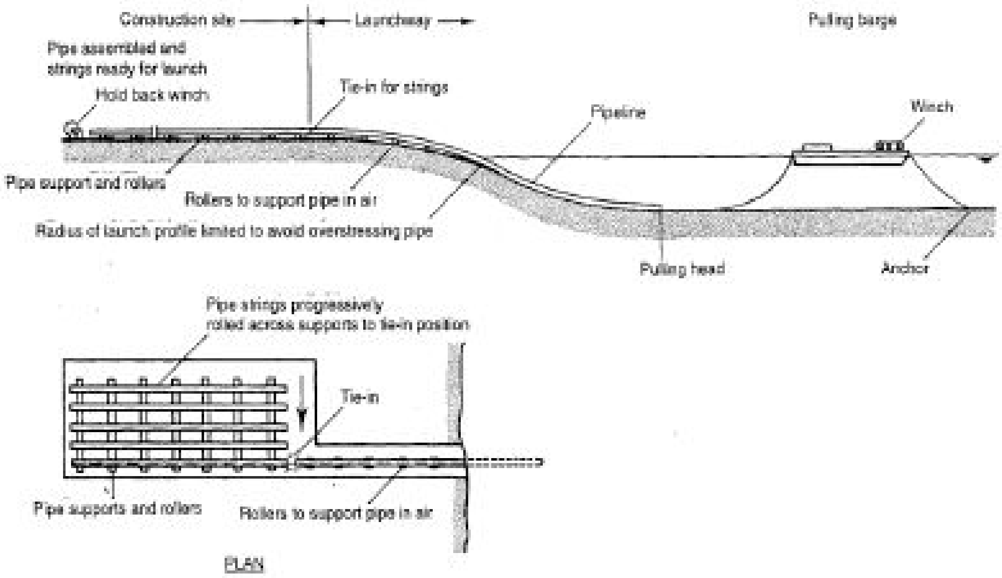
Overview

The use of the bottom-pull method would, in a similar manner to the float and flood method, require the formation of trenches and the placement of suitable bedding material to support and protect the positioned pipeline. The revetment crossing, trenching, placement of the bedding layer, scour protection, backfilling of the trench and the diffuser assembly procedures would also be the same as described in the Float and flood method section above. Laying of the outfall would be undertaken as described below.

Installation of the outfall pipeline

The bottom-pull method would involve joining and pulling sections of the outfall pipeline towards the sea by using a barge. The pipes would be pulled into place by the barge as illustrated in Figure 8.

Figure 8: Bottom pull method of installing the outfalls (Source: CIRIA [9]).



Small sections of the outfall pipe would be arranged on land (within the WwTP site) and readied for placing on rollers. The rollers would be aligned with the route of the outfall and the location of the revetment crossing to ensure that the correct pipe alignment is achieved. The sections of the pipe would be joined in sequence to make pipe strings that could be placed onto the rollers. The number and length of the pipe strings would be determined by the contractor based on the space that is made available within the WwTP site.

The pipe strings would be pulled by winches mounted on a barge anchored offshore in a stepped process. The first pipe string would be pulled towards the sea then the next string would be moved across the rollers and joined to the first string at the tie-in position. This procedure would be repeated until all the strings have been joined and the outfall pipe has been laid in position. Following the completion of pulling, the culvert (i.e. the interface between the outfall and the revetment) would be installed.

The total duration of the works is estimated to be 4-5 months (dependent on weather conditions).

Diffuser assembly

Once the long sea outfall has been laid, by whichever method (HDD, float and flood or bottom-pull), the diffuser would be assembled on the seaward end of the outfall. The diffuser arrangement would include up to 6 diffusers of approximately 0.16m diameter at a spacing of c. 10m intervals.

The diffuser would be prefabricated on land and placed on the seabed by barge as one complete unit. The exact procedure and depths of backfill required would depend on the equipment available from the contractor along with programme and cost considerations, however it is anticipated that this would be undertaken from the barges and it will likely require open excavation of the seabed, along the length of the diffusers.

3 Site conditions

3.1 Metocean conditions

This section presents a summary of the Metocean conditions relevant to the study area. Detailed information can be found in the Wave Modelling report included in Appendix A.

3.1.1 Tidal levels

The relevant tidal levels, based on information from the relevant Admiralty Tide Tables for Arklow Harbour, are shown in Table 1 below.

Table 1: Tide levels in Arklow Harbour.

Tidal Level	Referred to Chart Datum	Referred to OD Malin
Mean High Water Springs (MHWS)	1.4m	0.28m
Mean High Water Neaps (MHWN)	1.2m	0.08m
Mean Low Water Neaps (MLWN)	0.9m	-0.22m
Mean Low Water Springs (MLWS)	0.6m	-0.52m
Lowest Astronomical Tide (LAT)	0m	-1.12m

3.1.2 Extreme sea level

The extreme water level estimated at the site for both wave modelling and revetment design is 2.56mOD Malin or 3.68m Chart Datum. This level was obtained from the Irish Coastal Protection Strategy Study (ICPSS) [10] which includes the future scenario assessments of extreme coastal water levels. This predicted water level includes a combination of storm surge and extreme tidal levels, based on both numerical modelling and statistical analysis of historic tide gauge data. The High End Future Scenario levels also allows for land movement and +1.00m sea level rise due to climate change by the year 2100.

3.1.3 Currents

According to previous studies (See Ref. [11]) the oceanography at the site can be described as energetic with strong tidal currents, brief slack waters, large tidal excursions and good dispersive characteristics.

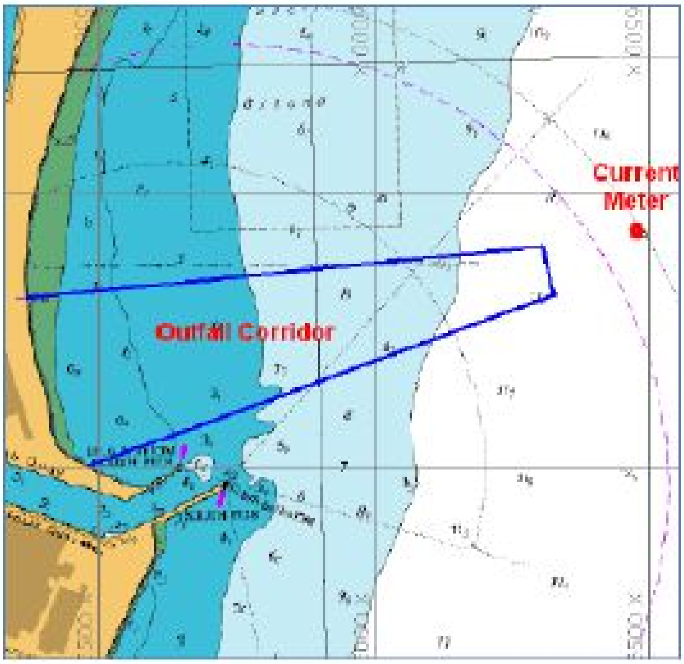
Table 2 below summarises depth averaged current speed and drogue trajectory data derived during the 1985 Irish Hydrodata study.

Table 2: Summary depth averaged currents.

Tide	Current Speeds (m/s)	
	Flood	Ebb
Spring	0.66	0.59
Neap	0.42	0.35

According to this information, a recording current meter was also deployed for 30 days during the 1985 survey. This was located approximately 1000m east-northeast from the harbour mouth on the (then) proposed outfall line (See Figure 9). It was positioned at a height of 1.5m above the seabed. The 95%'ile exceedance speed recorded at the current meter location was 0.05m/s. This indicates that the durations of slack water at the site are limited.

Figure 9: Location of the current meter.



3.1.4 Avoca river

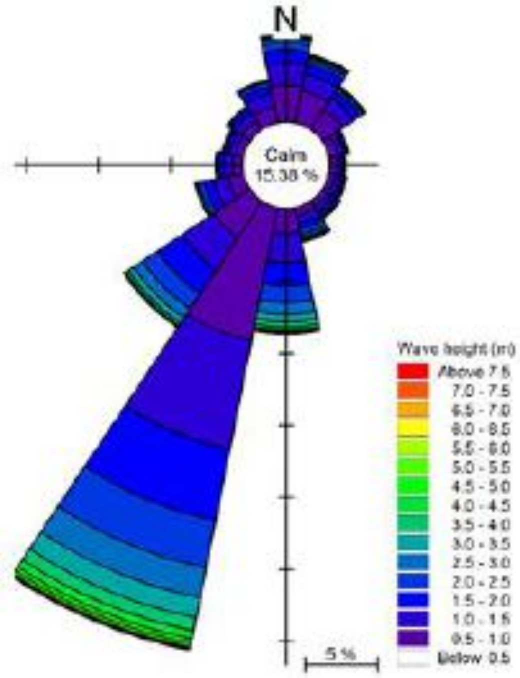
According to Ref. [11], the flow characteristics of the Avoca River based on the EPA Hydrometric data system are: DWF = 0.8 m^3/s, 95%'ile = 3.09 m^3/s and 50%'ile = 15 m^3/s. According to the Irish Hydrodata report, the river flow is assumed to be low so that there is no beneficial momentum from the river plume which would carry the wastewaters further offshore. Therefore, its influence in comparison with tidal effects, waves and currents is considered negligible in terms of coastal processes. Sediments transported by the Avoca river and an evolution of these in time has not been assessed.

3.1.5 Wave and wind data

The directional wave distribution of the offshore wave climate is represented in Figure 10.

Due to the orientation of the coastline at the study area and its surroundings in relation to the offshore waves, only waves approaching from the NE (northeast) to SE (southeast) are considered relevant for this assessment.

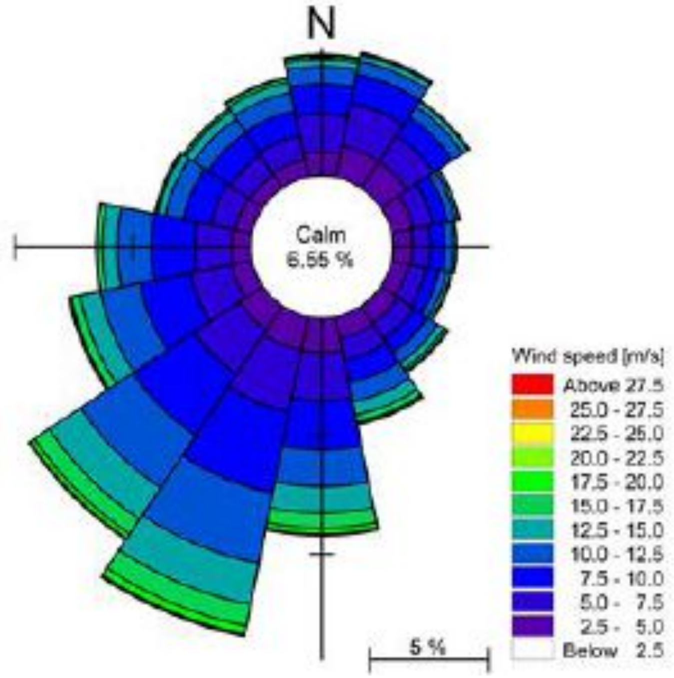
Figure 10: Offshore Wave Rose – All directions.



The directional wind distribution of the full wind rose is shown in Figure 11.

As for the offshore wave data, only offshore wind from the NE to SE has been considered for this assessment due to the orientation of the coastline at and near the study area. For these sectors, the predominant directions are NE and SE. Maximum wind speed values are roughly 25m/s for the south easterly directions.

Figure 11: Offshore Wind Rose – All directions.



3.1.6 Wave modelling results

Wave propagation from offshore to the proposed location for the revetment was modelled using MIKE21-SW.

Table 3 shows the model results for various combinations of wind/wave data and direction for the 500 year return period events for each of the relevant directions. The model results presented correspond to points located 20m offshore of the existing revetment crest.

Table 3: MIKE21-SW modelling results. Displayed are the return period (Tr), wave height (Hs), wave period (Tp) and Wind speed (Wsp) for a water level corresponding to Tr=500y.

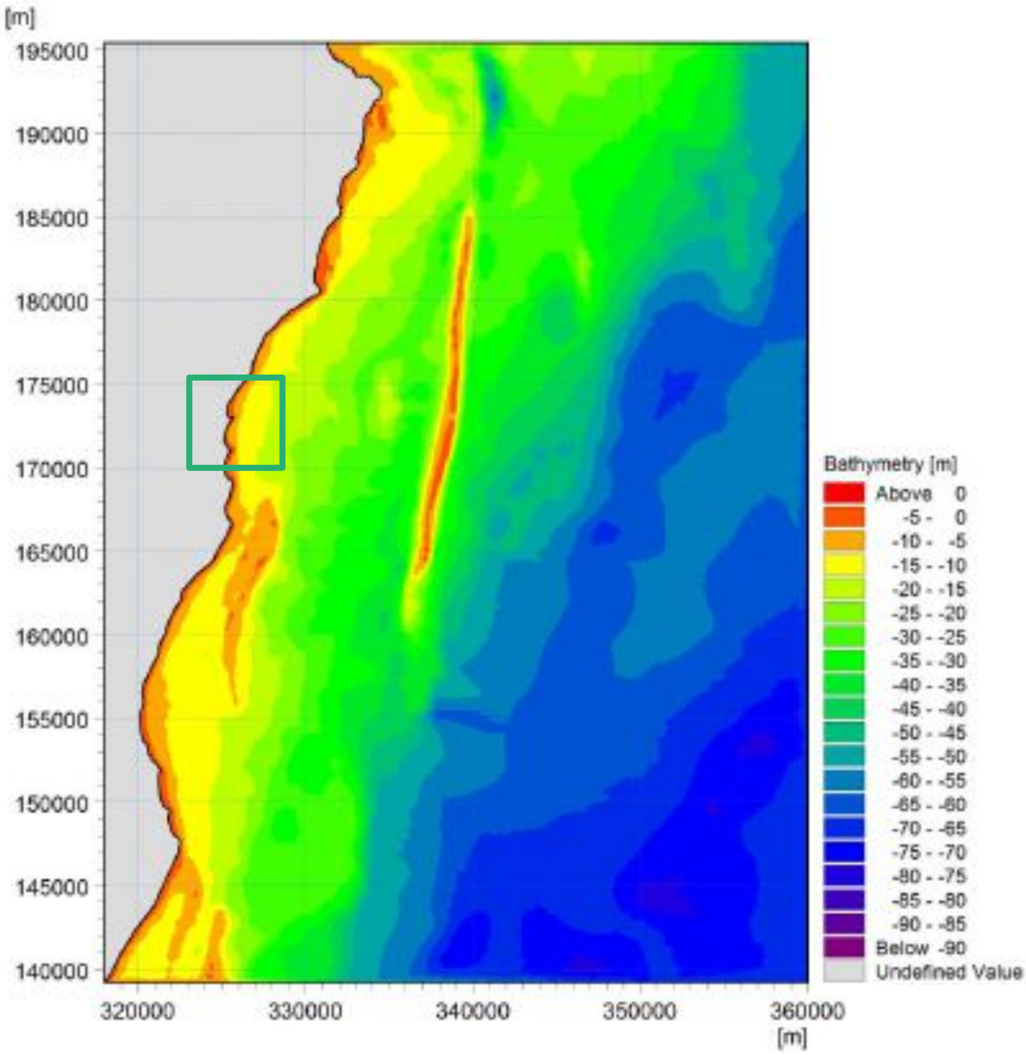
Direction	T_r [y]	Offshore (approximately -60m CD)		20m from existing revetment crest (approximately -3m CD)		
		H_s [m]	T_p [s]	W_{sp} [m/s]	H_s [m]	T_p [s]
NE	500	5.5	8.6	24.3	2.9	9.5
ENE	500	5.0	8.3	20.7	2.8	9.5
E	500	5.6	8.7	24.4	3.0	9.9
ESE	500	6.2	9.1	25.0	3.0	10.5
SE	500	7.1	9.7	23.0	3.0	11.4

The results show that storms from all the tested directions give similar resulting nearshore wave heights despite having significantly higher input offshore conditions from the south easterly directions.

This can be explained partly due to the presence of the Arklow Bank parallel (as can be observed in Figure 12) to the coast on which waves likely break and dissipate energy, and partly due to the shallow waters adjacent to the site ('depth limited wave conditions').

This effect was confirmed in the Irish Coastal Protection Strategy Study (Ref. [10]), where it was noted that "The banks that lie off the east coast of Ireland have a significant effect on the inshore wave climate at the shoreline of the study area. Even at high tide the banks reduce the height of the higher waves passing over and thus protect the shoreline."

Figure 12: Bathymetric model derived from the Admiralty Charts and bathymetric survey (site located in the middle of green square).



3.2 Ground conditions

3.2.1 Introduction

The following sections provide an overview of the ground conditions at the WwTP onshore site and the site of the proposed long sea outfall.

Ground conditions at the location of the proposed rock revetment are anticipated to be broadly in line with the onshore ground conditions at the site, however given the coastal location, the conditions identified in the vicinity of the long sea outfall may also be relevant over parts of the revetment footprint.

3.2.2 Rock revetment

A geotechnical interpretation of the ground conditions based on Ground Investigations undertaken within the site as well as an assessment of publicly available baseline information was carried out by Arup in 2018 as part of the EIAR and design development.

The following conclusions are relevant to the present assessment:

- The expected ground stratigraphy across the site is Made Ground over Sands and Gravels (Glacial Deposits) over Clay (Glacial Till) over Bedrock. Taking into account the excavation depth required for the revetment works, only Made Ground and Sands and Gravels are expected to be encountered during construction.
- It must be noted that, while the Sands and Gravels were generally described in the ground investigations as medium dense to dense, loose deposits were also encountered at some parts of the site.
- The footprint of the proposed development is within an area of reclaimed land dating back to the mid 1800's. The area was reclaimed using local deposits of sand and gravel. The site has a history of industrial use and from review of the ground investigation there is a risk of encountering contaminated ground across the site. There is a potential risk of encountering contamination in the ground underlying the existing revetment. (Refer to Chapter 14 EIAR [1]).

3.2.3 Long sea outfall

A geotechnical interpretation of the ground conditions around the footprint of the long sea outfall as well as an assessment of publicly available baseline information was carried out as part of the EIAR and design development.

The stratigraphy and material properties for the main geological units expected to be encountered across the area were derived as part of this study, and the associated geotechnical risks were identified.

The following conclusions are considered relevant to this assessment:

- Based on the results from the ground investigation undertaken along the outfall alignment, the anticipated ground conditions in the area are medium dense Sands and Gravels over Clay, over dense Sands and Gravels over Bedrock. The upper layer of Sands and Gravels are likely to comprise material of marine deposits, with the underlying materials being of glacial origin.
- The only geotechnical unit expected to be encountered during the outfall installation works is comprised of medium dense to dense marine sand and gravel deposits.

They were generally encountered as extensive granular deposits along the alignment of the marine outfalls of the proposed development. However, it must be noted that loose sands and gravels were occasionally encountered within the first 2m of the seabed. The underlying layers are not expected to be encountered given the limited trench depth.

- With regard to contamination of the existing material, it was estimated that a limited volume of material (approximately 18,000m^3) is proposed for excavation of the outfall, of which almost half would be classed as uncontaminated and inert. However, the environmental testing undertaken in the contaminated material indicates that the marine sediments are only very slightly contaminated at relatively low levels for some specific parameters (Refer to Chapter 14 EIAR [1]).
- The reusability potential of the seabed material that will be excavated during the trenching works will be confirmed by the contractor. Based on the existing information, it was concluded that the first 4m of the seabed are expected to be suitable as a General Granular Fill (Class 1) material.
- This Granular Fill is considered appropriate for use as the filter layer, but not as the bedding layer. As a preliminary estimate, it is considered that approximately 50% of the filter layer will likely be comprised of this material.
- The in situ materials will likely not be suitable for use as bedding material, and hence the bedding layer material will need to be imported to the site.

4 Environmental constraints

In this section, those areas considered to be most susceptible to a potential change in the existing coastal processes, as a result of the proposed development are presented.

Specific consideration has been given to those Natura 2000 sites protected under the provisions of Council Directive 92/43/EEC (Habitats Directive) and Council Directive 79/409/EEC (Birds Directive), as amended and codified in Council Directive 2009/147/EC.

These sites include:

- Buckroney – Brittas Dunes and Fen SAC (Site Code 000729) which lies approximately 4.5km to the north at its closest point;
- Kilpatrick Sandhills SAC (Site Code 001742) which lies approximately 6.5km to the south at its closest point; and
- Part of Magharabeg Dunes SAC (Site Code 001766) which also lies within 15km of the proposed development.

The potential impacts (from any potential changes in coastal processes) on ecological receptors is assessed in the EIAR in Chapter 11, with potential impacts on Natura 2000 sites assessed in the Natura Impact Statement for the proposed development.

5 Coastal processes

5.1 Uniform units

A desktop assessment of the coastal areas has been carried out. The coastline in the vicinity of the site consists of beaches limited by headlands. Barriers such as headlands accompanied by change in orientation of the adjoining areas suggest limited exchange of sediment between them. Some uniform units in terms of areas with similar orientation and limited by headlands have been identified in the vicinity of the area of study and are as follows:

- Kilmichael Point to Mizen Head; and
- Mizen Head to Wicklow Head.

Their location is shown in Figure 13.

Figure 13: Relevant uniform units within the study area.

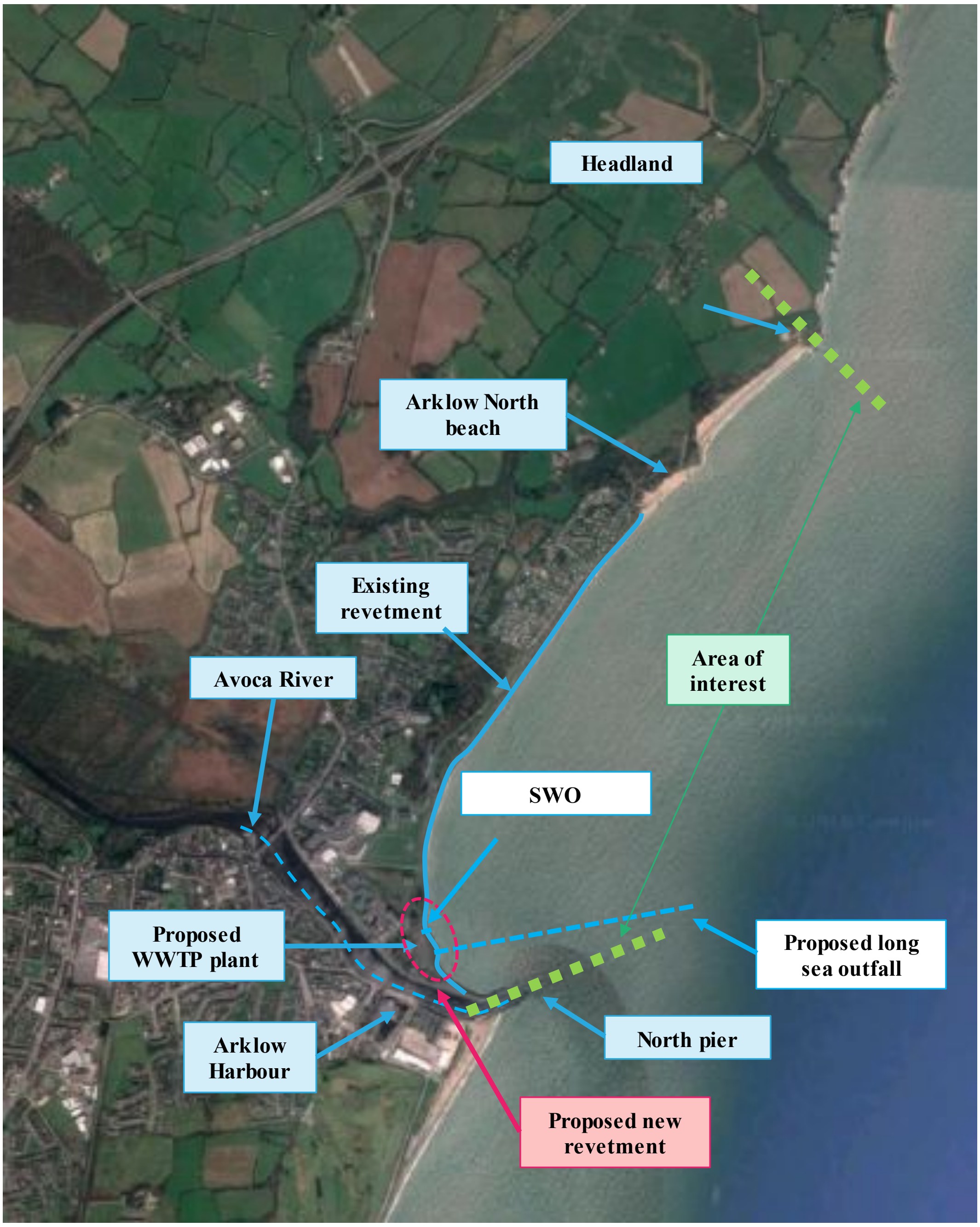
The proposed development is located within the Kilmichael Point to Mizen Head area, in a stretch of coastline that is limited to the south by breakwaters which protect the entrance to Arklow harbour, and to the North by the headland located at the north end of the Arklow North Beach. The extent and features of this sub-physiographic unit defined as an Area of Interest are shown in Figure 14.

This headland and the change in coastline orientation of the areas to the north limit partially the coastal processes within this area. The existing and proposed works are also involved in the coastline characterisation. It includes (from South to North):

- The river breakwaters (piers);
- The upgraded revetment; including the SWO and long sea outfall;
- The existing revetment; and
- The Arklow North Beach.

The existing 2.2km revetment starts at the northern pier at the harbour mouth and continues in a northerly direction, and then in a north-easterly direction as far as Arklow North Beach. The section of the revetment that is proposed to be upgraded is located near the existing revetment's southern end, immediately adjacent to the WwTP site. The extent of the proposed upgrade revetment is approximately 350m. The proposed long sea outfall alignment is also represented in Figure 14.

