



Old Colwyn Coastal Defence and Active Travel Scheme Environmental Statement

Volume 2: Technical Appendix 10 - Coastal
Processes and Flood Risk

July 2020

Mott MacDonald
Mott MacDonald House
5 Woodland Road West
Colwyn Bay LL29 7DH
United Kingdom

T +44 (0)1492 534601
mottmac.com

Conwy County Borough
Council
Environment, Road &
Facilities Team
Swyddfeydd Mochdre
Ffordd Conwy
Mochdre
Bae Colwyn
LL28 5AB

Old Colwyn Coastal Defence and Active Travel Scheme Environmental Statement

Volume 2: Technical Appendix 10 - Coastal
Processes and Flood Risk

July 2020

Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
P01	July 2020	A. Jones	N. Spofforth	C. Williams	First Issue

Document reference: 415437-MMD-00-XX-RP-N-1711

Information class: Standard

This document is issued for the party which commissioned it and for specific purposes connected with the above-captioned project only. It should not be relied upon by any other party or used for any other purpose.

We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

This document contains confidential information and proprietary intellectual property. It should not be shown to other parties without consent from us and from the party which commissioned it.

Contents

Appendix 10.1 – Water Framework Directive Assessment

Appendix 10.2 – Flood Consequence Assessment

Appendix 10.3 – Wave Overtopping Assessment

Appendix 10.4 – Detailed Modelling Study for Colwyn Bay Coastal Defence Scheme

Appendix 10.1 – Water Framework Directive Assessment



Old Colwyn Coastal Defence and Active Travel Scheme

Water Framework Directive Assessment

July 2020

Mott MacDonald
Mott MacDonald House
5 Woodland Road West
Colwyn Bay LL29 7DH
United Kingdom

T +44 (0)1492 534601
mottmac.com

Conwy County Borough
Council: Environment,
Roads & Facilities
Swyddfeydd Mochdre
Ffordd Conway
Mochdre
Bae Colwyn
LL28 5AB

Old Colwyn Coastal Defence and Active Travel Scheme

Water Framework Directive Assessment

July 2020

Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
A	July 2020	N. Spofforth	A. Crow	C. Williams	First Issue

Document reference: 417437-MMD-00-XX-RP-N-1721

Information class: Standard

This document is issued for the party which commissioned it and for specific purposes connected with the above-captioned project only. It should not be relied upon by any other party or used for any other purpose.

We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

This document contains confidential information and proprietary intellectual property. It should not be shown to other parties without consent from us and from the party which commissioned it.

Contents

1	Introduction	8
1.1	Overview	8
1.2	Background	8
1.3	Scheme Location	9
1.4	Coastal Defences – Current Condition	10
1.5	Current Overtopping Conditions and Storm Damage	12
1.6	Scheme Description	13
1.6.1	Rock Revetment Construction	13
1.6.2	Outfall Extensions and Groynes	13
1.6.3	Access Build Out	13
1.6.4	Beach Access Steps	14
1.6.5	Existing Groynes and Slipway	14
1.6.6	Fishing Platform	14
1.6.7	Promenade Raising	14
1.7	Scheme Construction	14
1.7.1	Phasing	14
1.7.2	Marine Construction Methodology	15
1.7.3	Rock Revetment Deliveries	15
1.8	Scheme Operation	16
2	WFD Assessment Methodology	17
2.1	The Water Framework Directive	17
2.2	Methodology of WFD assessment	17
2.2.1	Stage 1 (WFD Screening)	17
2.2.2	Stage 2 (WFD Scoping)	17
2.2