Figure 14: Extent and features of the Area of Interest (extent limited by dashed green lines).



5.2 Historical evolution

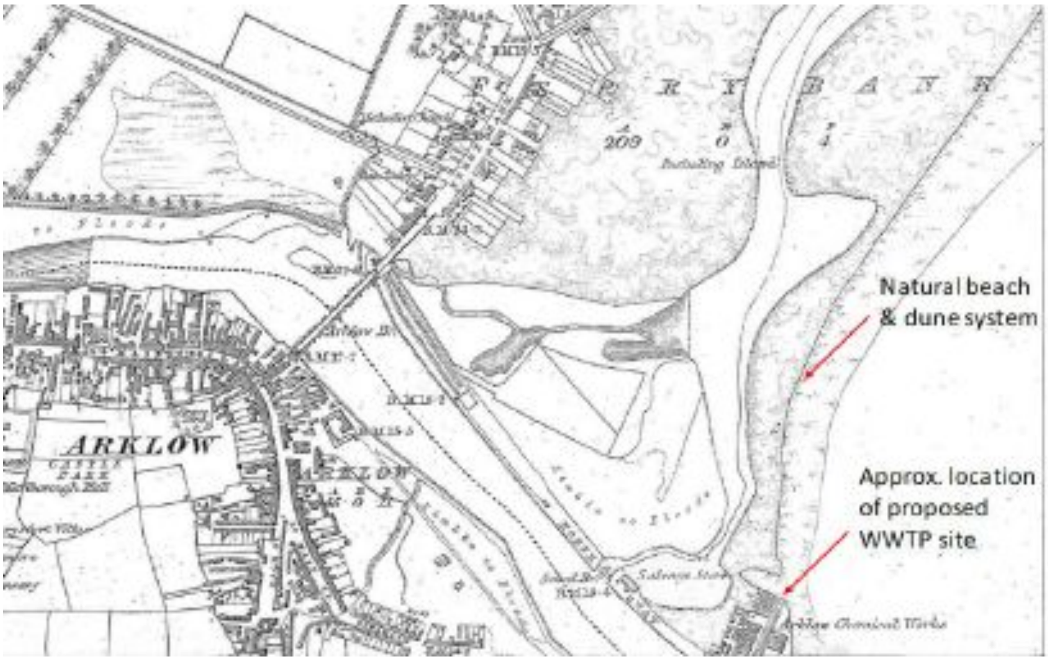
5.2.1 Background

A report produced by J.P. Byrne & Partners in April 1990 [12] following the construction of the existing revetment outlines the historical coastal defences at this location as well as details of the construction of this revetment. A paper presented by the same authors in February 1990 [13] gives further details of the previous coastal defences at the site.

Below is a summary of the relevant information from the aforementioned reports in relation to previous sea defences in this area.

Prior to the construction of Aklow harbour in 1860, the area under consideration was the estuary of the Avoca river. This formed a dynamic coastal system which included a natural beach and dune system. This system of sand dunes developed behind the beach, acting as a natural sea defence for the area. This is shown in Figure 15.

Figure 15: Ordnance Survey Map, Sheet 40, published 1880 [14].

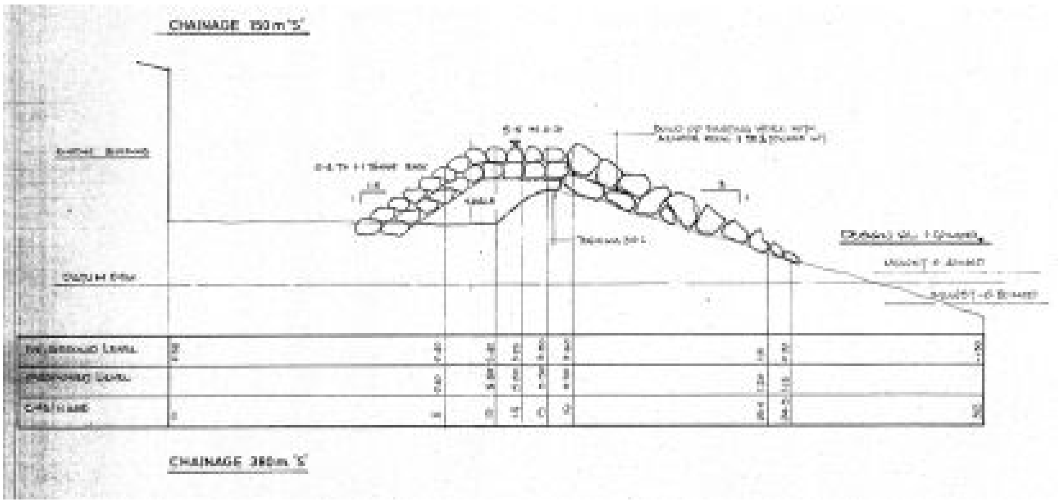


After the development of Kynoch munitions factory in 1912, an increased level of shore protection was required beyond that provided by the natural dune system. This additional shore protection took the form of a three-tiered timber piled solution to retain sand. This was reported as very efficient but was not maintained. A historical image of the remnant of these structures is shown below in Figure 16.

Figure 16: Beach and dune system with vertical piles remaining from previous defence structure. Date unknown.

In 1972, a rubble revetment was constructed to protect the Wallboard Factory at the location of the WwTP site, over a distance of about 400m. According to the J.P. Byrne & Partners report, this took the form of an earthen embankment with gabion and rubble rock protection and was later extended northwards of the site. A storm in December 1989 is known to have caused severe damage to this defence, in particular the natural sand dunes, and extensive flooding behind it. This led to the construction of the existing revetment in 1990 (Figure 17). This revetment was designed for a significant wave height of 2.85m and a water depth of 3m, however the design wave period is not specified in the design report. The design water depth allowed for 1m of beach scour.

Figure 17: Section of the 1990 revetment at the proposed WwTP location (Source: Byrne, K.P. and Motherway, F.K. [13]).



Arup carried out an inspection of this revetment on 28 February 2017. This inspection, combined with a subsequent assessment of the 1990 design, also by Arup, concluded that the protection currently offered by the existing revetment is insufficient to protect the proposed WwTP, particularly noting the critical infrastructure proposed for the site. Major rehabilitation works to the structure were recommended. During the inspection visit, undertaken at low tide, it was noted that the toe of the revetment, and seabed level, were not visible. Therefore, it was concluded that a loss of the beach which existed in front of the revetment at the time of its construction had occurred in this area in the time period between 1990 and 2018.

An image of the existing revetment taken during a project site visit undertaken in April 2018 is shown in Figure 18.

Figure 18: Photograph of the existing revetment taken from the north pier of Arklow Harbour towards the proposed WwTP site in April 2018.

5.2.2 Desk study coastal evolution

5.2.2.1 Introduction

There is historic evidence of a beach located in front of the current revetment which at present does not exist. This evidence was found in historical photographs and a paper presented at Engineer's Ireland [13] which states that the previously existing beach presented continuous erosion of about 1.5m between 1930 and 1980, with increased erosion rates following that period in particular years. Reasons cited for this erosion are as follows:

- The construction of the north and south piers at the entrance to Arklow Harbour (1860);

- Large quantities of sand from the North beach area were exported to England from 1930 to 1945; and
- Dismantling of the previously existing wooden coastal defence structures during World War II.

However, the information from [13] suggests that the beach was still fairly visible at the time the revetment was designed, as it is stated that the revetment was designed to be as far back from the existing beach as possible so that it would continue to be an amenity for the town. It was also made clear in the study that the performance of the coastal protection structure would be related to the erosion of the previously existing beach in front of the revetment. Tests confirmed that the reduced rear rock armour would be damaged if the beach was completely eroded and waves of around 3m height attacked the structure. Possible methods of resisting erosion recommended at that time were the provision of beach structures such as groynes and/or beach nourishment. Hard coastal protection measures such as groynes appear not to have been implemented based on visual observations.

As shown in the satellite imagery and observed during site visits, the beach which is known to have previously existed, is no longer visible at low tide.

Information from available satellite imagery and bathymetric surveys between 1985 and the present date have been studied in order to assess the historical coastal evolution at the site area and the adjacent areas from the construction of the first revetment and this is discussed below.

5.2.2.2 Satellite imagery

Satellite imagery from Google maps was used to examine shoreline retreat from 1984, when the first revetment was already in place, to the present day. A comparison of aerial photographs from 1984 to the present date is shown in Figure 19. Some retreat of the coastline (loss of emerged beach) appears to have taken place between the 1984 and 2005 images (Figure 20), while the coastline remains relatively stable from this date forward, due to the presence of the hard defence structure.

The phase of the tide in these images is unknown, and therefore beach material loss cannot be assessed quantitatively, but given the fact that the beach is no longer visible at low tide conditions the evolution suggests a loss of beach material after the construction of the existing revetment.

Figure 19: Comparison of satellite imagery of the Arklow coastline dating, from left to right: 1984, 1993, 2005, 2011 and 2017 (Source: Google Earth).

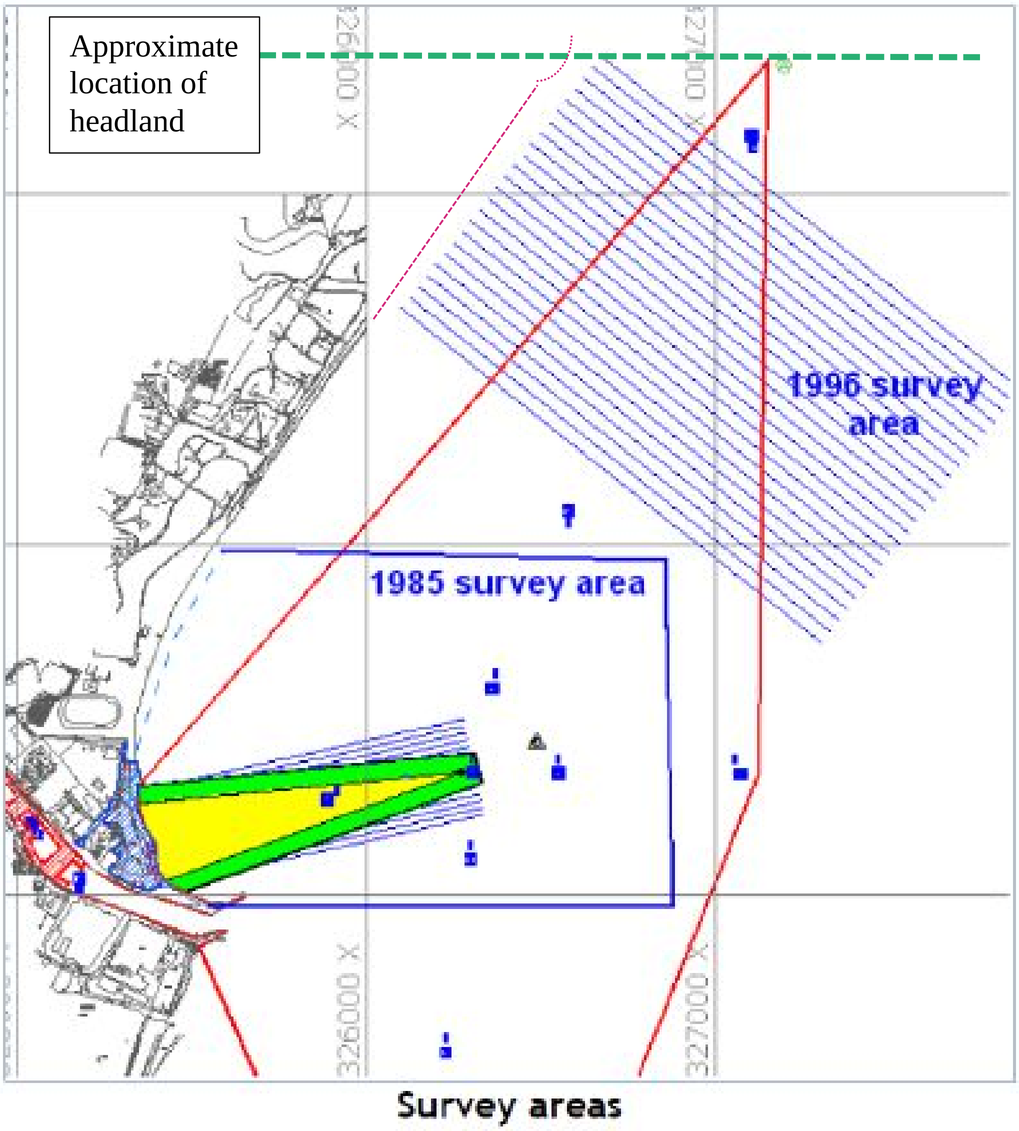
Figure 20: Zoom in comparison of satellite imagery from 1984 (left) and 2005 (right). Source:

5.2.2.3 Historical bathymetric surveys

A comparison of two available bathymetric surveys dating 1985 and 1996 by Irish Hydrodata Ltd and 2016 survey GSI INFOMAR data was carried out by Byrne Looby Consulting Engineers in 2017 [15]. The information contained in this study, summarised below, is relevant for assessing the evolution of the seabed profile.

In this study, the levels reported in each of the surveys for a number of cross sections taken within and near the WwTP site are compared. The full extent of the 1985 and 1996 surveys used for the assessment can be observed in Figure 21.

Figure 21: Survey areas (Source: Irish Hydrodata Limited report [15]).



In the area proposed for the upgraded rock revetment, long sea outfall and SWO at the WwTP specifically, 15 cross sections were analysed (profile lines no.1 to no.15, [15]). One of these profile lines falls close to/along the proposed alignment of the outfall (profile line no. 12).

Figure 23, Figure 24 and Figure 25 show the levels reported for profile line no.12 and the two lines that represent the study boundaries (i.e., profile lines no. 1 and no. 15). Their location is shown in Figure 22.

These figures suggest loss of material at the seabed in front of the existing revetment; the 2016 seabed level appears lower than the 1985 seabed level by 0.5 – 2m. In profile 12 (location of long outfall), the maximum seabed level difference is shown to be approximately 1m. This value, given the time difference between the two surveys (30 years), suggests that the sediment transport processes in this specific area are limited.

Figure 22: Approximate location of the relevant profile lines from the survey comparison study [15].

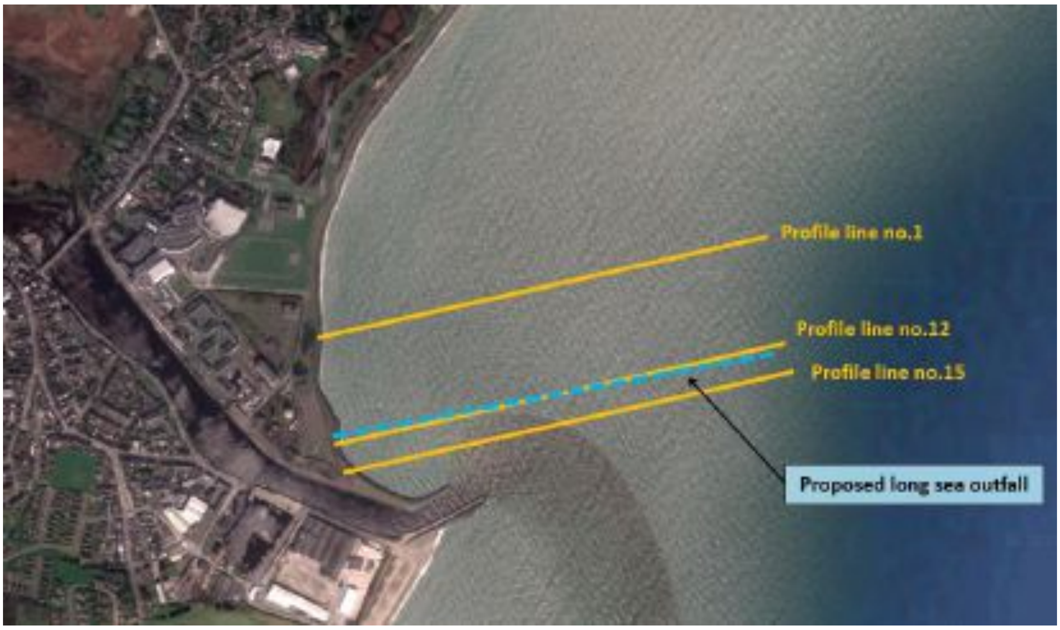


Figure 23: Comparison of 1985 and 2016 bathymetric surveys for profile line no. 1 (Source: Irish Hydrodata Limited report [15]).

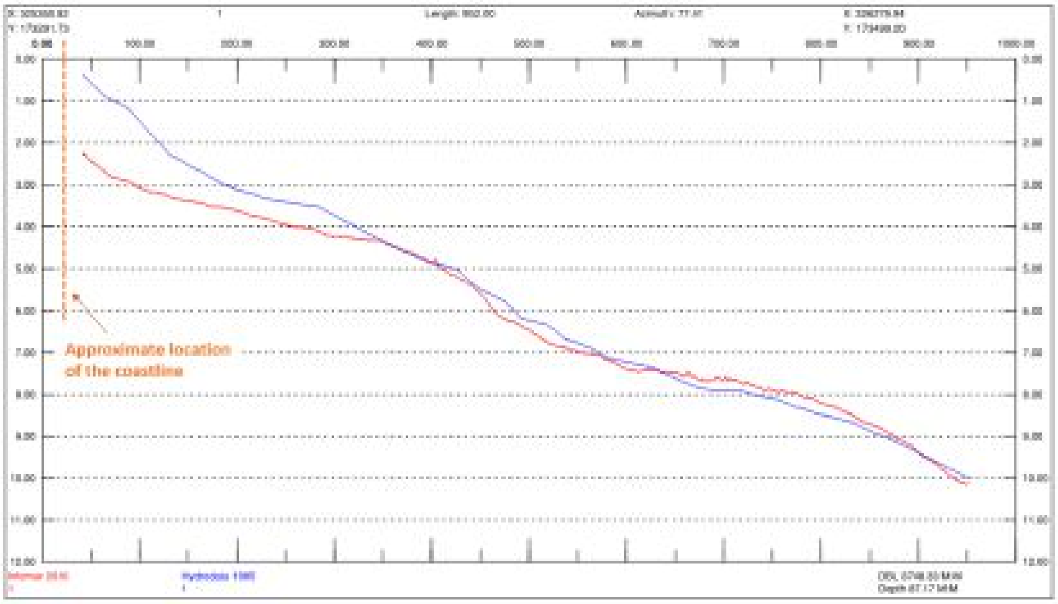


Figure 24: Comparison of 1985 and 2016 bathymetric surveys for profile line no. 12 (Source: Irish Hydrodata Limited report [15]).

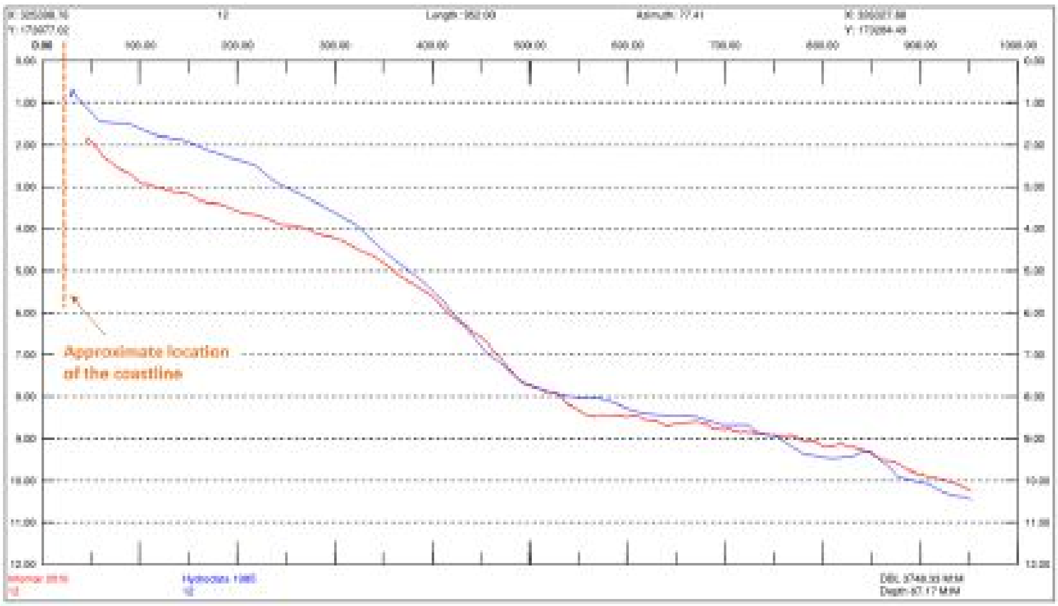
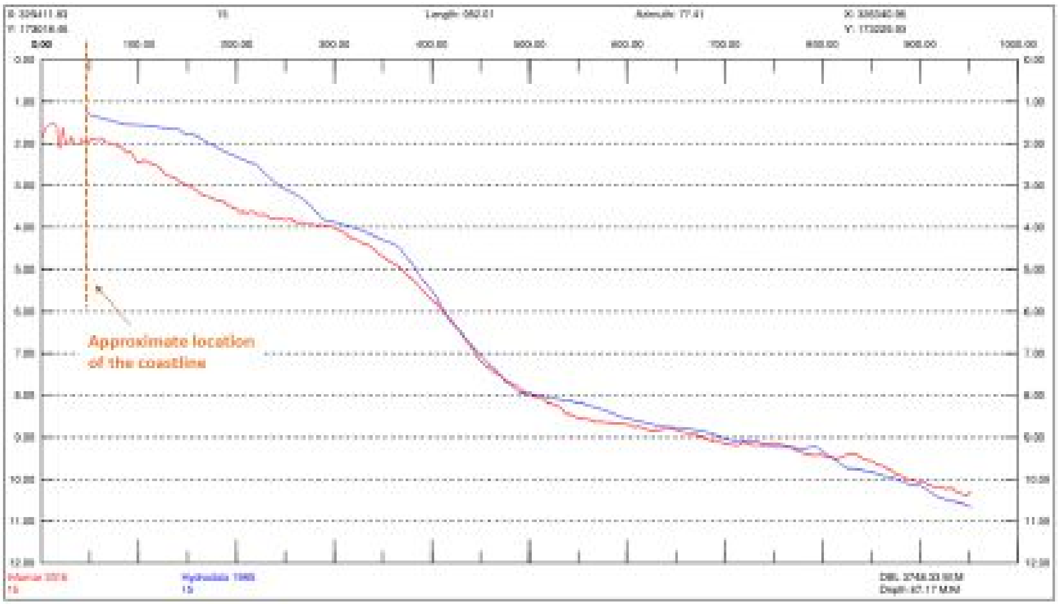


Figure 25: Comparison of 1985 and 2016 bathymetric surveys for profile line no. 15 (Source: Irish Hydrodata Limited report [15]).



The figures shows that the seabed erosion continues to approximately 400m offshore (depth of approx. 6m). Beyond this point, the seabed is shown to remain relatively stable between the survey dates.

Seabed lowering is shown to be higher in the northern sections, which could be explained by the shelter provided to the southern end of the revetment by Arklow harbour piers.

In the area surveyed to the north (1996 area) a larger volume of loss material can be observed. The seabed lowering and loss of material seem to be concentrated in depths from 7 to 11m and gain of material can generally be observed in deeper areas. This could be partially explained by seasonal changes (e.g winter and summer profiles), however, there seems to be an overall loss of material in the 20 years of comparison for these surveys (1996 vs 2016). Northern and southern profiles of this north area are shown for clarity in Figure 26 and Figure 27. This suggests offshore sediment transportation in this area.

Figure 26: Survey 1996 northern section (Source: Irish Hydrodata Limited report [15]).

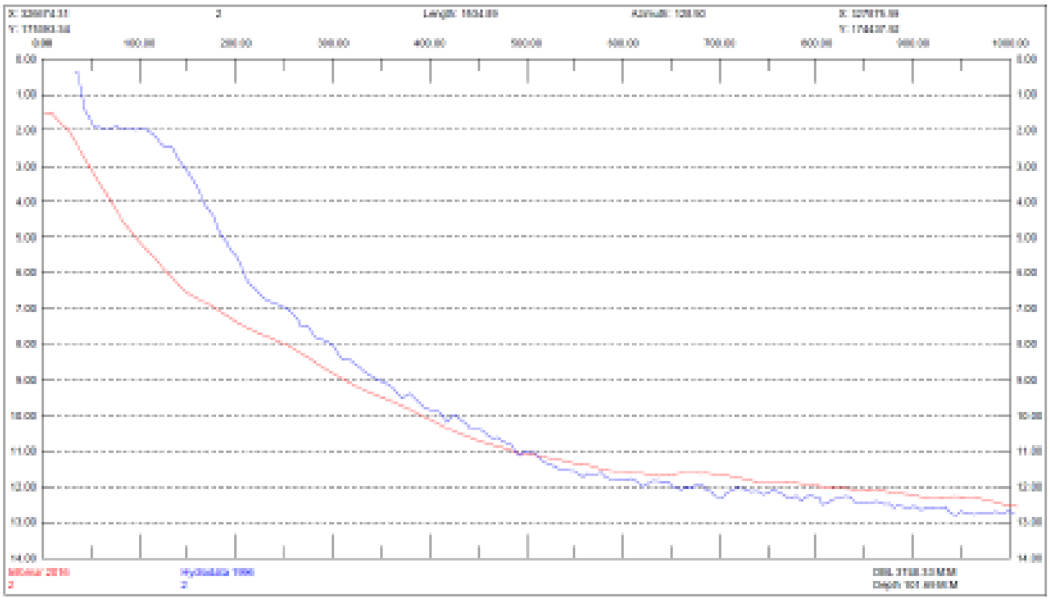
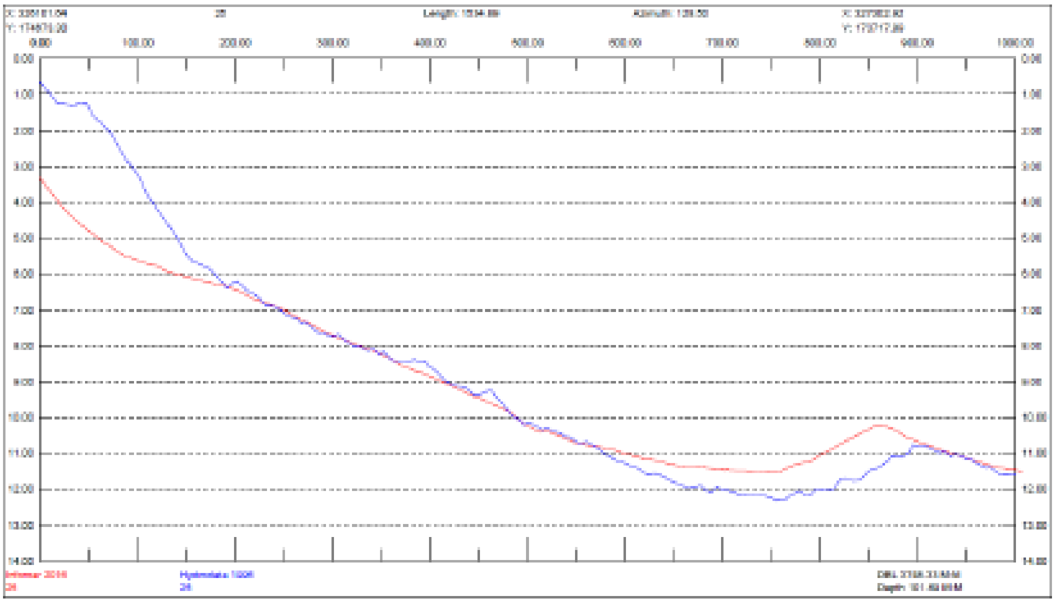


Figure 27: Survey 1996 southern section (Source: Irish Hydrodata Limited report [15]).



5.2.3 Conclusions

Several works are known to have been undertaken within or near the study coastline before the construction of the existing rock revetment, such as the removal of sand from the beach, installation and later dismantling of tiered timber piles, and the construction of the north and south piers at the entrance to Arklow Harbour. There is evidence of continuous historical beach erosion along the coastline beside the site (loss of previously existing beach) during this period. Coastal protection structures had been recommended in the past (See Ref. [13]); however, there is no visual evidence that these have been constructed.

The construction of the revetment in 1972 and 1990 caused the coastline to be rigidized. However, while the coastline is fixed since then, there is evidence of an ongoing natural loss of seabed material. As outlined, previously, the beach in front of the rock revetment at the site is no longer visible. The seabed lowering in front of the revetment at the location of the site between 1985 and 2016 ranges between 0.5m and 2m.

5.3 Existing coastal processes

5.3.1 Coastal processes

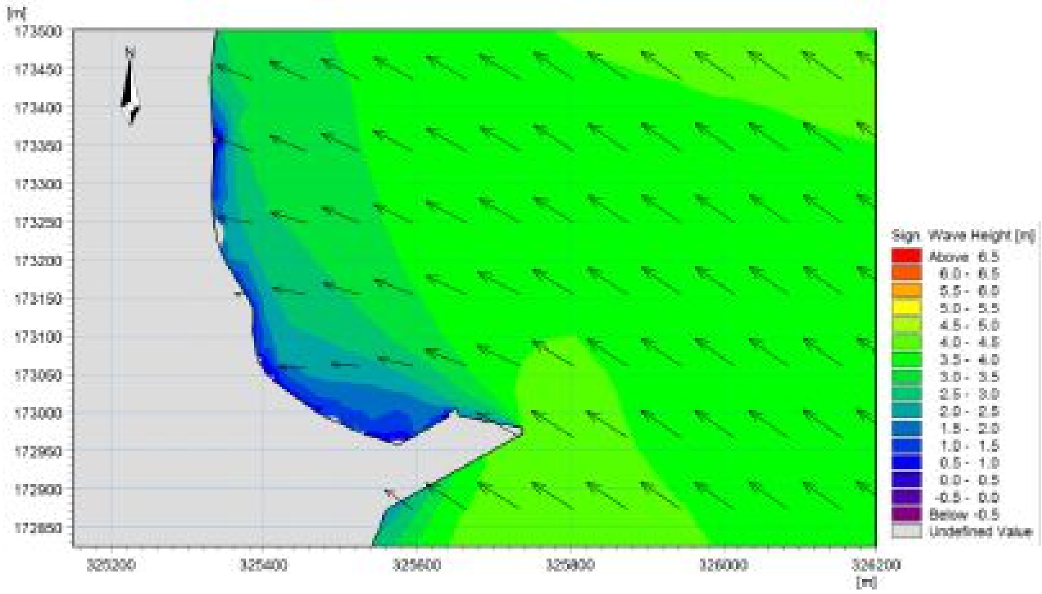
5.3.1.1 Introduction

As outlined in Section 3.1.5, the predominant directions of offshore waves along the study coastline are north-east and south-east.

It was assessed for the previous design of the revetment carried out by JP Byrne (Ref. [13]) that the main longshore drift of sediments in the Area of Interest moves from South to North. Therefore, the two piers which form the entrance of the Arklow harbour act as a barrier to sediment transport from the south. Hence, accretion of sediment is expected to still be occurring to the south of the Area of Interest (south to Arklow Harbour entrance) with further loss of sediments in the north.

However, the existence of the harbour entrance also provides shelter to the revetment at the site location from wave action from the second quadrant directions (south to east south-east). This shelter effect means that the stretch of the proposed upgraded revetment is more protected from wave action from the directions coming from the second quadrant (east-southeast to south) than the section of revetment to the north of the site. This can be seen in Figure 28 which is extracted from the Wave Modelling report (Appendix A) - it is shown that significantly reduced waves reach the revetment specifically at the WwTP site given its proximity to the harbour entrance. As also highlighted in Section 5.2, the coastline which is protected by the revetment does not retreat due to the presence of this hard structure. The stable coastline created by the revetment also means that there is a very limited sediment source existing in the Area of Interest apart from the seabed material and the unprotected areas to the north.

Figure 28: Wave height distribution with waves from the south-east. Zoomed in on Arklow revetment site location.

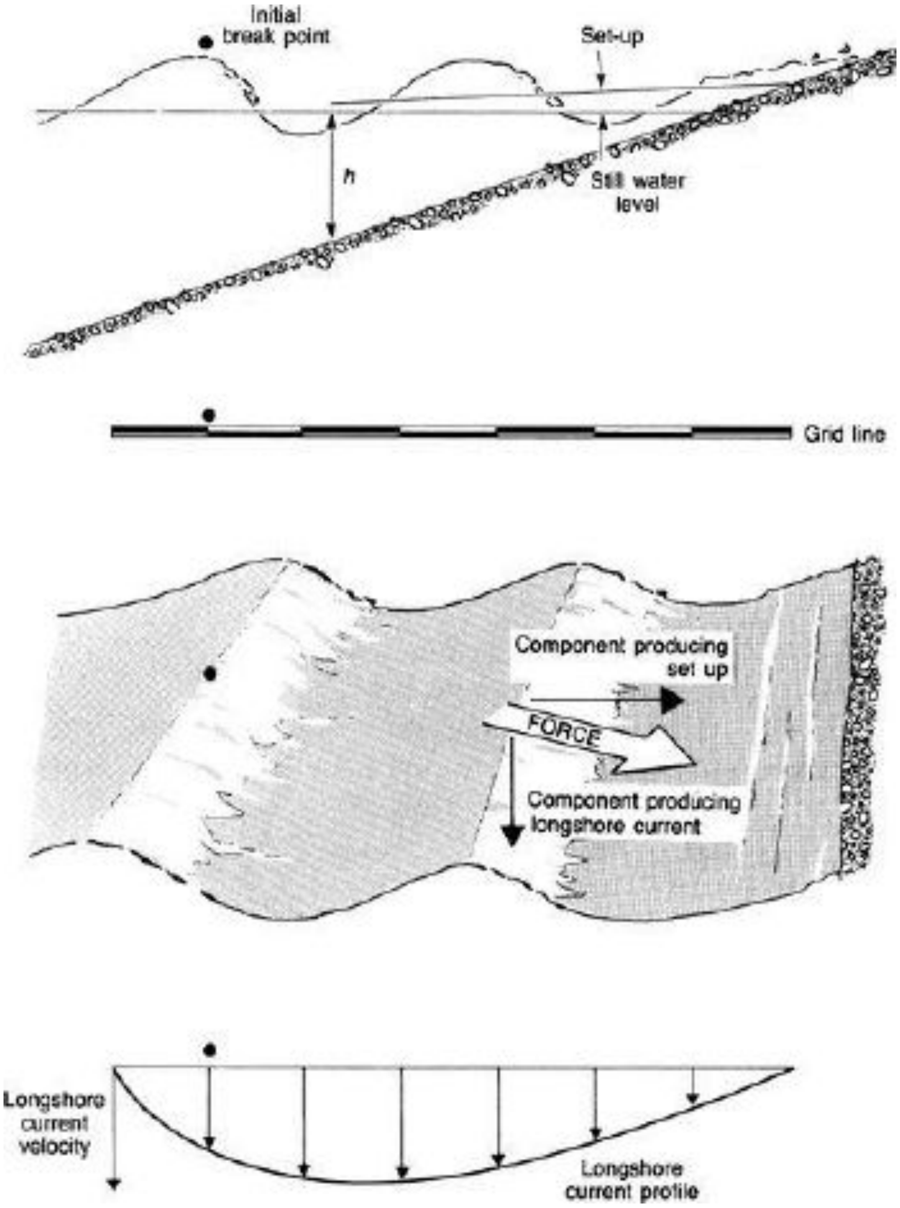


Surf Zone Processes

Waves start to break at some distance offshore of the shoreline/revetment. The area between the wave breaking point and the shoreline is known as the surf zone. The swash zone extends from the surf zone to the waves run-up level on the beach. In this region, the height of an individual wave is largely controlled by the water depth.

The mechanics of this progressive breaking are very complex. It involves turbulence in the breaking area and also a momentum force which may be resolved into two components. The component which lies parallel to the shoreline causes 'longshore current'. The component which is perpendicular to the shoreline produces an increase in the depth of water above the still water level called the 'set up'. Therefore, from a coastal context sediment transport can be separated into two different components - longshore and cross-shore transport. Offshore currents may also occur.

Figure 29: Schematic representation of the longshore current and set up with respect to the breaking point (Source: Reeve, D., Chadwick, A. and Fleming, C. [16]).



Sediment transport of the material which forms the coastline occurs through two different key mechanisms: bed load transport (material rolls or moves at the seabed when sheer stress is exceeded) and suspended load transport (material is suspended in the water column and moves above the seabed). Bed load represents a small fraction of longshore transport compared to suspended load transport [17].

Sediment may be transported by unbroken waves and/or currents, however most transport takes place in the surf and swash zones.

The breaking zone has been estimated based on the Goda 1985 method (Coastal Engineering Manual (CEM) [18] Part II) and the wave study (Appendix A). The maximum breaking wave heights have been estimated based on an approximate average seabed slope of 1V:70H (based on information from the available bathymetric surveys), for return periods of 1, 5 and 10 years.

The significant wave heights offshore (Ho) have been given as an input to the formulation. The results are shown in Table 4.

Table 4: Estimation of the wave height based on Goda 1985 (Coastal Engineering Manual (CEM) Part II [18]).

Tr (years)	**Ho (from wave analysis) (m)**	**Water depth at breaking (m)**
5	3.7	8.14
10	4.2	9.24

The breaking depth has been subsequently estimated for two tide conditions: Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS). A sea level rise of 1m due to potential effects of climate change has been accounted for in the calculations (see Appendix A for more details).

Table 5: Resulting breaking depths for the two tide scenarios and three return periods considered in the assessment.

Tide scenario	**Tide level (m CD)**	**Breaking contour (m CD)**	
		Tr = 5 years	**Tr = 10 years**
MHWS (m CD) + 1m of sea level rise	2.4	-5.74	-6.84
MLWS (m CD) + 1m of sea level rise	1.6	-6.54	-7.64

The resulting contour lines for the different return periods for the MHWS scenario (i.e. the scenario that gives the widest breaking area) are depicted in Figure 30. These lines represent the seaward extent of the breaking area for each of the return periods considered.

Return periods have been selected to identify the surf zone in average conditions (e.g. relatively low return periods which reflect an average behaviour). Based on these results and considering a return period of five years and climate change it could be expected that the surf zone, where most of the sediment transport occurs in this scenario due to wave breaking and currents, would be limited offshore to the bathymetric line of -6.5m CD. For annual average conditions, the extent of the surf zone is limited to shallower waters, closer to the coastline.

Figure 30: Approximate extent of the estimated breaking zones corresponding to return periods of 5 and 10 years.

5.3.1.2 Estimation of the sediment transport patterns

The potential direction of longshore sediment transportation has been estimated using the CERC formula (presented in the Shore Protection Manual [19]) and the results from the wave propagation model [1].

The resulting potential directions for sediment transport within the Area of Interest are shown in Table 6 for each of the directional sectors with influence on the study area. Estimated directions for the net longshore sediment transport for each wave sector have been assessed for 5 locations at the nearshore (bathymetric contour of -4m CD). These locations were superimposed along with the wave directions for the east south-east direction including shadow effect of the harbour entrance (see Figure 31).

Figure 31: locations for sediment transport calculations.

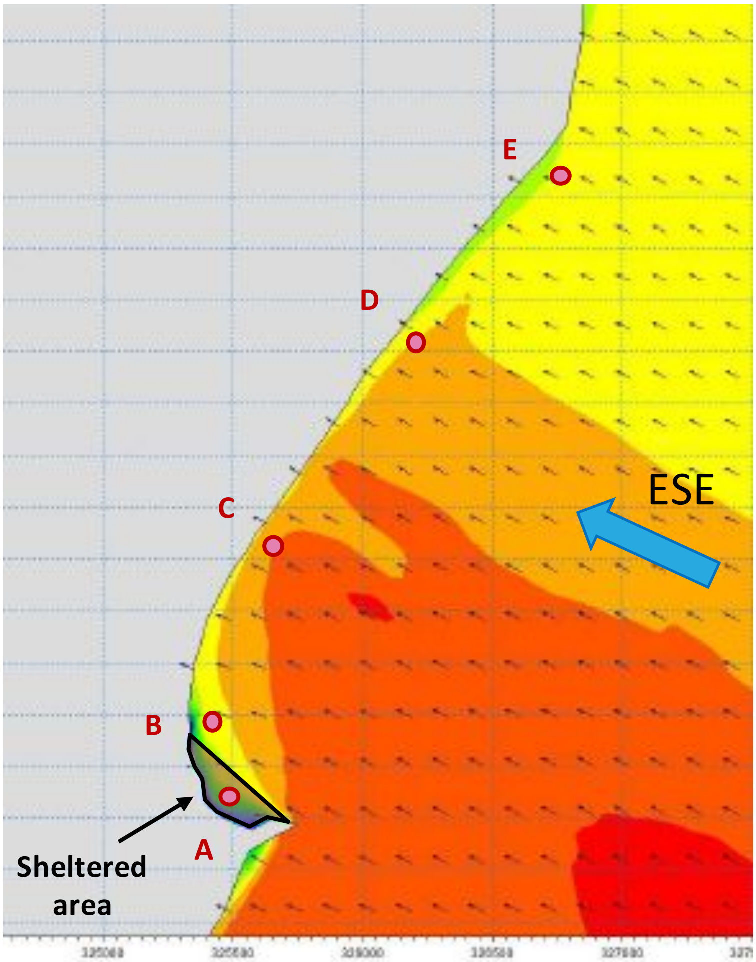


Table 6: Direction of potential sediment transport for each case assessed (red arrow indicates from north to south, green arrow indicates from south to north and yellow indicates neutral).

Points		NE			ENE			E			ESE			SE			SSE			S		
	α_r (°)	α_b (°)	α'_b (°)	**Q**	α_b (°)	α'_b (°)	**Q**	α_b (°)	α'_b (°)	**Q**	α_b (°)	α'_b (°)	**Q**	α_b (°)	α'_b (°)	**Q**	α_b (°)	α'_b (°)	**Q**	α_b (°)	α'_b (°)	**Q**
A	70	70	**0**	→	80	**10**	↑	95	**25**	↑	70	**0**	→	70	**0**	→	70	**0**	→	70	**0**	→
B	90	70	**-20**	↓	80	**-10**	↓	95	**5**	↑	110	**20**	↑	90	**0**	→	90	**0**	→	90	**0**	→
C	120	80	**-40**	↓	85	**-35**	↓	100	**-20**	↓	120	**0**	→	125	**5**	↑	140	**20**	↑	160	**40**	↑
D	130	85	**-45**	↓	90	**-40**	↓	105	**-25**	↓	120	**-10**	↓	135	**5**	↑	140	**10**	↑	160	**30**	↑
E	135	80	**-55**	↓	90	**-45**	↓	100	**-35**	↓	120	**-15**	↓	135	**0**	→	140	**5**	↑	160	**25**	↑

The CERC method assumes that there is an adequate and unlimited source of sediment on the seabed which can be suspended and transferred due to wave action depending on the direction of incoming waves. The formula also assumes bathymetry to be straight and parallel to the coastline. The study area does not consist of a beach- the only beach is the North Arklow Beach, therefore, these potential sediment transport patterns would only affect the nearshore seabed material.

The CERC formula has only been applied qualitatively to assess the potential directions of sediment transport along the coastline.

5.4 Coastal processes affected by the upgraded revetment

5.4.1 Construction phase

It has been considered that the only likely effect that the upgrading works could have on the existing coastal dynamics is the dispersion of material at the location of the revetment works during construction.

The excavation of material from the seabed is limited at the toe of the proposed revetment and the volume of material is expected to be small.

The assessment of likely significant effects associated with the potential presence of potential contaminants within and on the existing revetment is outside the scope of this study, and is covered in Chapter 15 the EIAR [1].

5.4.1.1 Potential effects within the area of interest

As previously mentioned, the coastline at the Area of Interest is mostly covered by the existing rock revetment along approximately 2.2km, while the northern area is comprised of an unprotected sandy beach to the north – the North Arklow Beach.

The potential transport of any suspended material will be mostly confined within the surf zone (approximately limited by the bathymetric contour of -6.5m CD, as outlined in Section 5.3). Moreover, the coastal section of the site is sheltered from the second quadrant directions by the entrance of Arklow harbour. Therefore, any potential dispersion of the material is expected to be naturally deposited within the Area of Interest and mostly limited by both the harbour entrance at the south and the natural headland at the north.

It is important to note that the excavated sediment may either be reinstated in front of the toe of the revetment or disposed of at a suitably licensed facility off-site.

Therefore, the likely effect of dispersing material on coastal processes is considered to be not significant within the Area of Interest during construction of the revetment upgrade.

5.4.1.2 Potential effects outside the area of interest

Based on the envisaged construction methodologies, the site conditions and the existing coastal processes described in the previous sections, the following is noted:

- The areas to the south of the Area of Interest are not affected by the new changes being introduced in the site due to the longshore drift being from south to north, the location of the upgrade of the revetment and the existing barrier of the Arklow harbour entrance.
- The change in orientation of the adjoining Area of Interest to the north limits the influence of any potential sediment transport derived from the excavation in the site.
- The excavation required during construction is limited to the area of the toe of the upgraded revetment. The excavation of the toe extents approximately up the -5m CD bathymetric line.
- The excavated sediment obtained during excavation of the existing seabed in front of the existing revetment may either be reinstated at the toe location or disposed of at a suitably licensed facility off-site

Thus, the likely effect of dispersing material is considered to be not significant in relation to coastal processes outside the Area of Interest during construction of the revetment upgrade.

5.4.2 Mitigation and monitoring

No mitigation or monitoring measures are proposed with respect to the construction of the revetment.

5.4.3 Operational phase

5.4.3.1 Potential effects within the area of interest

No significant effects on existing coastal processes are likely within the Area of Interest during the operational phase given the coastline has already been stabilised by the existing rock armour revetment. Further, the alignment of the upgraded revetment will generally follow the existing revetment alignment.

The revetment upgrade will ensure coastal protection within the site for a 500 year return period storm event as it has been designed to protect against wave overtopping and satisfy functional and safety requirements.

The design ensures that the upgraded revetment can withstand the expected incident waves. The upgraded revetment is a porous flexible structure where wave energy can be partly absorbed and dissipated. For this reason, local wave reflections are expected to be minimum and similar to those currently experienced. The upgraded revetment, being parallel to the coastline and located in the shadow of the Arklow harbour entrance, does not impose a barrier, or an obstruction to the predominant longshore sediment transport patterns.

In this regard, no change in sediment transport is expected with the upgraded revetment from that which exists currently.

Therefore, the likely effect of the existence of the upgraded revetment is considered to be not significant in relation to coastal processes within the Area of Interest during operation of the proposed development.

5.4.3.2 Potential effects outside the area of interest

The areas south of the Area of Interest are not affected by the revetment upgrade predominantly due to the barrier imposed by the Arklow harbour entrance and prevailing longshore drift from south to north. Given the change in orientation of the adjoining area to the north of the Area of Interest, it is concluded that any local potential changes in the Area of Interest will have no effect to the north. Furthermore, the assessment of the effects within the Area of Interest apply (see section 5.4.3.1).

Therefore, the likely effect of the existence of the upgraded revetment is considered to be not significant in relation to coastal processes outside the Area of Interest during the operation of the proposed development.

5.4.4 Mitigation and monitoring

The revetment and its toe will be monitored to ensure its performance. The revetment will be monitored by Irish Water as part of the overall maintenance of the works. Revetment maintenance would include visual inspection either by divers or robotics and would be performed every year and after significant storm events. The inspection crew would check the revetment for damage to the toe, rock stability, lowering of nearshore bed levels or other damage. Suitable remediation works will be undertaken as required.

5.5 Coastal processes affected by the SWO

With regard to the SWO, given that it discharges at the shoreline (below MLWS), the construction and operation of the SWO, similar to that of the revetment, will not result in a significant effect in relation to coastal processes inside and/or outside the Area of Interest. Refer to Sections 5.4.1.1 and 5.4.1.2 for further detail on this assessment.

5.6 Coastal processes affected by the long sea outfall

5.6.1 Introduction

This section considers the likely significant effects on coastal processes as a result of the two open cut construction methodologies for the long sea outfall (i.e., construction by means of the float and flood or bottom pull method which requires a trench to be excavated) and the method for installation of the diffusers, for all three construction methods.

The likely significant effect due to dispersion of the excavated seabed material (which may be side casted along the edge of the trench during construction), dispersion of any sediment mobilised during the dredging process and the exposure of the outfall and/or scour protection during operation of the proposed development have been assessed.

The likely significant effects associated with the horizontal directional drilling method would not involve any change in the seabed geometry during construction or operation, therefore this option is not considered to result in any significant effects on coastal processes.

The assessment of likely significant effects associated with the potential presence of potential contaminants at the outfall location is outside the scope of this study, and is covered in Chapter 14 of the EIAR [1].

5.6.2 Construction phase

5.6.2.1 Potential effects within the area of interest

The construction of the outfall pipeline could result in an increased rate of sediment dispersion, with the dredged sediments being completely moved from their original position near the trench. Local currents could suspend the limited volume of sands causing its dispersion by waves and currents. This could have an effect on coastal processes, and in turn on sensitive ecological receptors, such as marine species and Natura 2000 sites.

However, there are a number of factors which will reduce the significance of effect in this regard, as follows:

- This material given its limited volume and the wave conditions necessary for the dredging operation (low wave conditions generally required) would be mostly deposited within the coastal Area of Interest, and if any, it would slightly increase the overall volume of seabed material in the seabed and submerged beach of the adjoining area.
- The seabed material is expected to be non-cohesive and with a low content of fines (Section 8.2), therefore significant suspension of fines is not anticipated. The CIRIA Report 159 [9] states that tide-induced seabed velocities alone are rarely sufficient to initiate motion of non-cohesive sediments at coastal sites, and hence significant movement of sand and gravel tends to be associated with periods of high wave activity only. In this regard, the most significant movement may happen in or close to the surf zone.

  The bed sediment has been characterised as non cohesive and reasonably coarse, therefore it can be inferred that any sediment mobilised from the works is likely to be deposited in the vicinity of the outfall and will not impact on the wider marine environment.
- Works are envisaged to be undertaken in the summer season to facilitate the necessary calm wave conditions to operate the plant and equipment required for excavation of the trench.

A maximum wave height of 0.5m is a typical operational limit for the dredging operations. Under these wave conditions, the surf zone is estimated to be nearshore. Due to the vicinity of the outfall with the river's breakwaters, this area is sheltered from the south. Where the outfall falls outside the nearshore surf area and Arklow Harbour entrance, the suspended sediment transport is expected to be very limited (some minor local sediment movements may occur on the seabed) as shown by the estimation of the break area and also historical evidence as shown in the historical comparison of the profiles for the offshore area.

- The marine environment is dynamic and there is a continuous process of sedimentation/deposition which naturally occurs. Against this background, the impact of the sedimentation due to the engineering works will not be significant.
- The volumes of excavated material are considered relatively low are and expected to be partially re-used as described in section 2.4.2.2, if deemed suitable by the contractor.

In summary therefore, it is considered that the reasonable worst case will not affect the overall coastal patterns. No erosion or accretion of adjoining areas is expected to result from the outfall construction.

Thus, the likely effect of local sediment movement is considered to be not significant in relation to coastal processes within the Area of Interest during construction of the long sea outfall. Effects on other environmental receptors, such as Natura 2000 sites and marine species are addressed in the EIAR and NIS.

5.6.2.2 Effects outside the area of interest

The risk of the sediment transport having an impact on the areas outside of the Area of Interest is considered very low due to the following:

- those factors presented above in Section 5.6.2.1;
- There is a very limited potential for dredged material to be dispersed within a larger area outside the Area of Interest; and
- The presence of the Arklow Harbour piers provides shelter to the adjacent area to the south in the area where most of sediment transport is expected (nearshore area).

No negative impacts on receptors from sediment transport (such as emerged beach or dunes) are anticipated given the very limited increase of the material that could be transported.

Thus, the likely effect of local sediment movement is considered to be not significant in relation to coastal processes outside the Area of Interest during construction of the long sea outfall. Effects on other environmental receptors, such as Natura 2000 sites and marine species are addressed in the EIAR and NIS.

5.6.3 Operational phase

5.6.3.1 Effects within the area of interest

Scour protection will be installed to ensure the structural integrity of the outfall during operation. The scour protection will consist of a layer of concrete mattresses embedded in the existing seabed. This scour protection will be designed to be stable and prevent any scour of the seabed against nearshore wave action and currents. The scour protection will be designed to match the seabed level to avoid the creation of a sediment transport barrier. The scour protection will also stabilise and prevent the movement of seabed material in the local area of the outfall.

In the event that seabed levels in the area close to the scour protection reduce, the concrete mattresses would accommodate to the new geometry. It is important to note that the outfall and associated scour protection will be designed against this outcome, but it is assessed as a reasonable worst case scenario. This potential lowering of seabed will not impose a barrier to sediment transport based on the following:

- Longshore sediment transport occurs within the break area.
- The break area of the outfall is mostly sheltered by the entrance of Arklow Harbour.
- Bed load represents a small fraction of longshore transport compared to suspended load transport and therefore any local new feature of the seabed would not change any existing longshore sediment transport patterns.

On this basis, no change in the existing coastal processes involving erosion or accretion of the adjoining coastal areas is expected due to the presence of this outfall and therefore no significant effects are likely during operation of the proposed development.

Thus, the likely medium to long term effect of the outfall is considered to be not significant with respect to coastal processes within the Area of Interest during operation of the proposed development. Effects on other environmental receptors, such as Natura 2000 sites and marine species are addressed in the EIAR and NIS.

5.6.3.2 Effects outside the area of interest

Given that there are no significant effects within the Area of Interest, it can be concluded that are no significant effects are likely to arise outside of the Area of Interest from the existence of the outfall for the same reasons as described above.

Thus, the likely effect of the outfall is considered to be not significant in relation to coastal processes outside the Area of Interest during operation of the proposed development. Effects on other environmental receptors, such as Natura 2000 sites and marine species are addressed in the EIAR and NIS.

5.6.4 Mitigation measures

Construction of the long sea outfall will generally be restricted to the period May – September, with the period between November-February generally avoided. In this manner, the months with likely worst wave and wind conditions, which lead to higher levels of sediment suspension and transport, are avoided.

5.6.5 Monitoring

As for all such infrastructure, the scour protection shall be monitored to ensure its performance and avoid any potential risk derived from the potential future exposure of the pipe. Scour protection will be monitored by Irish Water as part of the overall long outfall maintenance. Outfall monitoring would include visual inspection either by divers or robotics and would be performed every 5 years and after significant storm events as part of the overall operational management regime. The inspection crew would check the pipeline for scour protection damage, slide, anchor, or other damage. Scour protection shall be reinstated and/ or repaired if any damage is observed.

5.7 Residual effects

It is considered that, with the implementation of the proposed mitigation and monitoring measures, that there are no significant residual effects from the proposed development on coastal processes including sediment dispersion and local scour/siltation effects. Residual effects on other environmental receptors, such as Natura 2000 sites and marine species are addressed in the EIAR and NIS.

6 References

[1] Arup (2018) 'Environmental Impact Assessment Report', ref. 247825/EIA/EIAR/1

[2] Drawing M-R-1001 Arklow WWTP Revetment Upgrade Existing Layout Plan

[3] Drawing M-R-1002 Arklow WWTP Revetment Upgrade Proposed Layout Plan

[4] Drawing M-R-2001 Arklow WWTP Revetment Upgrade Cross Sections – Sheet 1 of 3

[5] Drawing M-R-2002 Arklow WWTP Revetment Upgrade Cross Sections – Sheet 2 of 3

[6] Drawing M-R-2003 Arklow WWTP Revetment Upgrade Cross Sections – Sheet 3 of 3

[7] Stevens (2015) 'Trenchless solutions for sewer networks and sea outfalls'

[8] WRC (1990) 'Design guide for marine treatment schemes: Volumes I – IV'

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[10] ICPSS report Irish Coastal Protection Strategy Study Phase 2 - South East Coast

[11] Irish Hydrodata Limited report (2018), 'Arklow WWTP Investigation of the Impact of Treated Wastewater discharges to the Irish Sea'

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[17] Robert B. Nairn, Howard N. Southgate, "Deterministic profile modelling of nearshore processes. Part 2. Sediment transport and beach profile development" Coastal Engineering Volume 19, Issues 1–2, February 1993, Pages 57-96

[18] U.S. Army Corps of Engineers (2002) 'Coastal Engineering Manual'.

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Appendix A

Wave modelling report

Irish Water

Arklow Waste Water Treatment Plant

Wave modelling report

247825-00

Issue | 28 August 2018

Job number 247825-00

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Contents

1 Introduction

Arup has been commissioned by Irish Water to provide Engineering services for the Arklow Waste Water Treatment Plant (WWTP) including specimen design. The scope includes the design of the upgraded section of the revetment at the eastern site boundary (see Figure 1), which requires an accurate estimation of the design wave height. This estimation has been carried out by undertaking numerical wave modelling.

This includes:

- Acquiring offshore wave data
- Setting up and applying a spectral wave model to model wave propagation from offshore to the near shore

Figure 1: Arklow waste water treatment plant preferred location including the existing revetment.

2 Methodology

The following steps were undertaken as part of the wave modelling study:

1. Analysis of the offshore wave climate;
2. Setup of the bathymetry, computational mesh and boundary conditions and application of the model;
3. Extraction of the model results at the location of the revetment;

2.1 Software

The model used for wave propagation from offshore to the proposed location is MIKE21-SW developed by DHI. This software is a 3rd generation spectral wind-wave model that simulates the growth, decay and transformation of wind-generated waves and swell in offshore and coastal areas. The software includes the following physical phenomena:

- Wave growth by wind action;
- Non-linear wave-wave interaction;
- Dissipation by white-capping;
- Dissipation by wave breaking;
- Dissipation due to bottom friction;
- Refraction due to depth variations:
- Wave-current interaction;
- Diffraction;
- Reflection;

A major application area for this model is the design of nearshore structures where accurate assessment of wave loads is of utmost importance for a safe and economic design.

3 Site condition analysis

3.1 Site location

The location of the proposed revetment at the site of the Arklow WWTP is located to the north of the entrance to Arklow port (see Figure 2). The site is fully exposed to waves from the NE and E but is partially protected from waves from the SE due to the presence of the piers.

Figure 2: Location of upgraded revetment at Arklow WWTP – Source: Google Maps - ©2014 Google.

3.2 Design water level

The design water level for the proposed revetment is based on the following sources:

- Tidal levels in Arklow Harbour [1]
- Irish Coast Protection Strategy Study [4]

Tidal levels were taken from Admiralty Chart 1468 as shown in Table 1 below. LAT is not provided by the tide tables, but is taken as 0m Chart Datum.

Table 1: Tidal levels in Arklow Harbour.

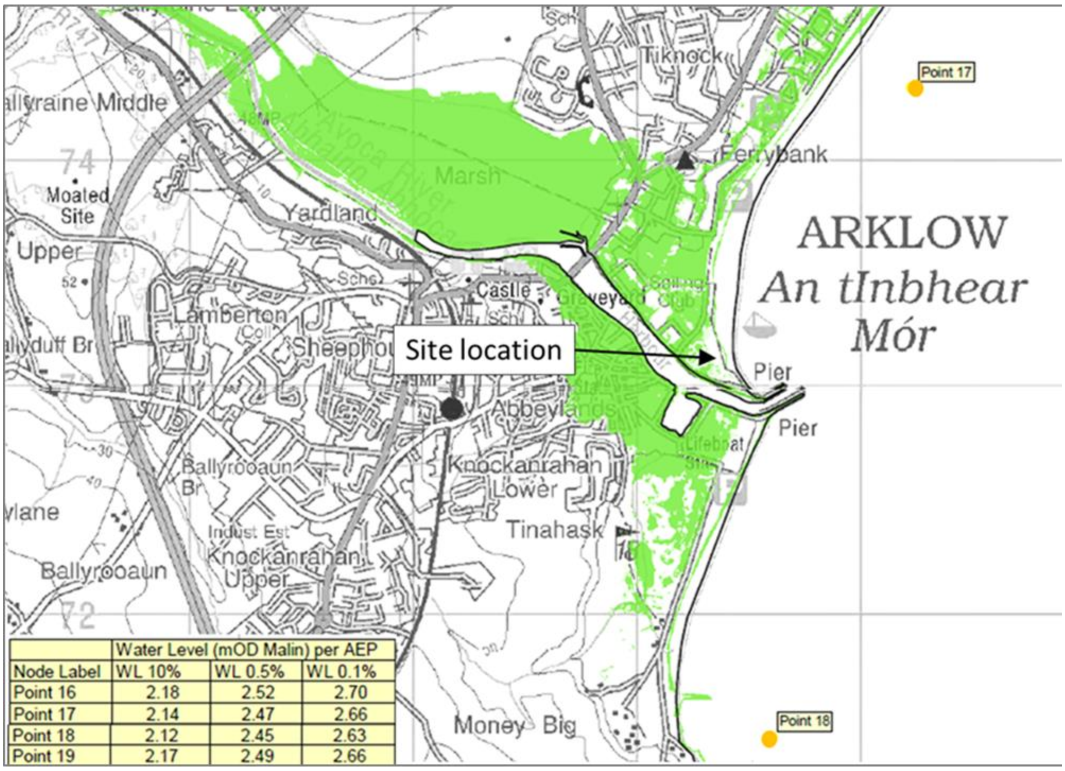
Tidal Level	Chart Datum	OD Malin
MHWS	1.4 m	0.28m
MHWN	1.2 m	0.08m
MLWN	0.9 m	-0.22m
MLWS	0.6 m	-0.52m
LAT	0 m	-1.12m

The Irish Coastal Protection Strategy Study (ICPSS) is a national study that maps extreme water levels along the Irish coast. Package 9A of this study, which includes the future scenario assessments of extreme coastal water levels, was used to obtain predicted extreme water levels for the design of the revetment. Since the WWTP is deemed critical infrastructure, the high end future scenario (HEFS) water levels were adopted. These predicted water levels include a combination of storm surge and extreme tidal levels, based in both numerical modelling and statistical analysis of historic tide gauge data. The HEFS levels also allow for land movement and +1.00m sea level rise by the year 2100.

A return period of 500 years was calculated using BS 6349-1:2000, for a 50 year design life and a 10% occurrence probability, which is considered appropriate for the significance of the infrastructure. As the ICPSS maps do not provide HEFS water levels for a 500 year return period, interpolation between the 200 and 1000 year return periods was used to obtain this value. As shown in Figure 3, the site is located approximately half way between two data points on the ICPSS maps. Therefore, water levels at the site are found by interpolation between these two points.

The resultant extreme water level at the site is 2.56mOD Malin or 3.68m Chart Datum.

Figure 3: Extract from ICPSS drawing no. SE / RA / EXT / HEFS / 9 and 10.



	Water Level (mOD Malin) per AEP		
Node Label	WL 10%	WL 0.5%	WL 0.1%
Point 16	2.18	2.52	2.70
Point 17	2.14	2.47	2.66
Point 18	2.12	2.45	2.63
Point 19	2.17	2.49	2.66

3.3 Offshore wave and wind data

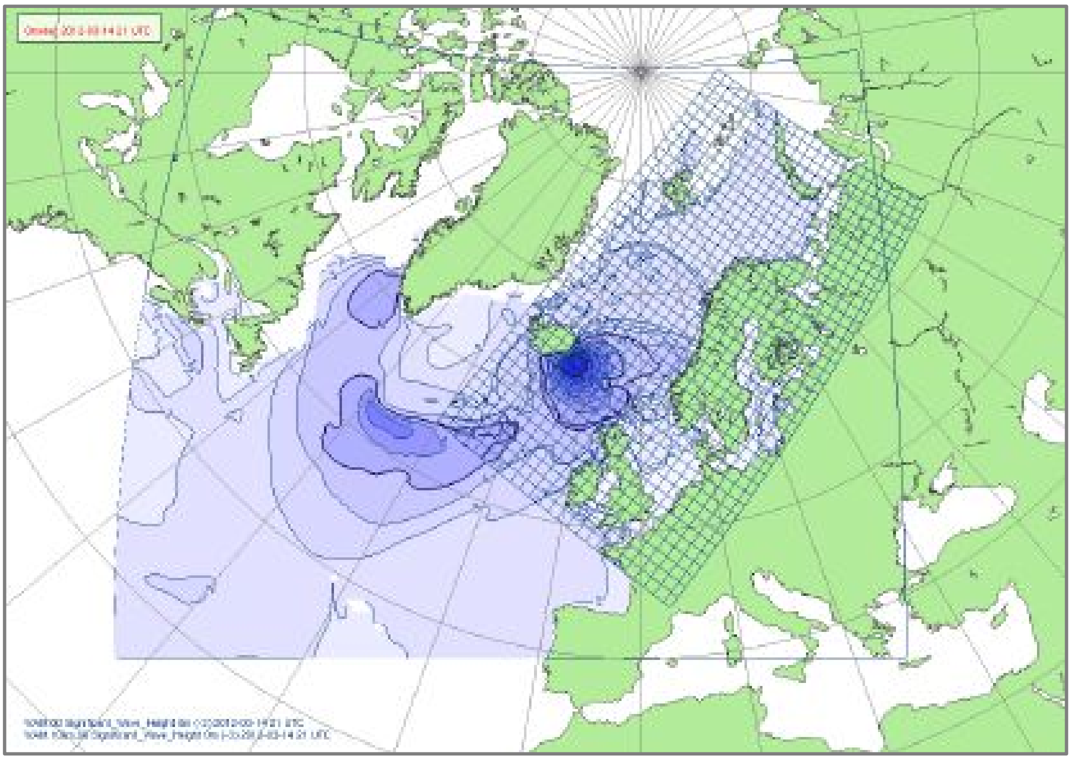
To approximate the design wave height for the new revetment design process, a computational model was used that simulates wave propagation from offshore to nearshore. The quality of the offshore data used to define the boundary conditions of the model is a key factor in setting up a reliable wave model.

3.3.1 Data source

For this site, Arup used the Norwegian ReAnalysis 10km database (NORA10) [1] This database consists of wave and wind data records for the period September 1957 to September 2017.

The NORA10 hindcast model was developed by the Norwegian Meteorological Institute[2]. It is a regional atmospheric and wave hindcast model (HIRLAM and WAM Cycle 4) covering the Northern European waters. The regional model uses wind and wave boundary conditions from the ERA-40 reanalysis (based on wind data from1958 to 2002) and is extended using the ERA-Interim reanalysis from 2002 to 2011. NORA10 produces three-hourly wave and wind fields at 10km spatial resolution, see Figure 4.

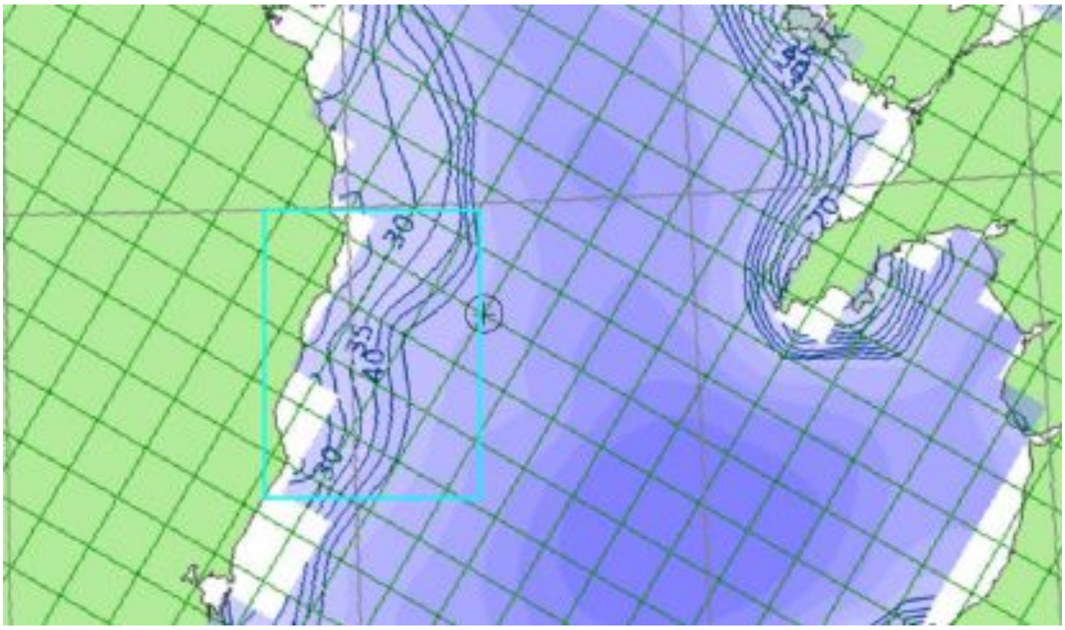
Figure 4: NORA10 (Norwegian ReAnalysis 10km) database: Area coverage.



For this wave study, the data has been obtained from the NORA10 grid point at location 52.80N, 5.62W (see Figure 5) as the offshore position on the East coast of Ireland allows for the estimation of the wave climate in the offshore area adjacent to Arklow.

This 60 year dataset provides sufficiently long record for a reliable statistical extreme value analysis.

Figure 5: NORA10 wave buoy location (52.80N, 5.62W) and computational boundaries used.



Directional analysis of the offshore wind and wave climate was carried out to assess the metocean conditions at the proposed model boundary. Only waves originating from the first and second quadrants (from North to South directions clockwise) propagate to the proposed location. For this reason, only offshore wind and wave conditions from the first and second quadrant were considered.

Wave data

Figure 6 presents the directional wave distribution of the offshore wave climate; this corresponds to the NORA10 offshore node. From Figure 6, it is shown that the predominant wave direction is SSW with an associated frequency of approximately 36%.

Figure 6: Offshore Wave Rose – All directions.

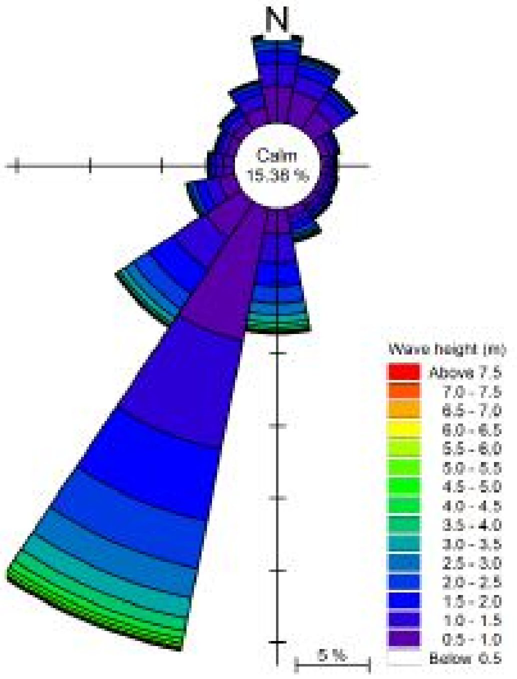
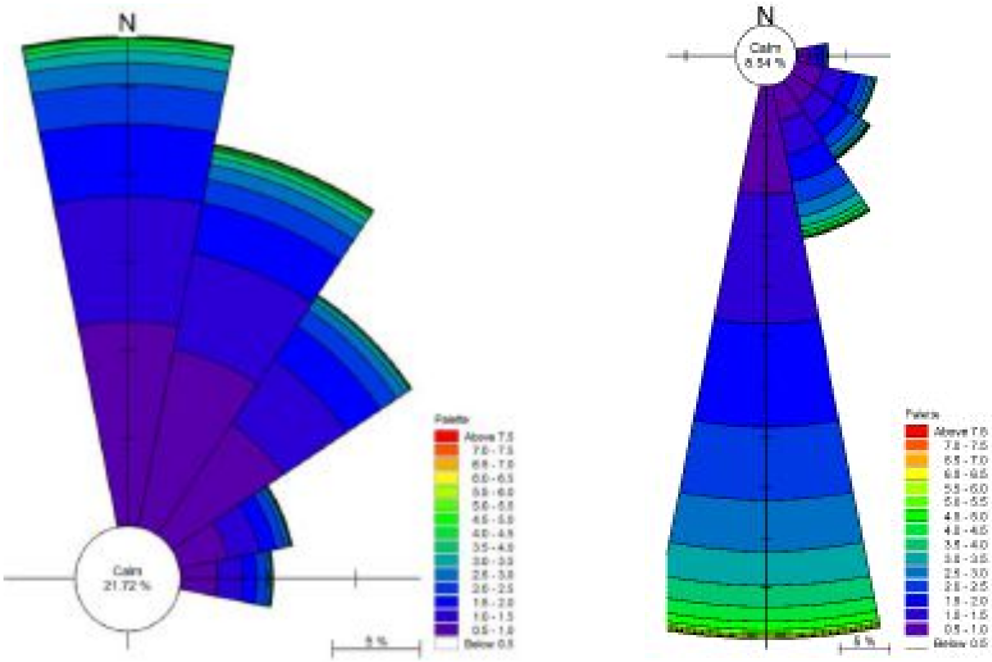


Figure 7 shows the directional wave distribution in the first and second quadrant respectively. Within the first quadrant the most frequent directions are N, NNE and NE with decreasing frequency towards the east.

Within the second quadrant the most frequent direction is S. The northern and southern directions also have higher offshore significant wave height values, H_s, with a maximum of approximately 7.8m.

Figure 7: Offshore wave roses first and second quadrant.

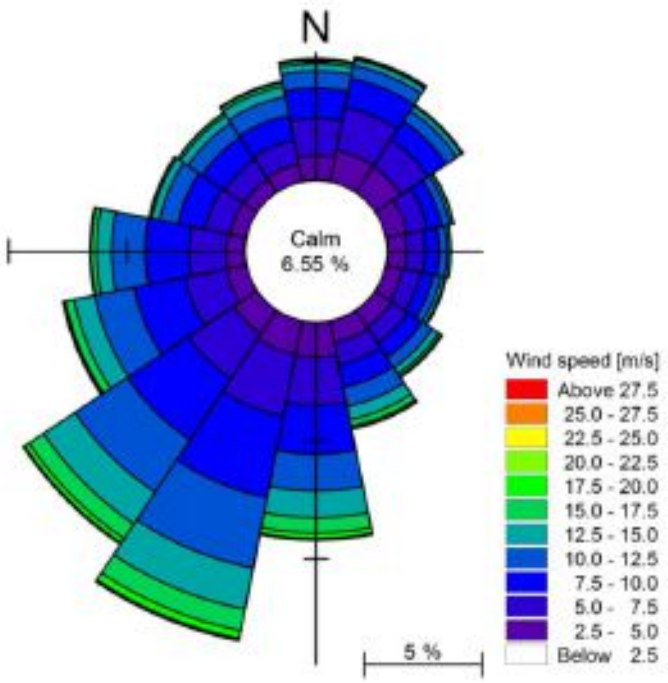


As previously stated, the proposed location is only exposed to waves from both the first and second quadrants. Therefore, based on the bathymetry and the directions likely to affect the location, waves coming from north to south will be assessed.

Wind data

Figure 8 shows the directional wind distribution of the full wind rose at the NORA10 grid point. The predominant wind directions are SSW and SW. For the first and second quarter, the predominant directions are NNE and NE. Maximum wind speed values for the first and second quarter are approximately 25m/s for the south easterly directions.

Figure 8: Offshore Wind Rose – All directions



3.3.2 Extreme value analysis

The offshore data has been analysed statistically using the EVA module of MIKE software, which is also used for the wave modelling. Specific analysis of all directions from North to South has been carried out to obtain the best fit to the function of extreme values of H_S.

Annual maximum values have been analysed to select the extreme value of H_S for each of the directions. This analysis was based on both, the Gumbel extreme value function and the Generalised Extreme Value (GEV) function, which are given by Equation 1 and Equation 2 respectively:

$$T_R = \frac{1}{1-F(Hs)}, \text{ where } Hs(x) = e^{-e^{\left(-\frac{(x-\mu)}{\Psi}\right)}} \quad (1)$$

$$T_R = \frac{1}{1-F(Hs)}, \text{ where } F(Hs) = e^{-\left(1+\xi\frac{Hs-\mu}{\psi}\right)^{-\left(\frac{1}{\xi}\right)}} \quad (2)$$

In which T_R is the return period, H_s is the significant wave height, μ (location), ψ (scale) and ξ (shape) represent the statistical parameters for the functions chosen.

Wave analysis

This analysis was carried out in order to determine the distribution of significant wave height (H_s [m]) over the return period [y]. For each of the directions assessed the software provides a best fit curve through the data for all requested distributions. Generally, the GEV distribution fits better the significant wave height dataset. The chosen distribution curves for the 5 most important directions for the site (NE, ENE, E, ESE and SE clockwise) are shown in Figure 9 to Figure 13 respectively. The distribution curves for the other directions can be found in Appendix A.

In each of the diagrams, the solid line represents the best fit curve whereas the dashed lines on either side represent the confidence limits which indicate the 90% confidence around the predicted function.

The best fitting formula was used to calculate the significant wave height for the required return period. The wave peak period (T_p) is matched with the significant wave height (H_s) using the Jonswap-formula based on Holthuijsen, 2007 [7]. The result is shown along with an extrapolation of the NORA10 hindcast data in Figure 14.

Figure 9: NE: Extreme value analysis for the significant wave height (H_s).

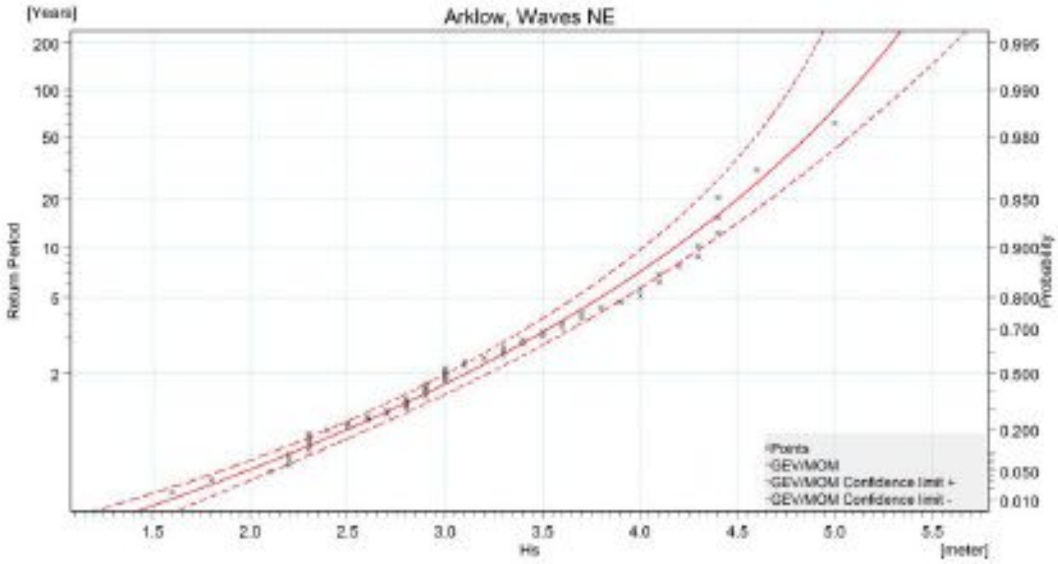


Figure 10: ENE: Extreme value analysis for the significant wave height (H_s).

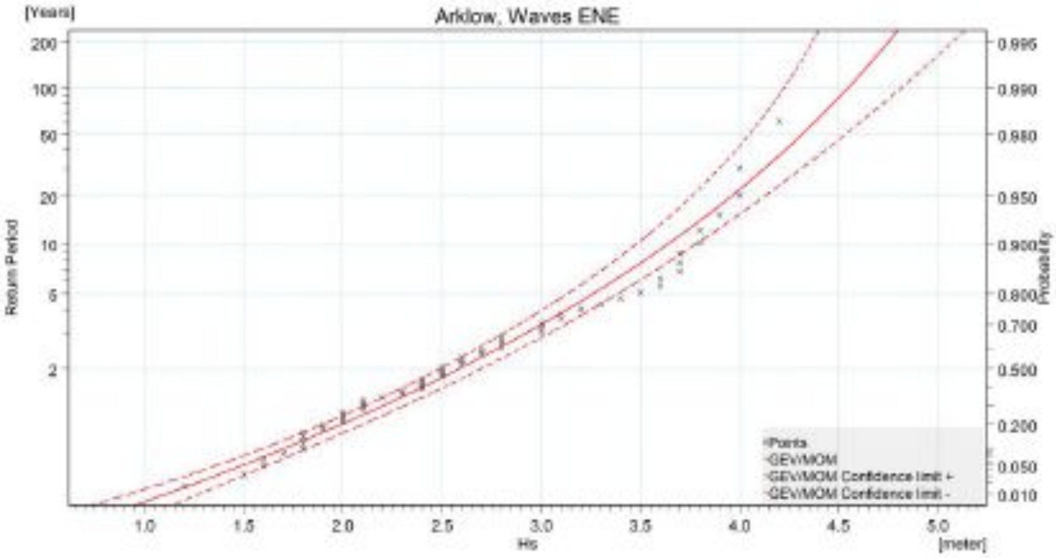


Figure 11: E: Extreme value analysis for the significant wave height (H_s).

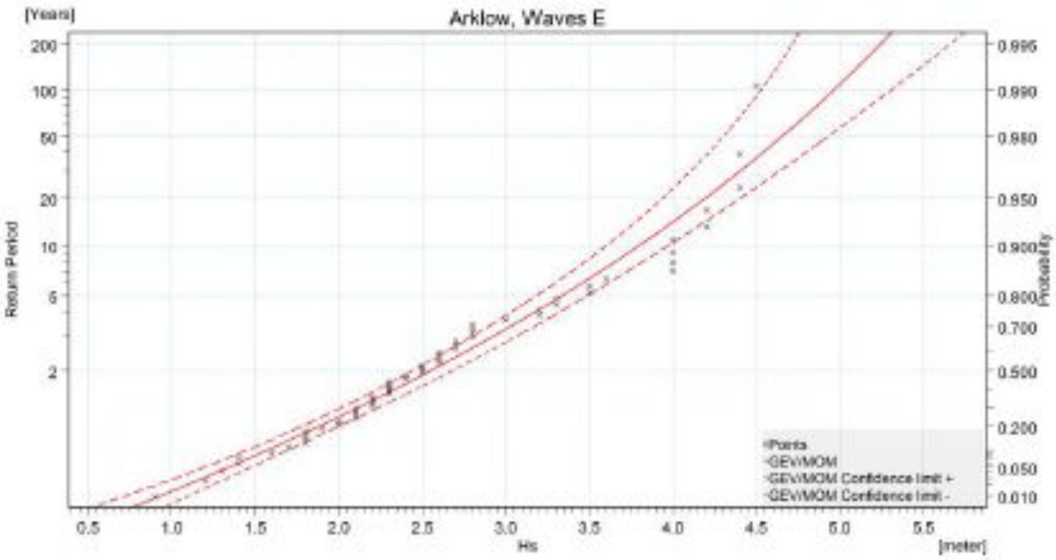


Figure 12: ESE: Extreme value analysis for the significant wave height (H_s).

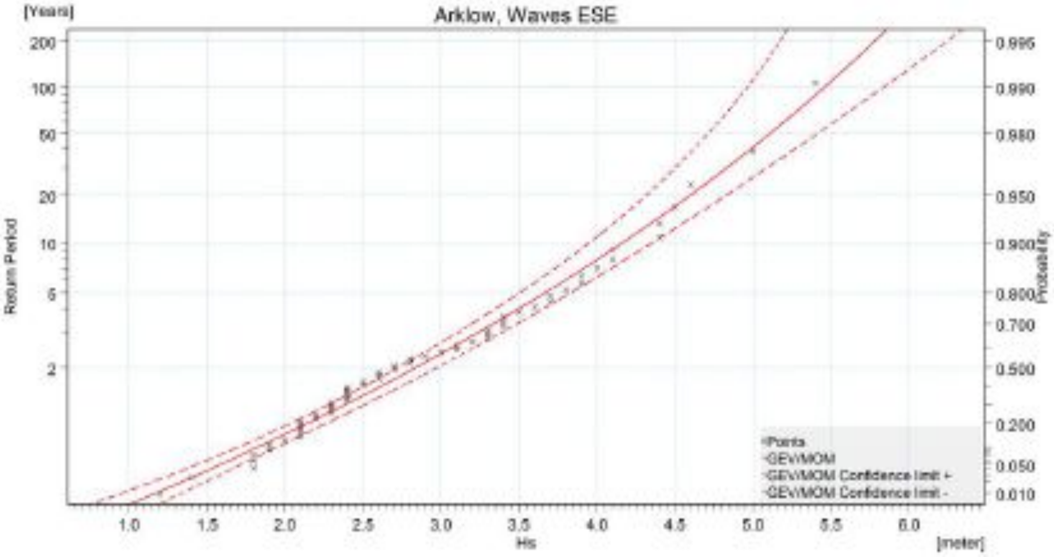


Figure 13: SE: Extreme value analysis for the significant wave height (H_s).

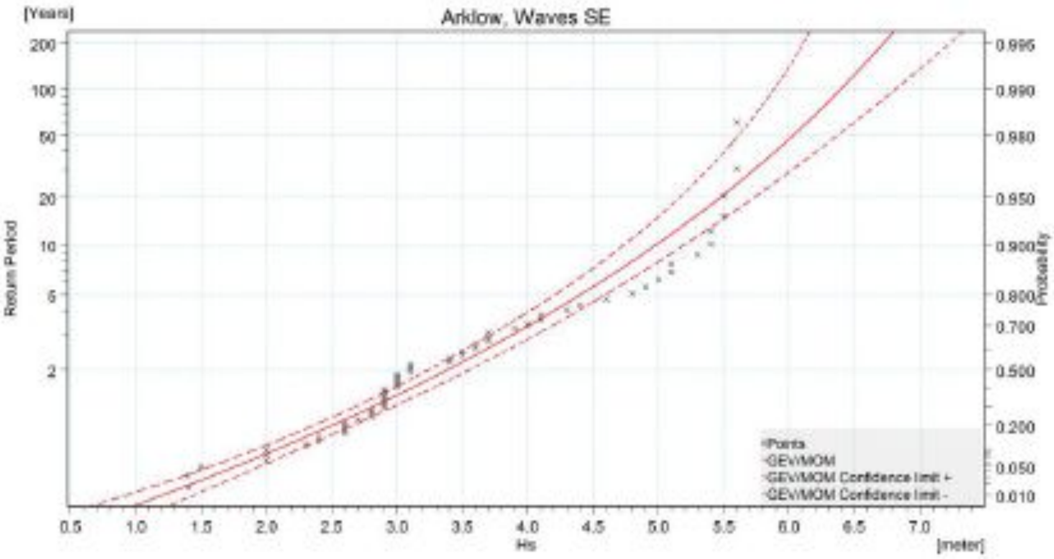
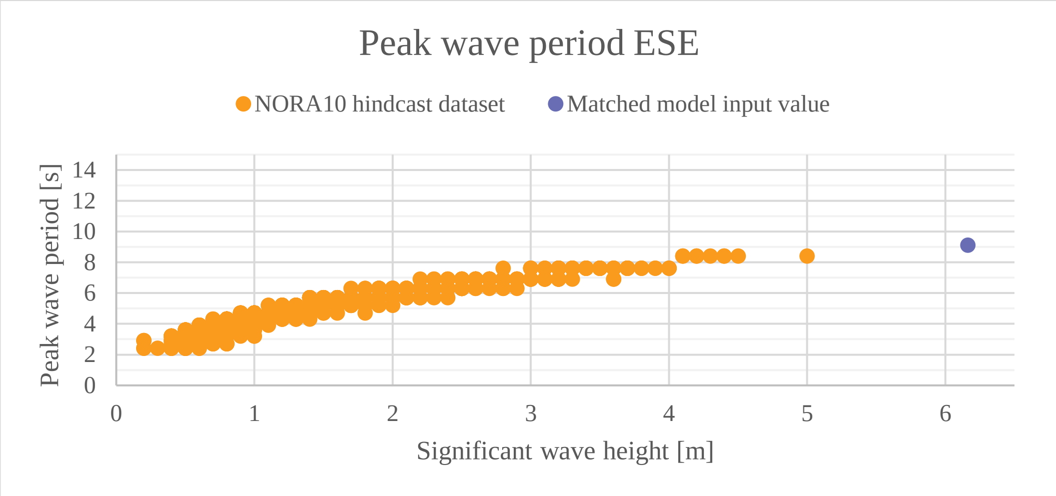


Figure 14: ESE: Comparison of cloud plot from NORA10 hindcast dataset with the matched peak wave period (Tp) based on Jonswap formula.



Wind analysis

This analysis was carried out in order to determine the distribution of average wind speed (W_{sp} [m/s]) over the return period [y]. For each of the directions assessed, the software provides a best fit curve through the data for all requested distributions as has been done for the significant wave height analysis. Generally, the Gumbel distribution fits better the wind speed dataset. The plots can be found in Appendix A.

3.4 Summary of model input data

Table 2 below summarises the results of the assessments of design water level and offshore wind and wave data as described in the previous sections. This data will be used as boundary input data in the numerical wave modelling and will be used to define a number of model runs as appropriate.

Table 2: Water level, wave and wind input summary.

			Extreme sea level		Offshore wind and wave data			
Wave direction		Scenario	Return Period	Water Level	Return Period	H_S	T_p	V_w
	^{0}N		[year]	[m CD]	[year]	[m]	[s]	[m/s]
NE	45	HEFS	500	3.68	500	5.5	8.6	24.3
ENE	67.5	HEFS	500	3.68	500	5.0	8.3	20.7
E	90	HEFS	500	3.68	500	5.6	8.7	24.4
ESE	112.5	HEFS	500	3.68	500	6.2	9.1	25.0
SE	135	HEFS	500	3.68	500	7.1	9.7	23.0

4 Wave modelling analysis

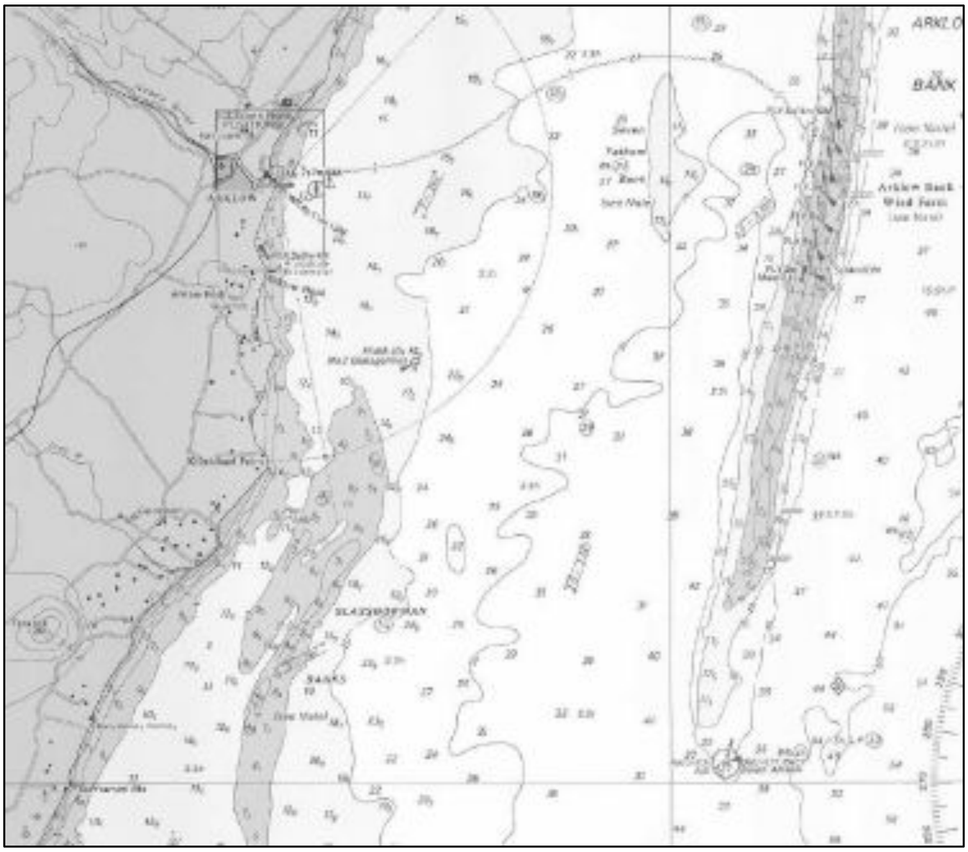
When waves approach the coastline, they undergo a number of changes caused by refraction, diffraction, breaking and shoaling, which affect their characteristics; steepness, wave height, propagation velocity and direction. In this study, a wave transformation model was used to propagate the waves from offshore to the nearshore at the site location. As described in the "Methodology" section the model used for wave propagation from offshore to the proposed location is Mike21-SW developed by DHI.

4.1 Bathymetric data

In order to assess the changes in wave characteristics it is necessary to gather all available bathymetric data for the proposed site location. The sources used are:

- UK Hydrographic Office Admiralty Chart number 1787 (high level): Carnsore Point to Wicklow Bay, scale 1:100,000, depths in metres reduced to Chart Datum (see Figure 15 below).
- UK Hydrographic Office Admiralty Chart number 633 (nearshore): Arklow, scale 1:10,000, depths in metres reduced to Chart Datum.
- GSI Infomar 2016 bathymetric survey (nearshore): 20m grid, main source of nearshore bathymetry, depths in metres reduced to Chart Datum.
- Murphy Surveys topographic survey, March 2016 (governing nearshore): revetment contour lines, main source of nearshore coastline location, depths in metres reduced to Chart Datum.

Figure 15: Snapshot of Admiralty Chart 1787.

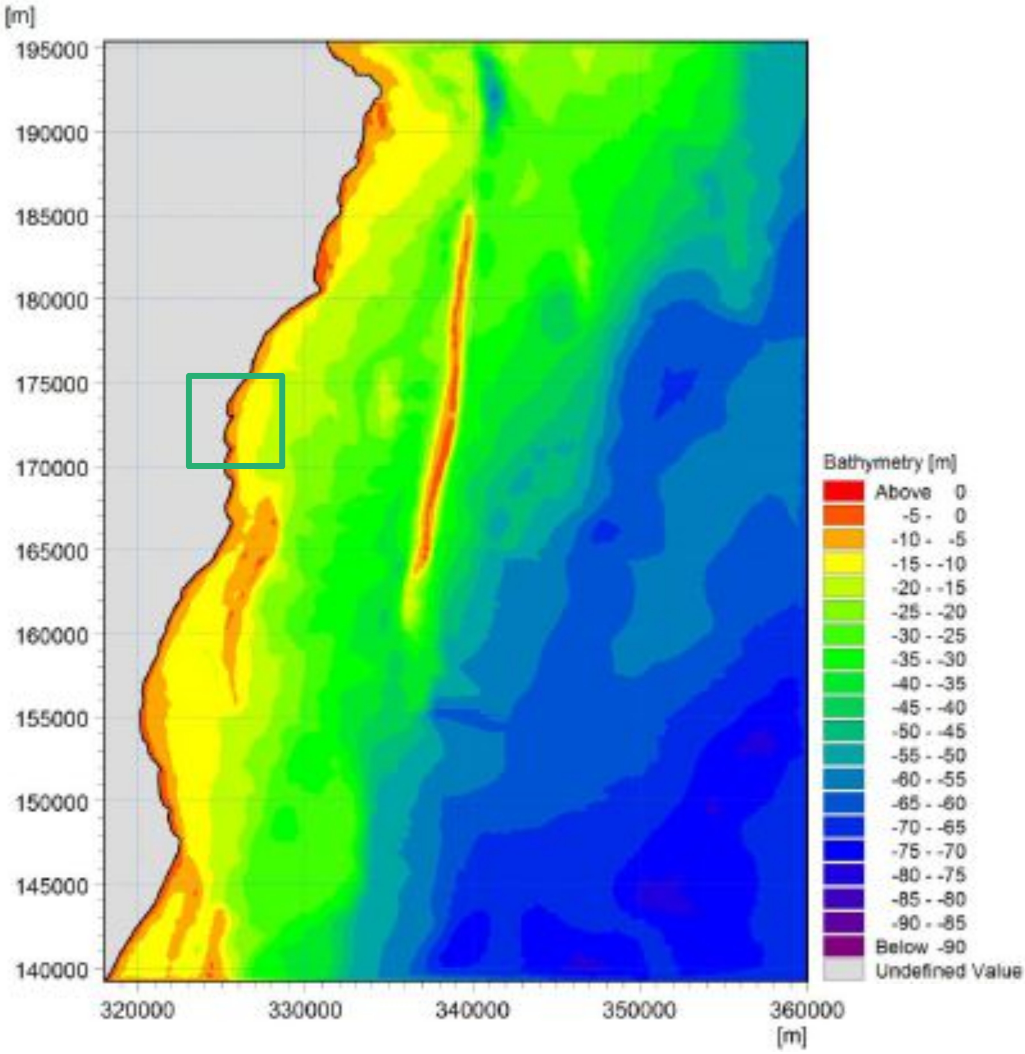


4.2 Model

4.2.1 Model bathymetry

The admiralty chart was digitized and combined with the topographic and bathymetric surveys in order to extract the bathymetric data in xyz format relevant to Chart Datum for use with the MIKE21-SW model, see Figure 16. The model bathymetry varies from approximately -70m CD to 0m CD and takes into account bathymetric features such as the Arklow Bank.

Figure 16: Bathymetric model derived from the Admiralty Charts and bathymetric survey. The box shows approximately the revetment location.



4.2.2 Computational Mesh

The MIKE21-SW model uses a flexible mesh to calculate wave parameters within the computational domain. This mesh can be manipulated to be finer in area of interest and coarser in less significant areas. Three different areas have been defined within the model for mesh generation. Each area has different mesh sizing with a finer mesh for the area of interest and coarser grid elsewhere. Figure 16 shows the bathymetry used in the model whereas the size of the mesh in the various model areas is shown in Figure 18, and Figure 19.

Table 3 gives the mesh sizing adopted for the different areas.

The initial conditions of wave height, Hs, peak wave period, Tp, and direction of the offshore waves are provided within the model boundaries.

Table 3: Mesh size for various areas in the computational domain.

Section	Mesh Size
Offshore (course density)	80,000 m^2
Intermediate	10,000 m^2
Nearshore (high density)	1000 m^2

Figure 17: Bathymetric computational mesh showing coarse and intermediate densities. Blue square shows the boundaries of Figure 18.

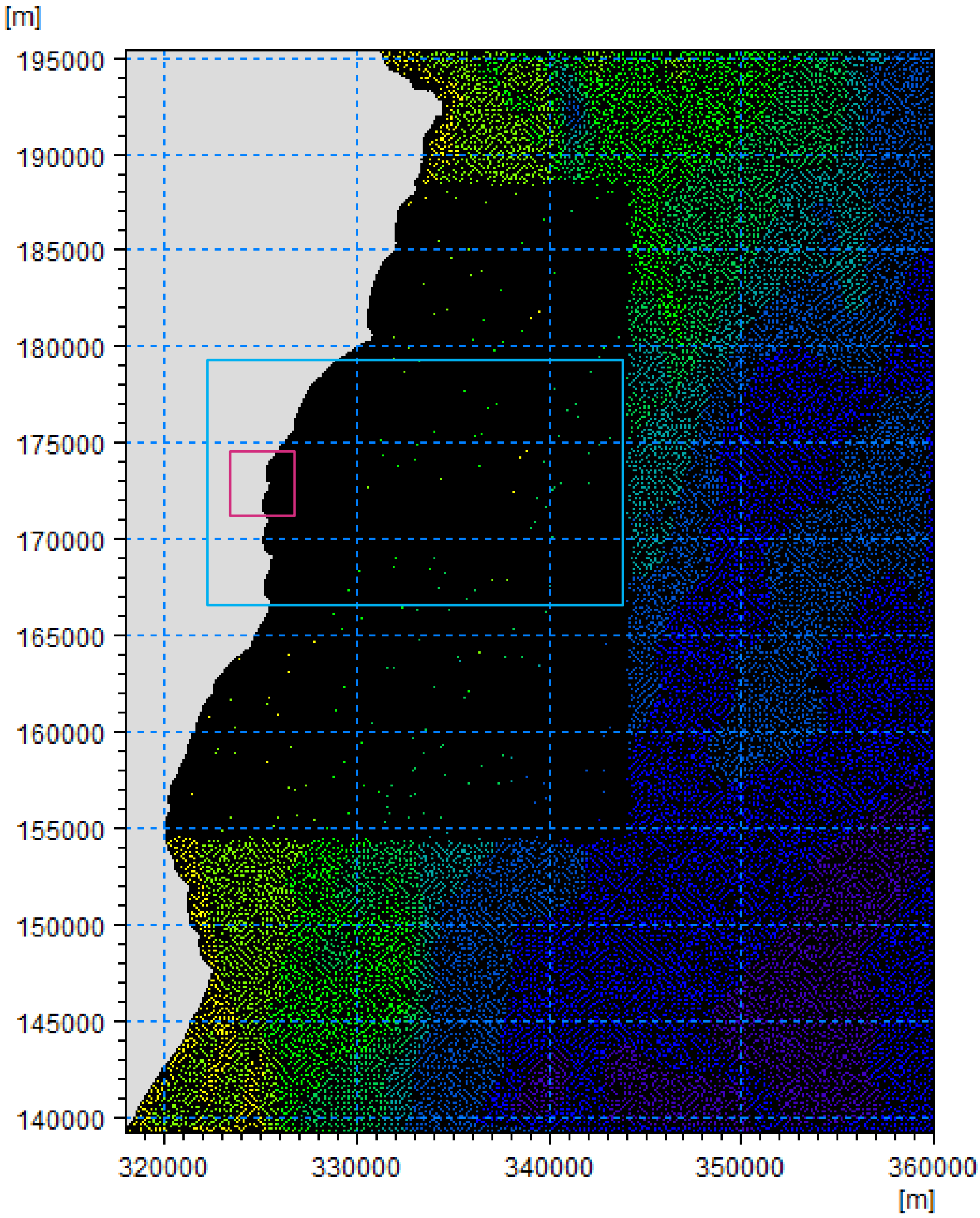


Figure 18: MIKE21-SW mesh (intermediate and high density). Blue square shows the boundaries of Figure 19.

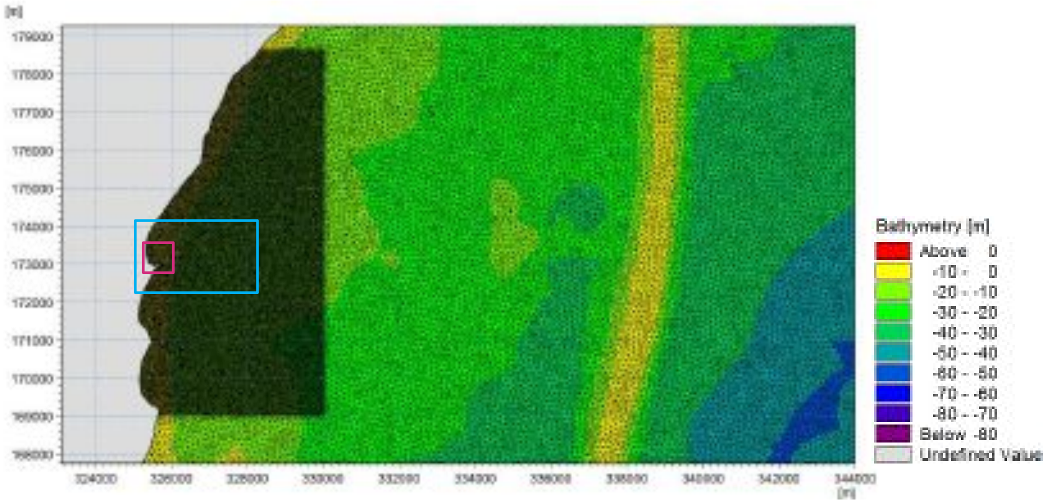
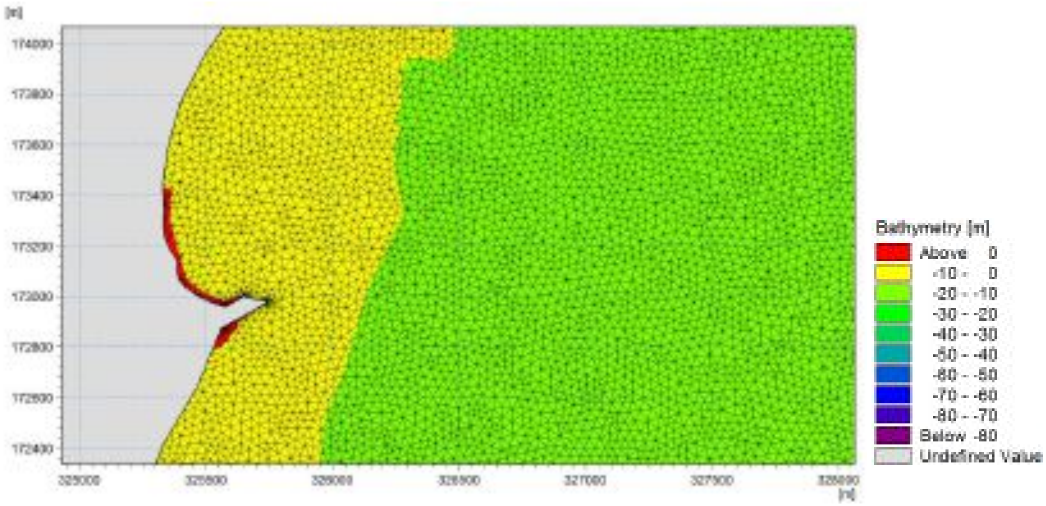


Figure 19: MIKE21-SW (high density) mesh at revetment location.

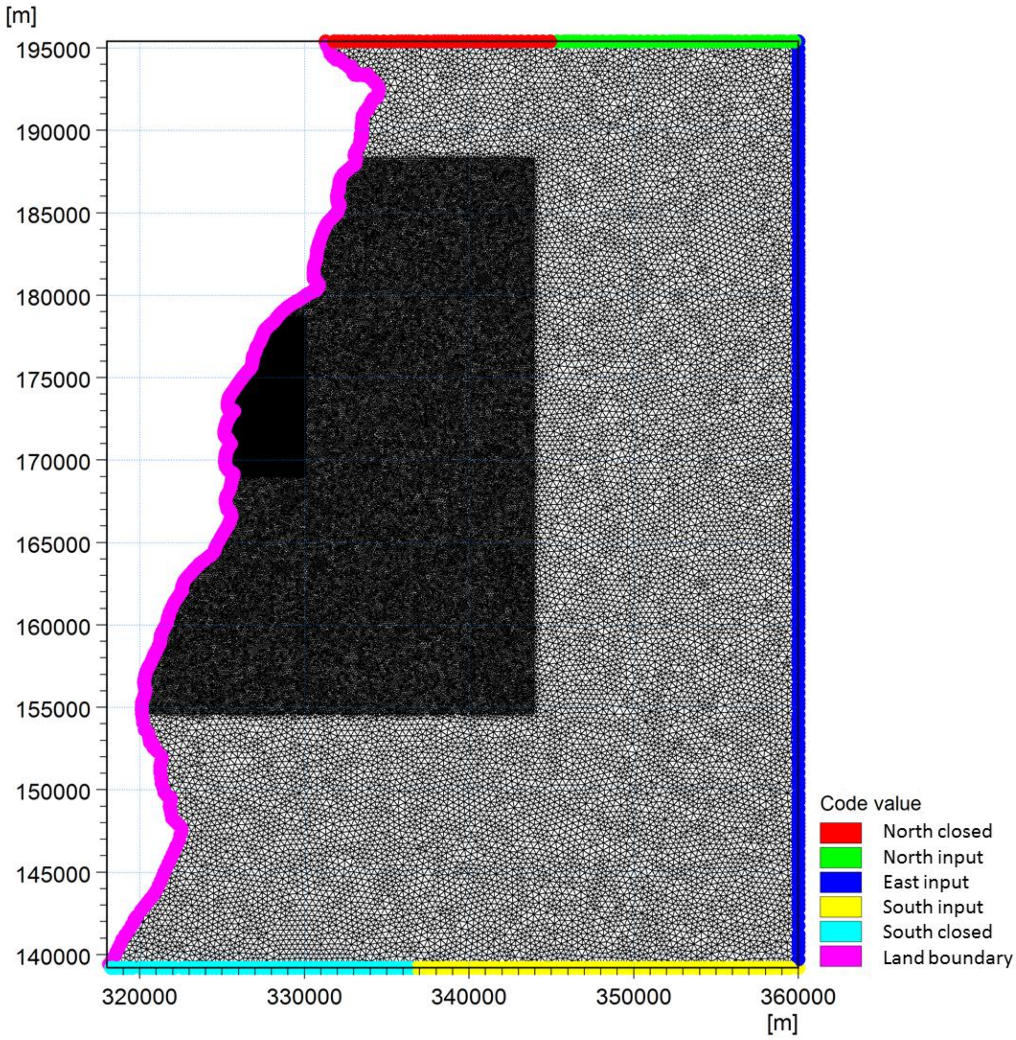


4.2.3 Model boundaries

The offshore waves were transformed over the domain, assuming conditions at the boundary to be the same as the NORA10 point (deep water conditions). In addition to this, the wind at NORA10 point was assumed to be acting along the entire computational domain (constant in time and space).

For this study, the input boundaries were extended along the northern and southern boundaries in order to generate a more accurate representation of the NE and SE wave directions. The boundaries are shown in Figure 20.

Figure 20: Boundaries used in the MIKE21-SW model. The green, blue and yellow boundaries are input boundaries using the NORA10 deep water conditions.



4.3 Results

The model was run in a fully coupled mode for wind and waves, hence it took into account both the waves entering the model domain through the offshore boundary as well as the waves generated within the model domain due to wind action. Figure 21 and Figure 22 show the wave height distribution in the offshore and revetment site location respectively for the ESE wave and wind direction.

Table 4 shows the model results for the various combinations of wind/ wave data and direction for the 500 year return period events for all the directions assessed. The model results were derived at distances of 20m and 40m from the point of contact of the revetment with the water level used for the model. The results shown are the maximum values for the points located 20m offshore of the existing revetment.

Table 4: MIKE21-SW modelling results. Displayed are the return period (T_r), water level (h), wave height (H_s), wave period (T_p) and Wind speed (W_{sp}).

			Offshore		**20m from existing revetment**		
Direction	**T_r [y]**	**h [m CD]**	**H_s [m]**	**T_p [s]**	**W_{sp} [m/s]**	**H_s [m]**	**T_p [s]**
NE	500	3.68	5.5	8.6	24.3	2.9	9.5
ENE	500	3.68	5.0	8.3	20.7	2.8	9.5
E	500	3.68	5.6	8.7	24.4	3.0	9.9
ESE	500	3.68	6.2	9.1	25.0	3.0	10.5
SE	500	3.68	7.1	9.7	23.0	3.0	11.4

From Table 4, it can be seen that storms from all directions give similar nearshore wave heights despite having significantly higher input offshore conditions from the south easterly directions. This is partly due to the presence of the Arklow Bank located parallel to the coast on which waves likely break and lose energy (visible in Figure 21 at x=339000), and partly due to the shallow waters adjacent to the site. The latter phenomenon can also be described as ‘depth limited wave conditions’ in which the limited water depth limits the possible wave height. As the area affected by diffraction is not governing for the determination of the design wave height of the new rock revetment, the results presented do not include diffraction.

Refer to Appendix B for graphical output from all the model runs. For storms coming from SE and E, the significant wave height at the site is in the region of 3.0m for the 500 year return period. The proposed design condition is the ESE wave and wind direction. As this direction has the highest significant wave height for the largest area of the revetment.

On the basis of the hydraulic modelling results, the proposed design conditions for the revetment design phase are:

- H_s=3.0 meters
- T_p=10.5 seconds

Figure 21: Offshore wave height distribution with waves from the ESE.

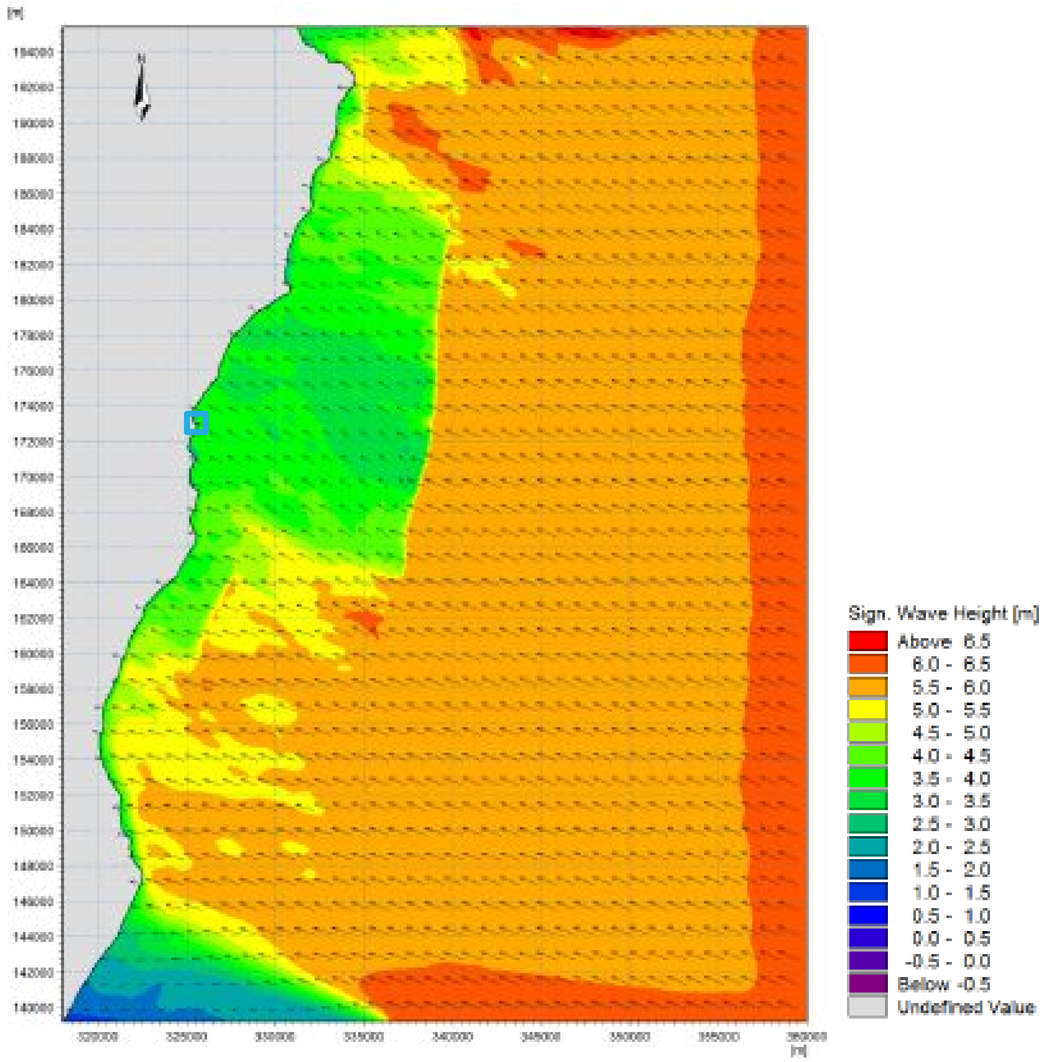
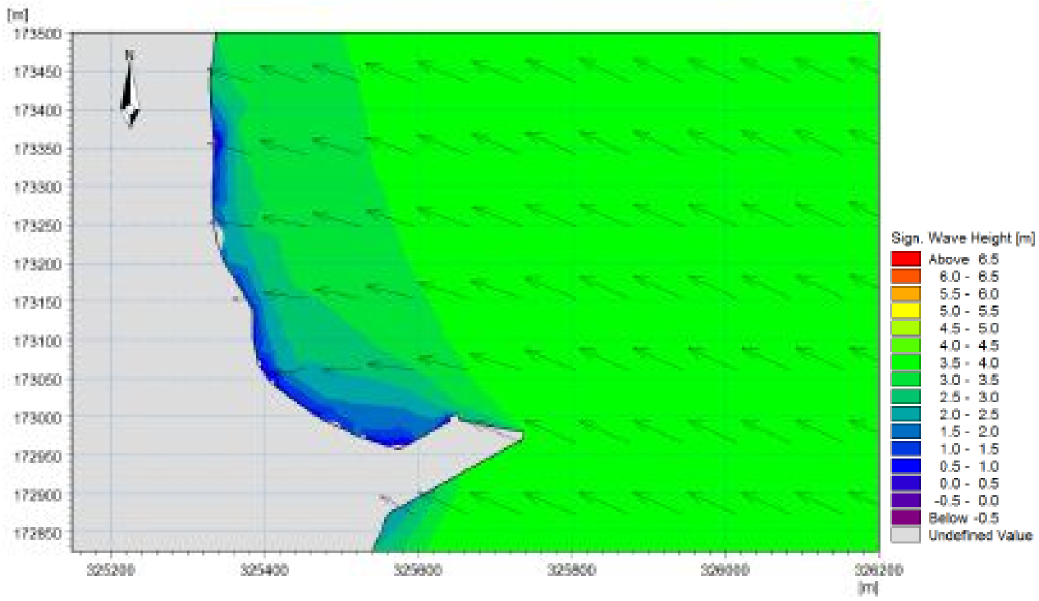


Figure 22: Nearshore wave height distribution with waves from the ESE.



5 Summary and conclusions

A wave modelling study was carried out in order to estimate nearshore wave heights adjacent to the proposed site for the Arklow waste water treatment plant. The wave modelling results are used to determine the design wave height for the design of the upgraded revetment adjacent to the proposed site. The model used for this study was the spectral transformation model MIKE21-SW.

The results of the wave modelling study indicate that storms approaching from the east to south east cause the largest wave conditions at the proposed site. Variations in the maximum wave heights between the different directions are small due to the presence of the Arklow Bank and the local bathymetry that is limiting wave heights adjacent to the site. The wave modelling results are represented in graphical format for all test cases in Appendix B.

The design wave conditions to be considered for the design of the revetment are significant wave height of 3.0 meters with a peak wave period of 10.5 seconds.

References

[1] NORA10 (2011) Norwegian ReAnalysis 10 km

[2] Reistad M., Breivik O., Haakenstad H., Aarnes O.J. and Furevik B.R., 2011. A high-resolution hindcast of wind and waves for the North Sea, the Norwegian Sea and the Barents Sea. J. Geophys. Res., 116, C05019, doi:10.1029/2010JC006402

[3] Admiralty Tide Tables, 2010, Volume 1, United Kingdom and Ireland

[4] Irish Coastal Protection Strategy Study Phase 2 - South East Coast. Work Package 9A -Appendix 2 - Flood Mapping for High End Future Scenario. IBE0104/November 2013, OPW

[5] UK Hydrographic Office Admiralty Chart number 1787: Carnsore Point to Wicklow Bay, scale 1:100,000, depths in metres reduced to Chart Datum

[6] UK Hydrographic Office Admiralty Chart number 633: Arklow, scale 1:10,000, depths in metres reduced to Chart Datum

[7] Holthuijsen L.H. 2007. Waves in Oceanic and Coastal Waters, p16-19, ISBN-13: 978-0521129954

Appendix A

Extreme value analysis results

A1 Waves

Figure 23: Extreme value analysis for the significant wave height (H_s) and N.

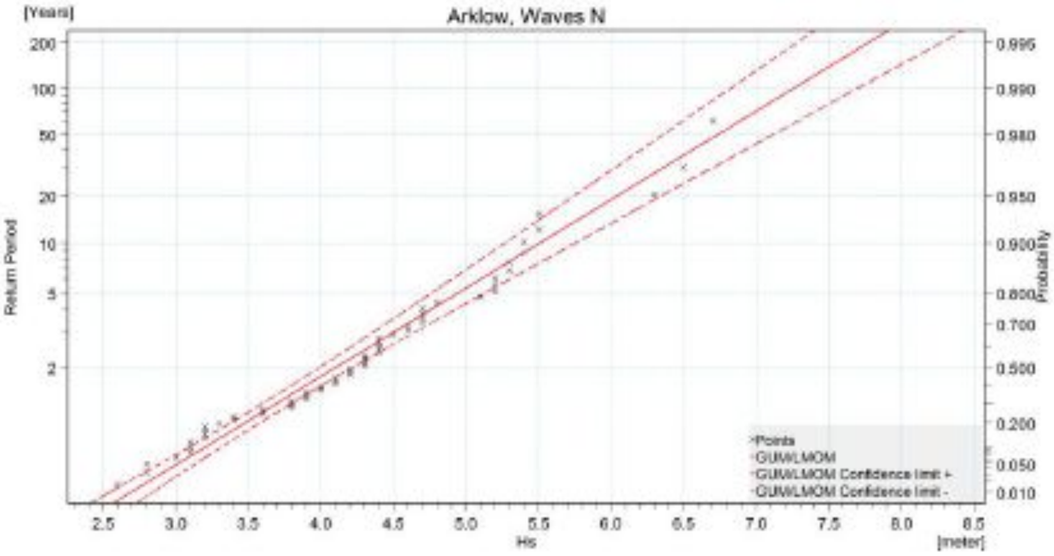


Figure 24: Extreme value analysis for the significant wave height (H_s) and NNE.

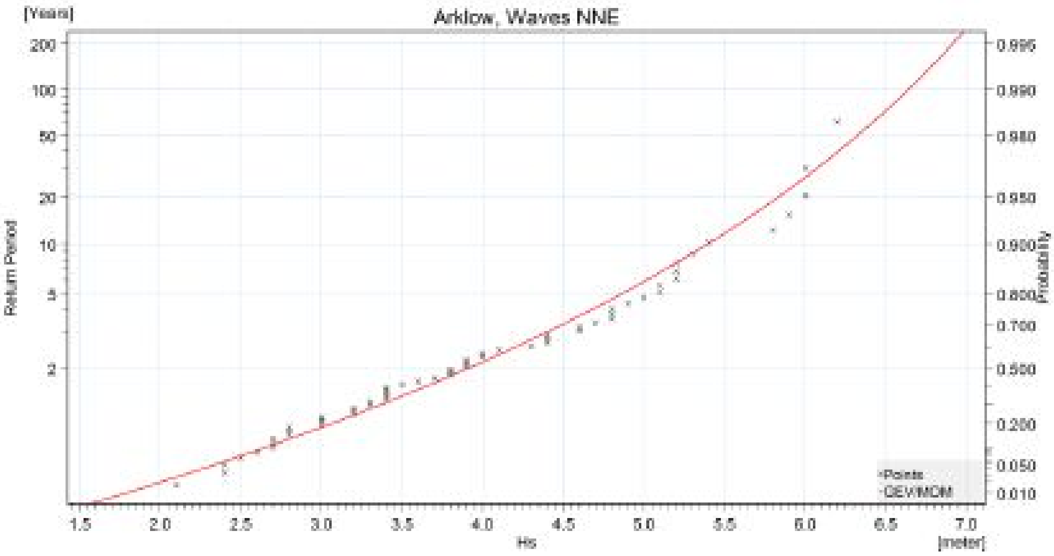


Figure 25: Extreme value analysis for the significant wave height (H_s) and NE.

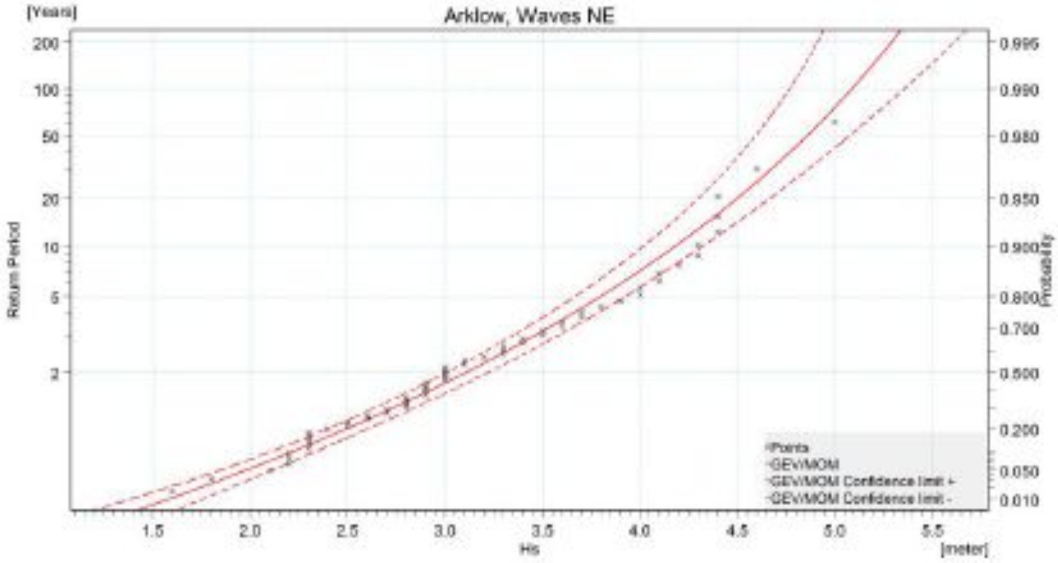


Figure 26: Extreme value analysis for the significant wave height (H_s) and ENE.

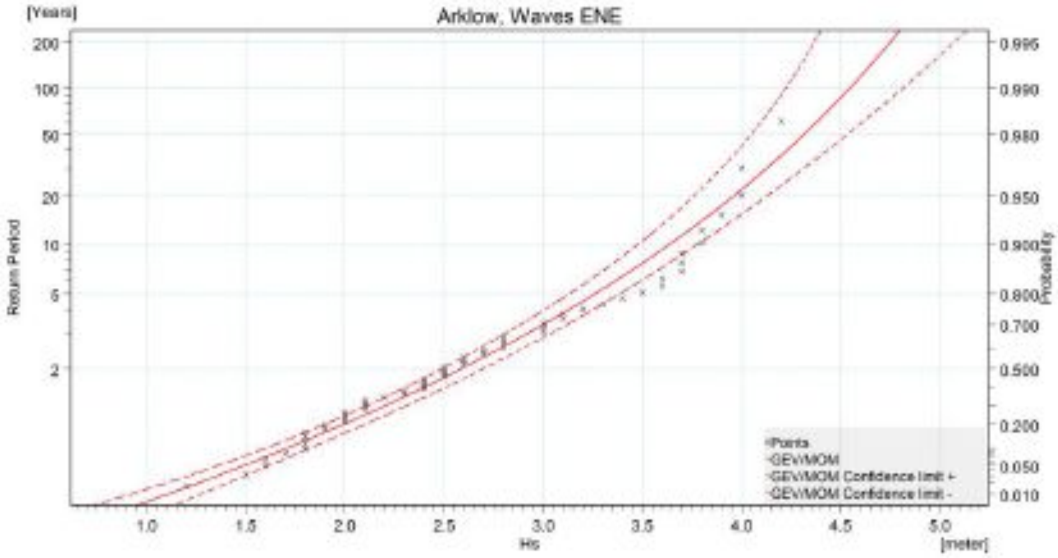


Figure 27: Extreme value analysis for the significant wave height (H_s) and E.

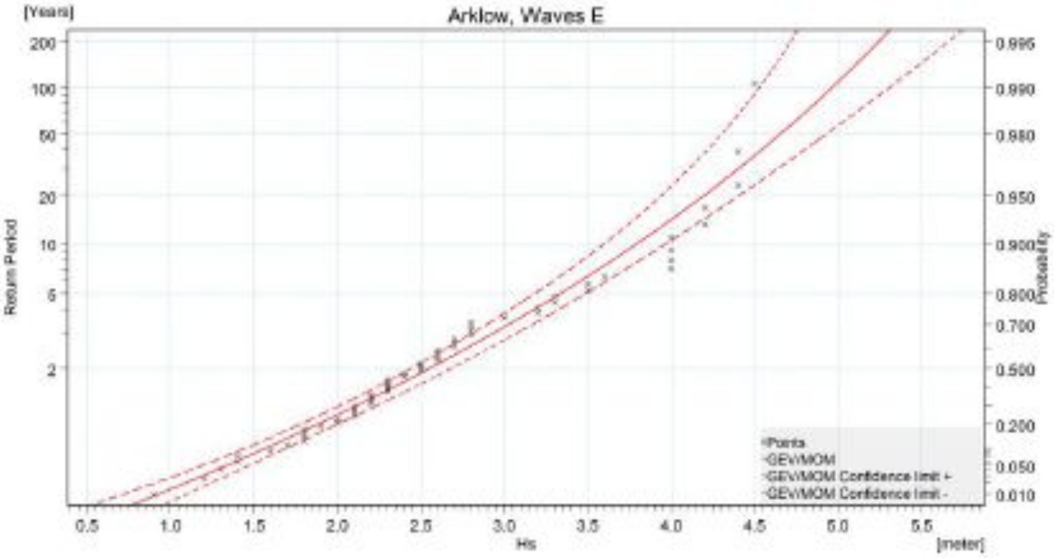


Figure 28: Extreme value analysis for the significant wave height (H_s) and ESE.

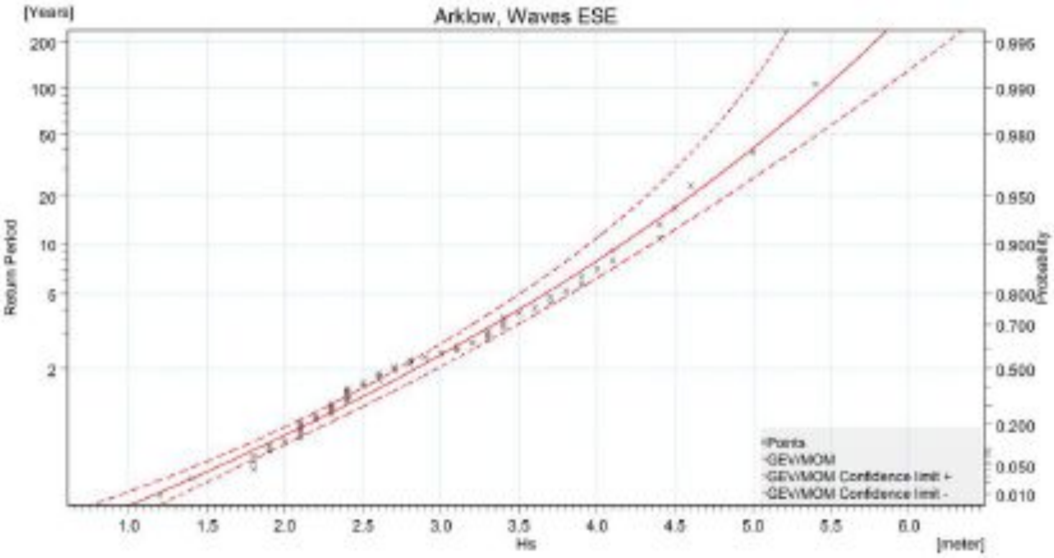


Figure 29: Extreme value analysis for the significant wave height (H_s) and SE.

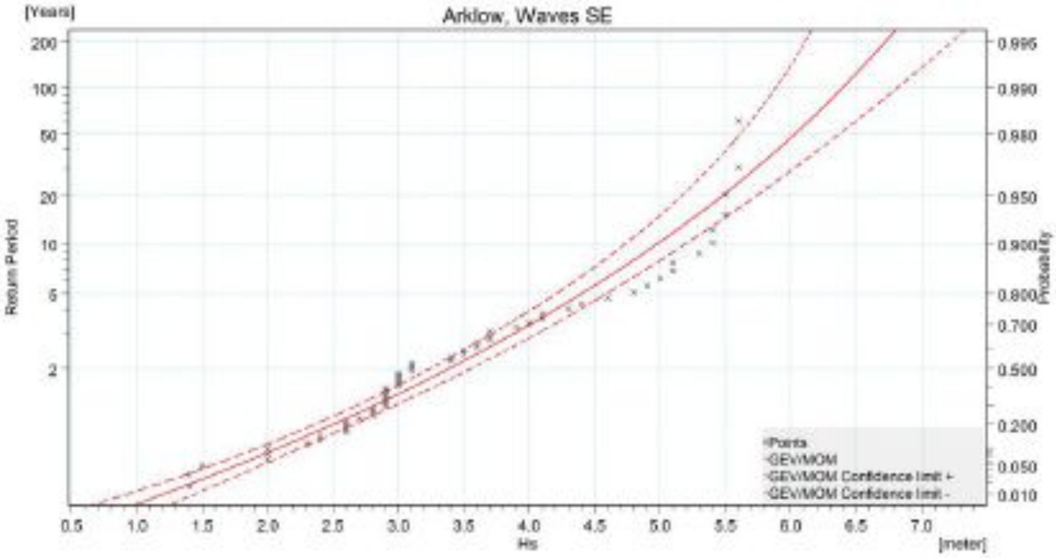


Figure 30: Extreme value analysis for the significant wave height (H_s) and SSE.

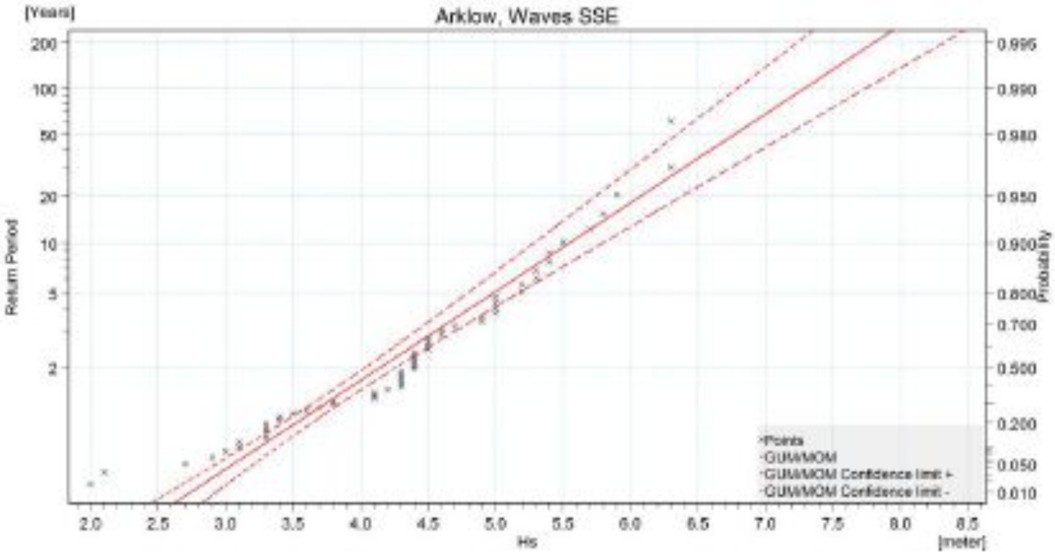
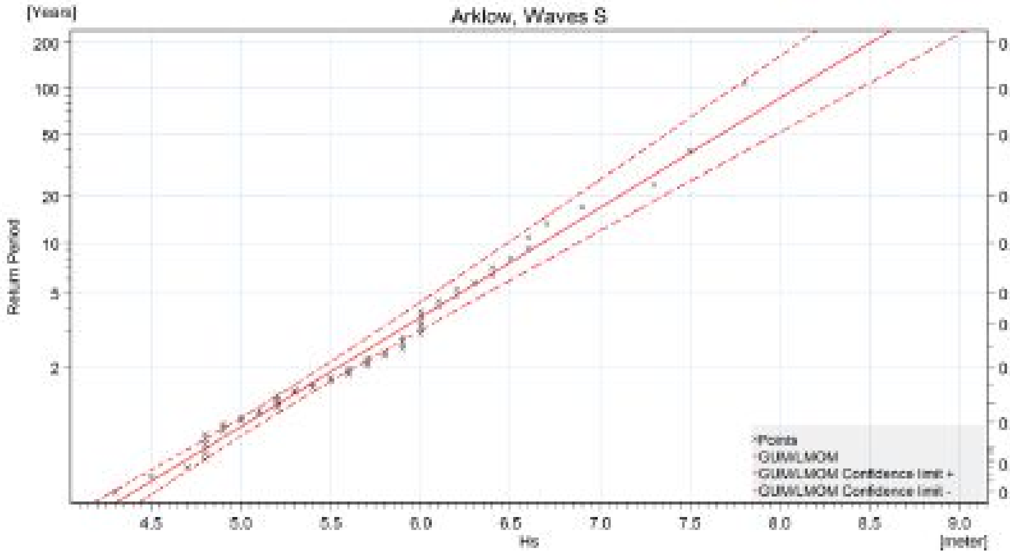


Figure 31: Extreme value analysis for the significant wave height (H_s) and S.



A2 Wind

In addition to the distributions used in the wave height extreme value analysis, the Weibull distribution is also considered.

Figure 32: Extreme value analysis for the wind speed (W_{sp}) and N.

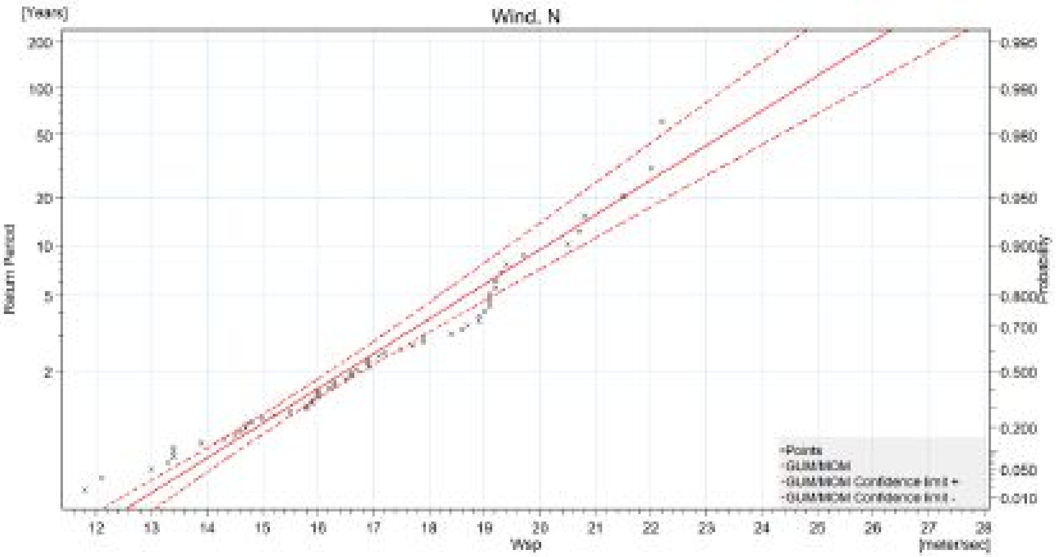


Figure 33: Extreme value analysis for the wind speed (W_{sp}) and NNE.

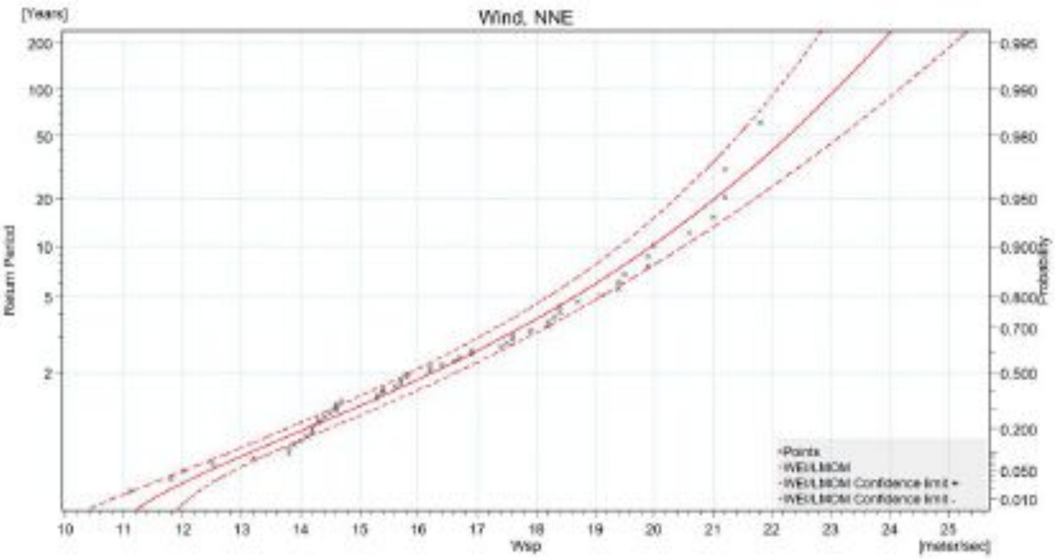


Figure 34: Extreme value analysis for the wind speed (W_{sp}) and NE.

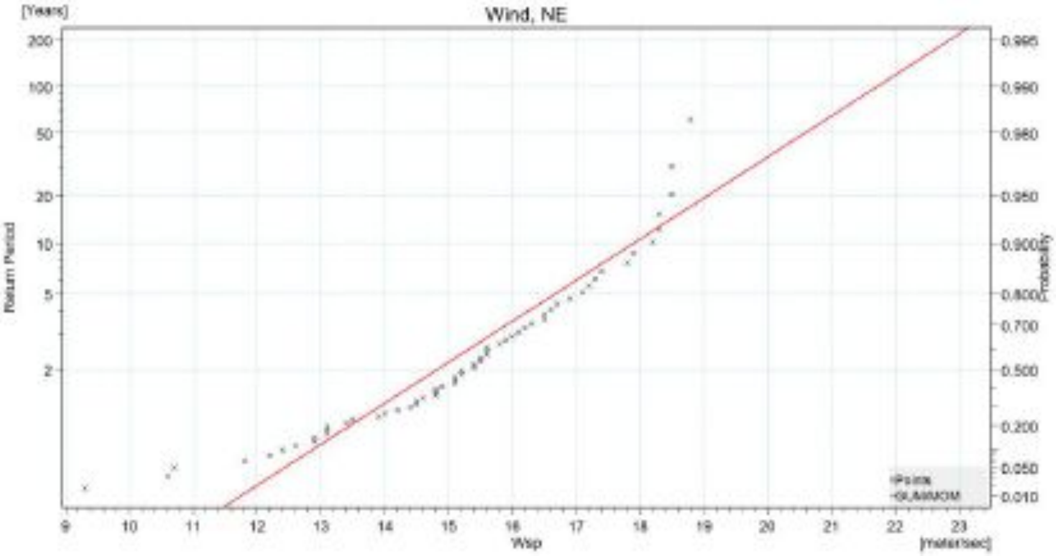


Figure 35: Extreme value analysis for the wind speed (W_{sp}) and ENE.

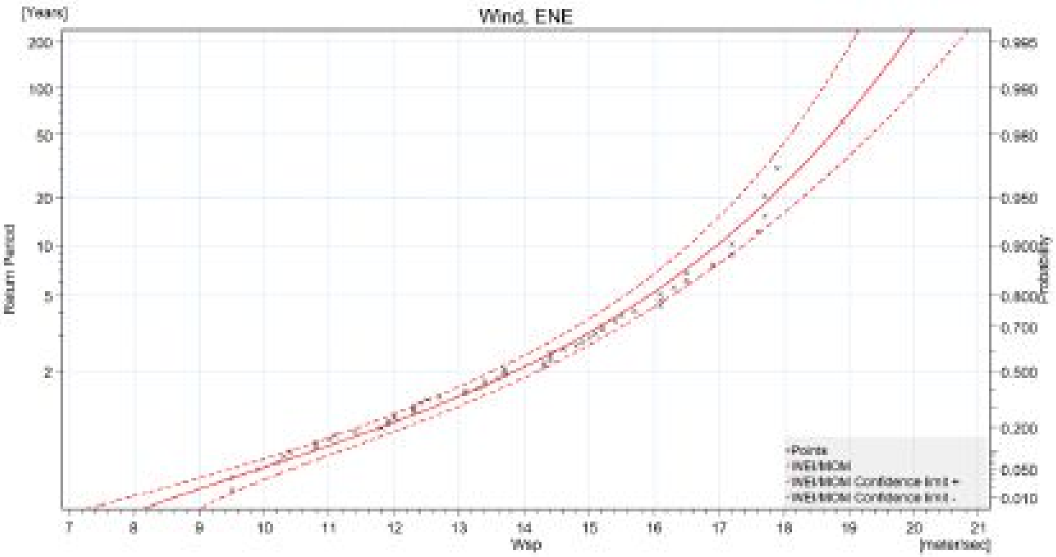


Figure 36: Extreme value analysis for the wind speed (W_{sp}) and E.

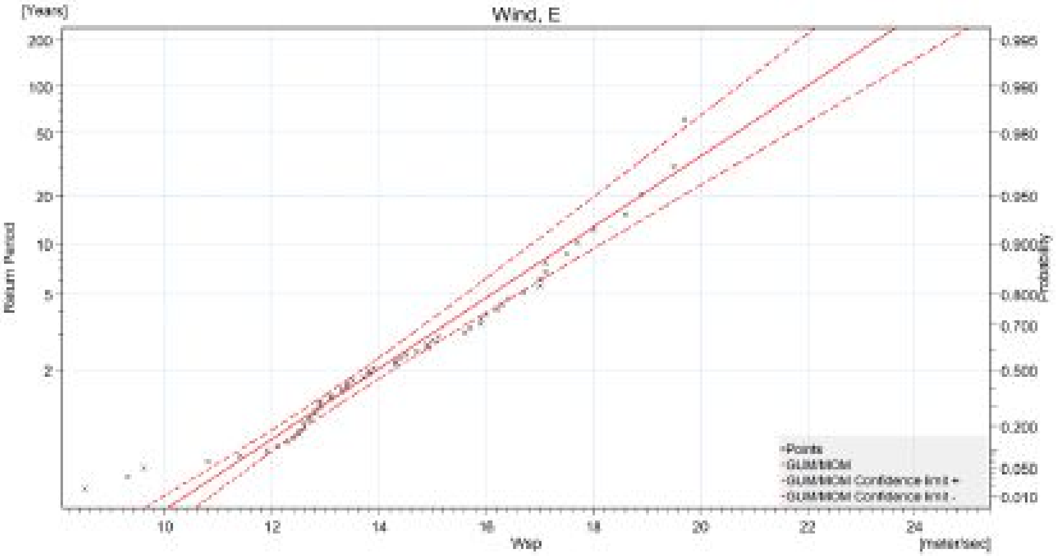


Figure 37: Extreme value analysis for the wind speed (W_{sp}) and ESE.

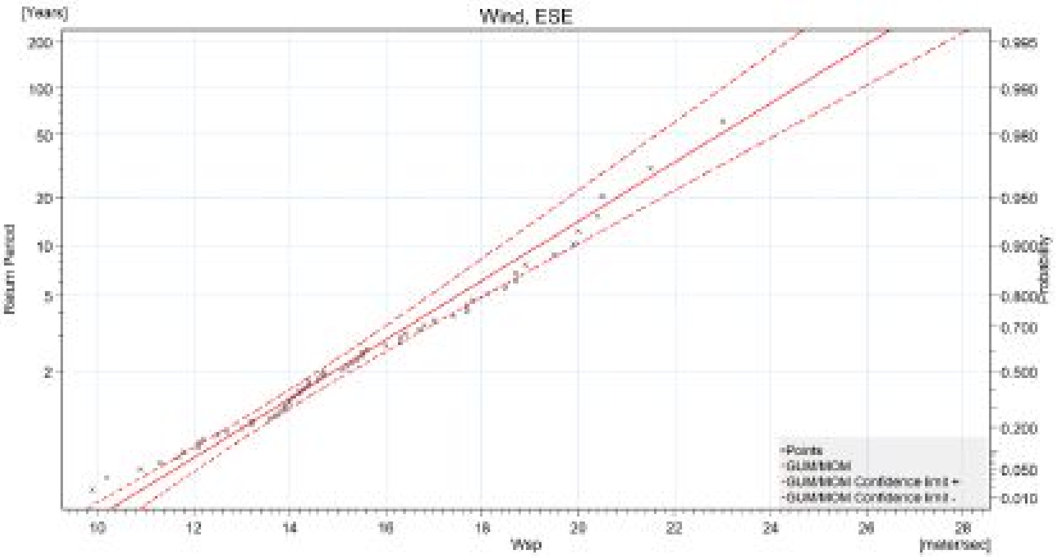


Figure 38: Extreme value analysis for the wind speed (W_{sp}) and SE.

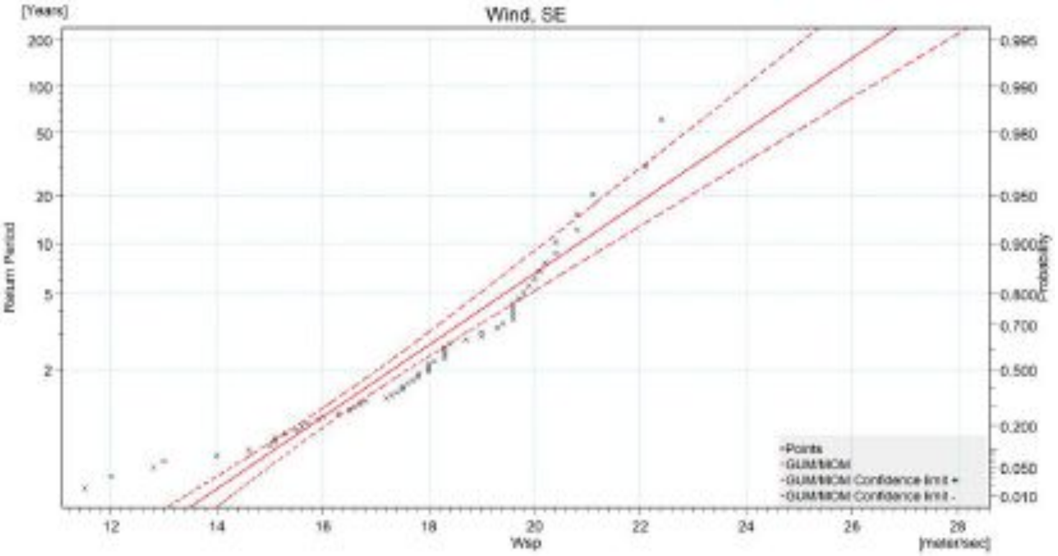


Figure 39: Extreme value analysis for the wind speed (W_{sp}) and SSE.

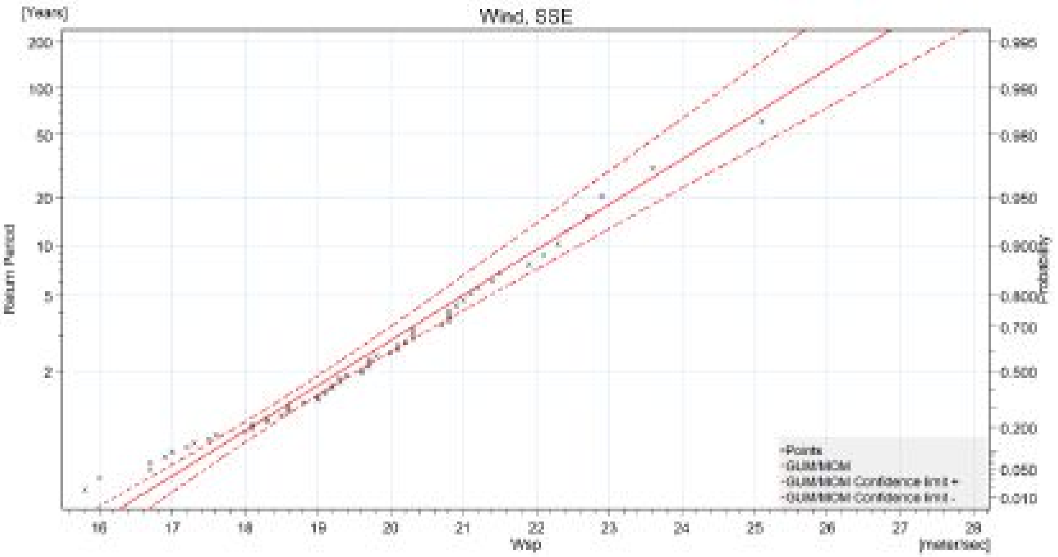
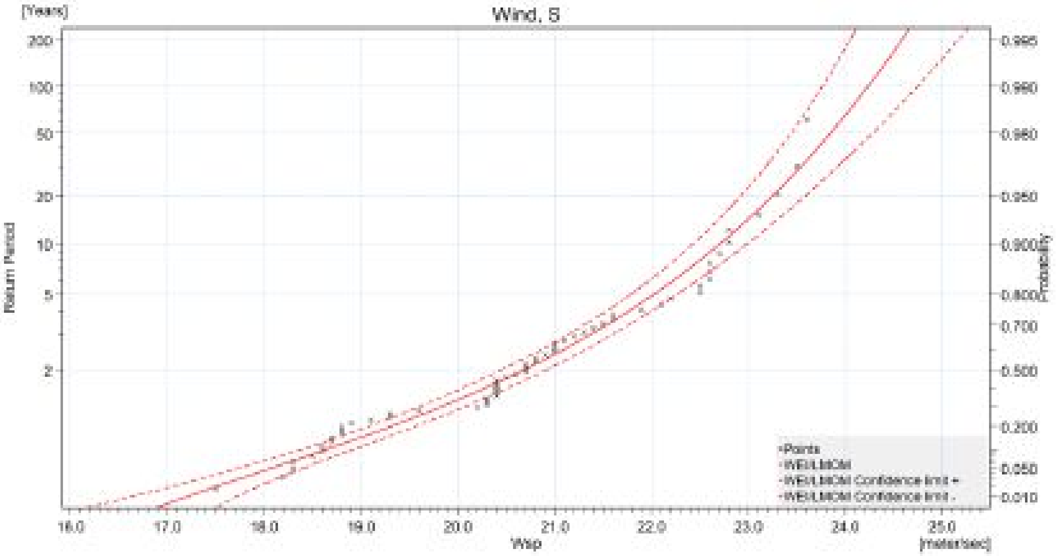


Figure 40: Extreme value analysis for the wind speed (W_{sp}) and S.



Appendix B

Wave height distribution results

B1 Wave height distribution results

Figure 41: Offshore wave height distribution with waves from the NE. Total computational domain.

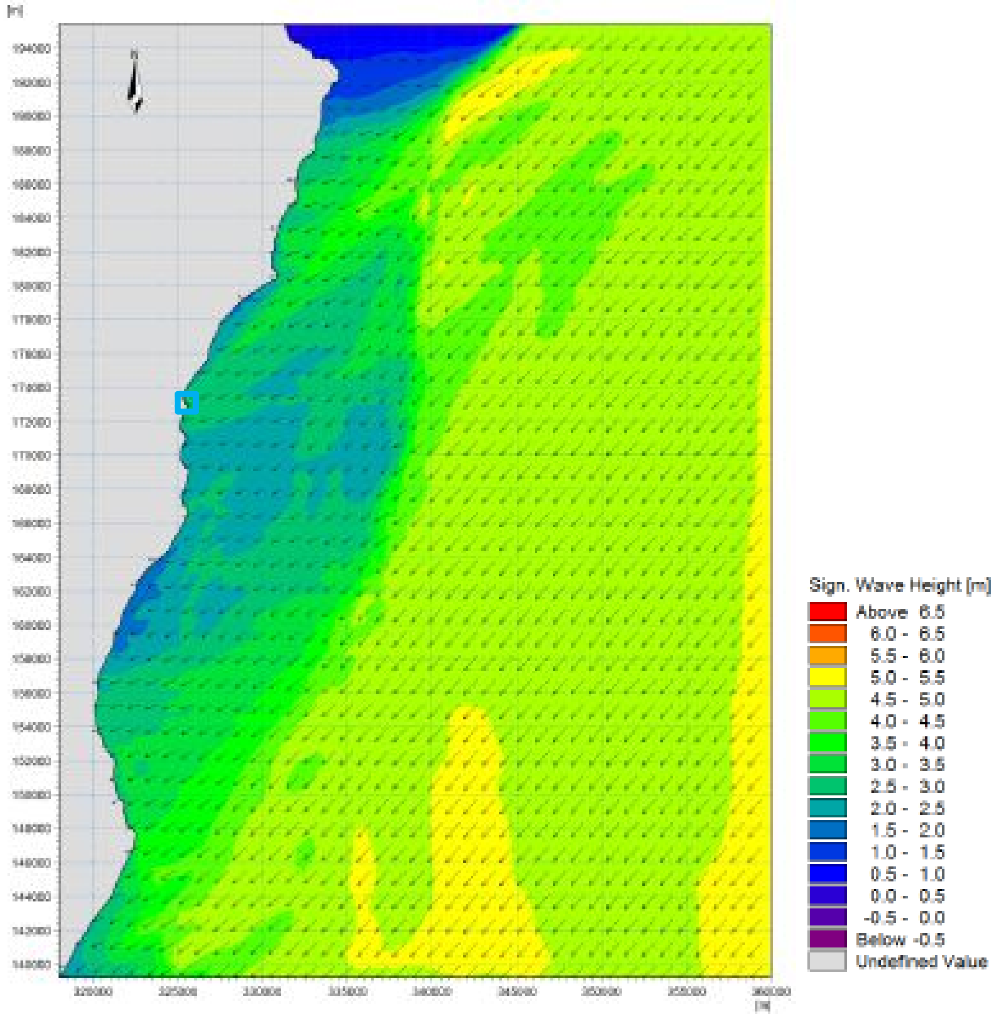


Figure 42: Wave height distribution with waves from the NE. Zoomed in on Arklow revetment site location.

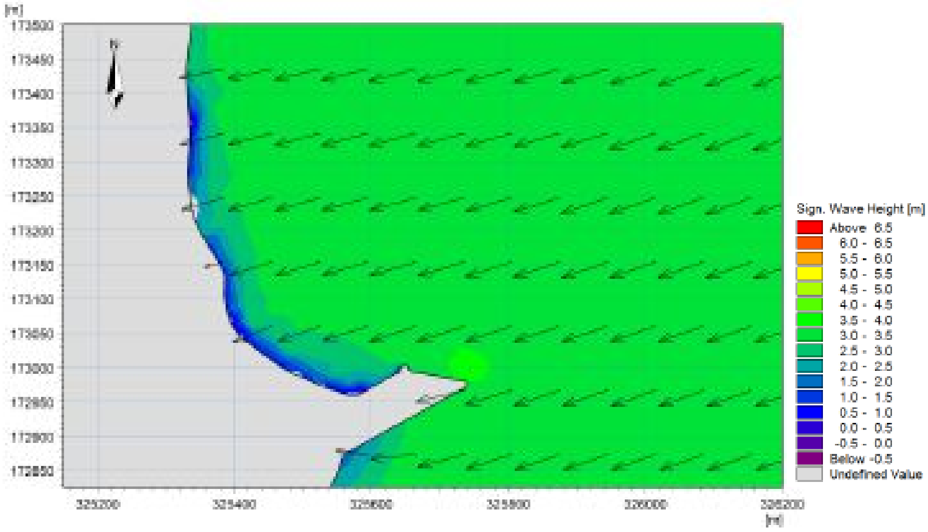


Figure 43: Offshore wave height distribution with waves from the ENE. Total computational domain.

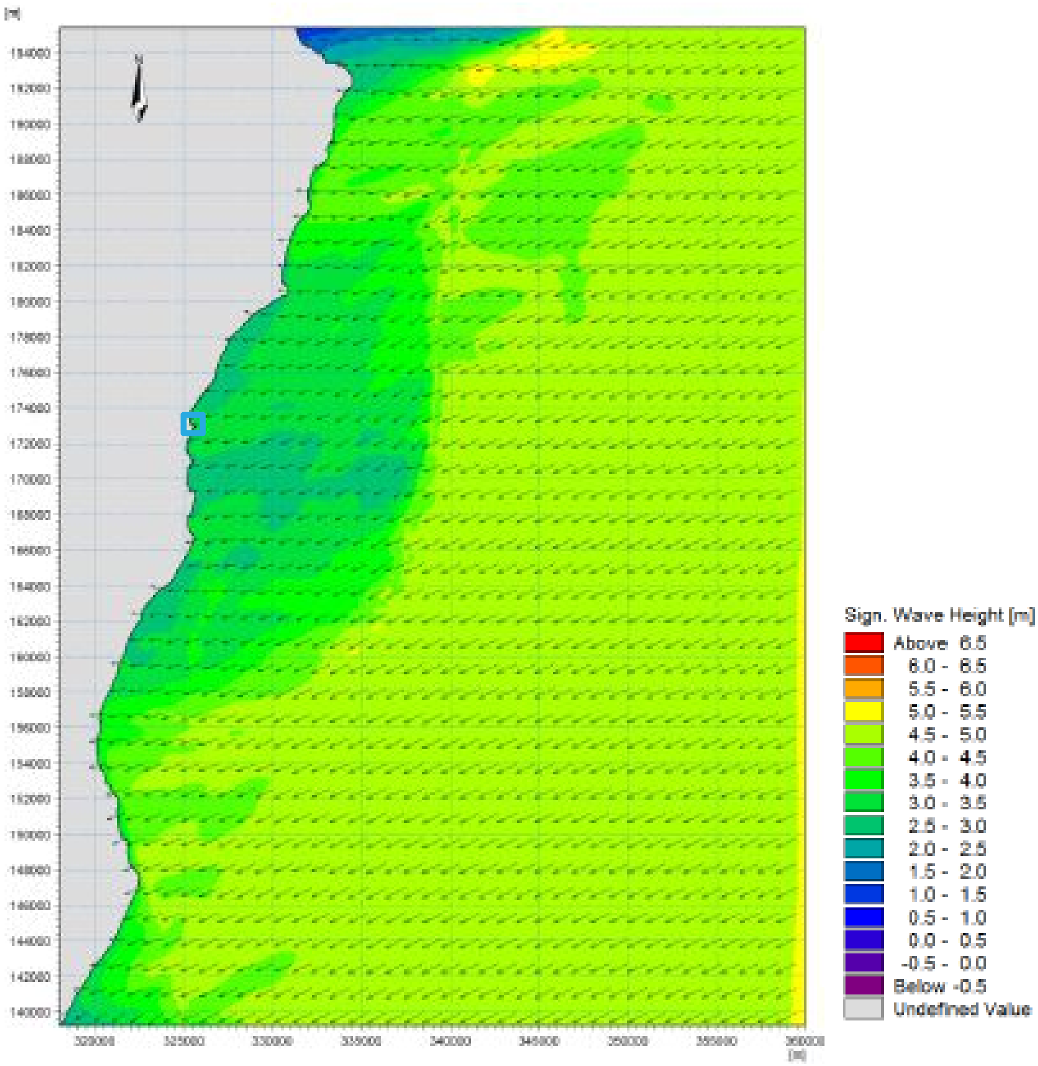


Figure 44: Wave height distribution with waves from the ENE. Zoomed in on Arklow revetment site location

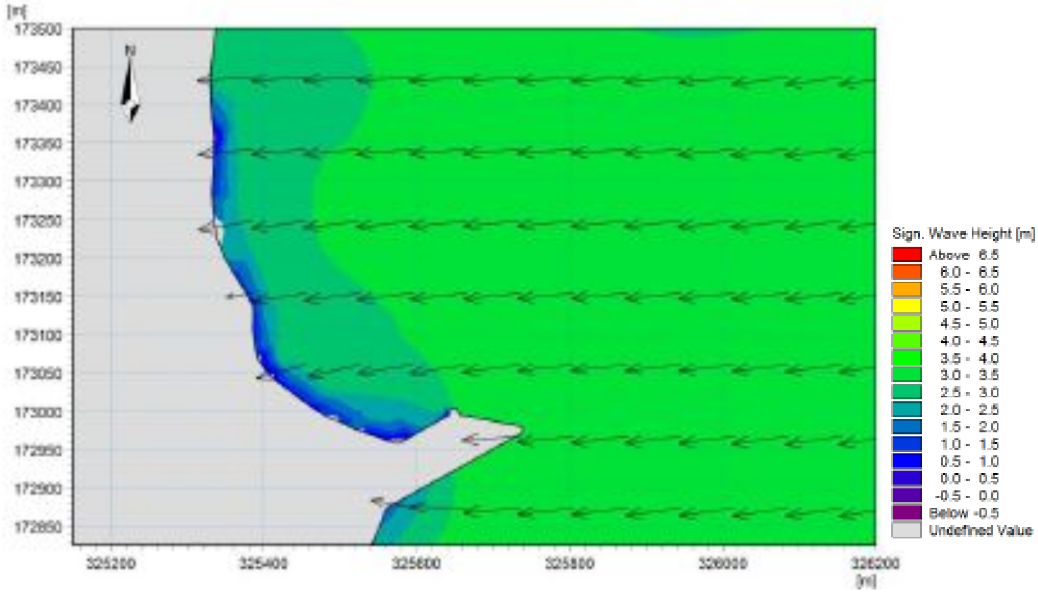


Figure 45: Offshore wave height distribution with waves from the E. Total computational domain.

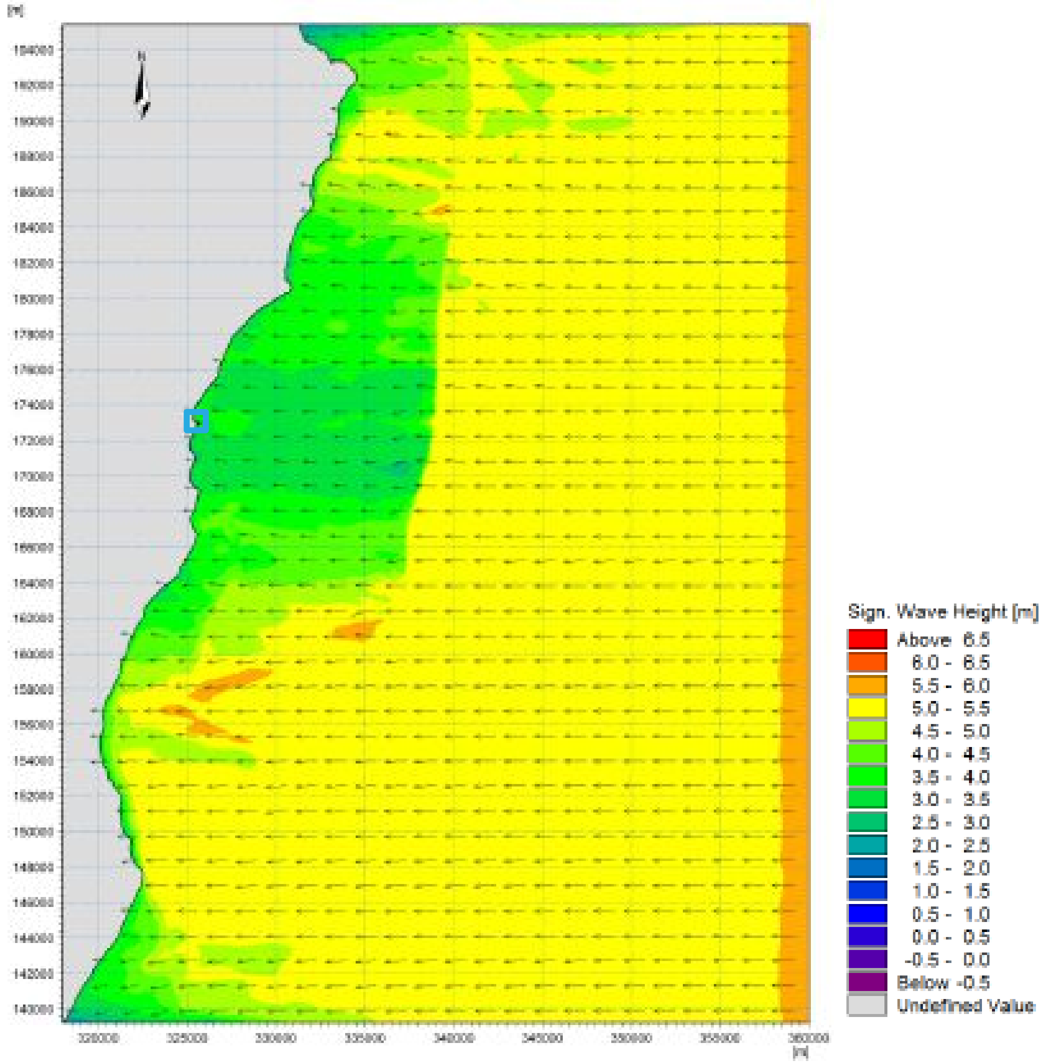


Figure 46: Wave height distribution with waves from the E. Zoomed in on Arklow revetment site location.

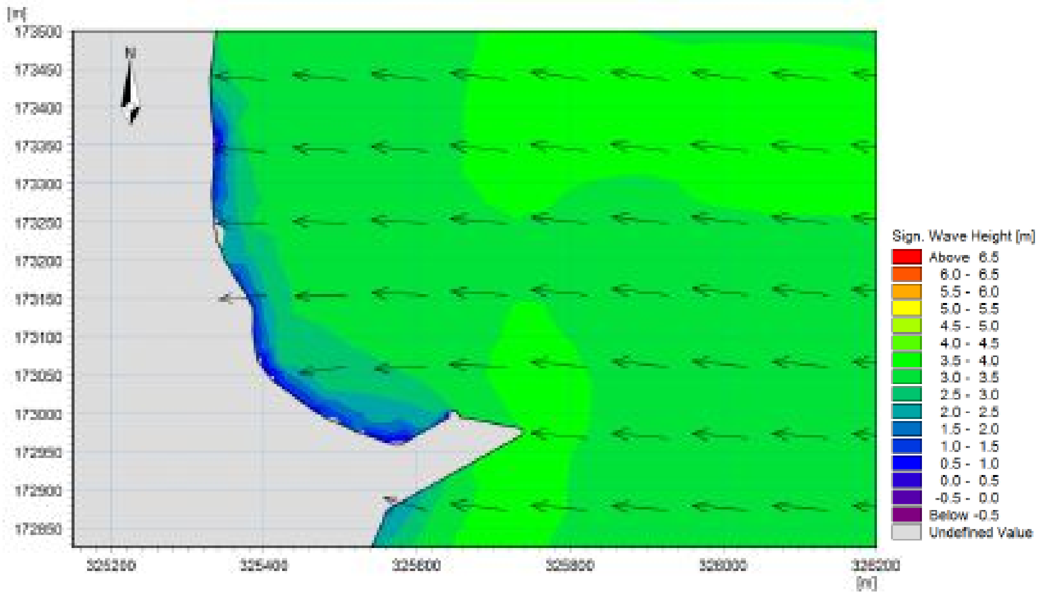


Figure 47: Offshore wave height distribution with waves from the ESE. Total computational domain.

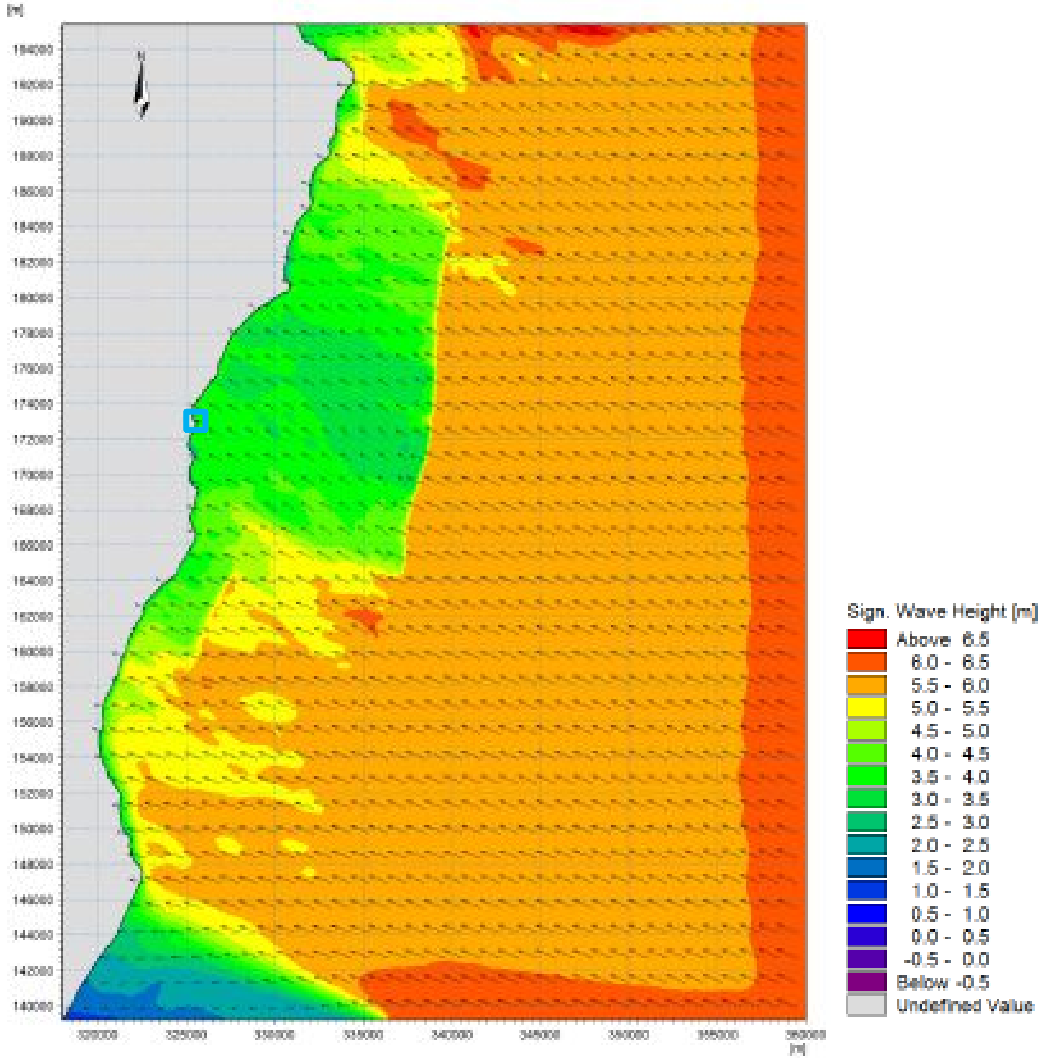


Figure 48: Wave height distribution with waves from the ESE. Zoomed in on Arklow revetment site location.

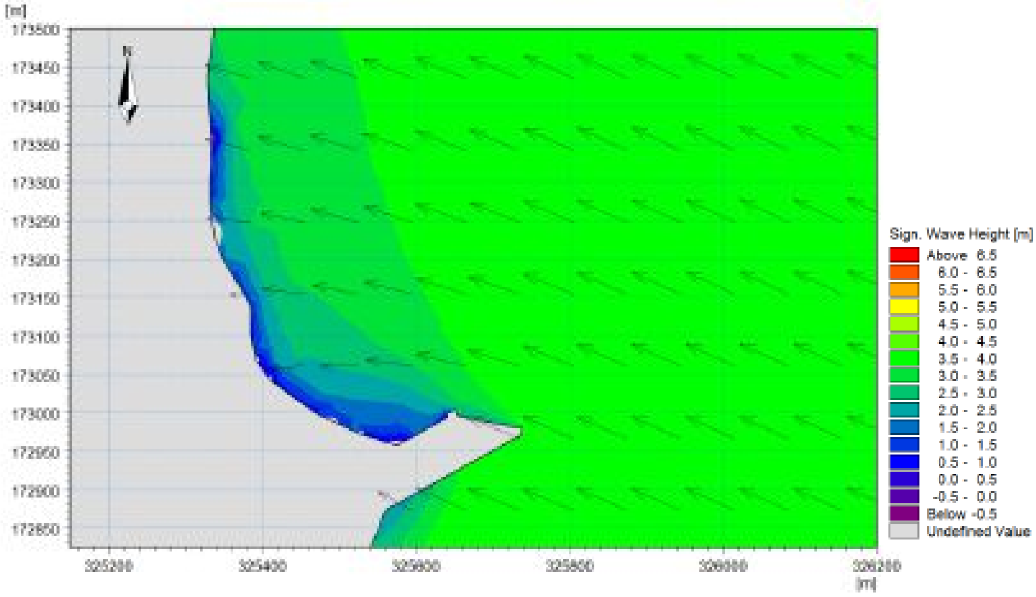


Figure 49: Offshore wave height distribution with waves from the SE. Total computational domain.

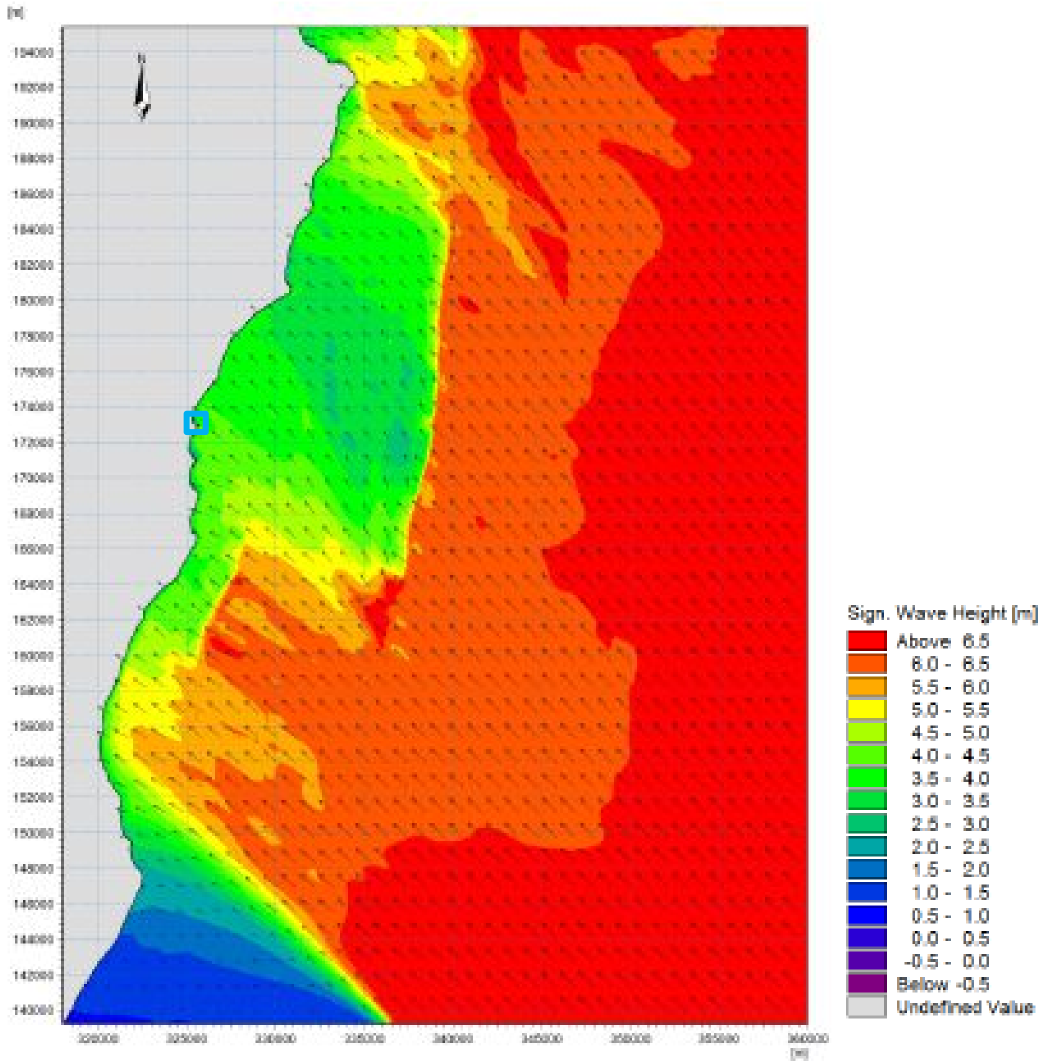


Figure 50: Wave height distribution with waves from the SE. Zoomed in on Arklow revetment site location.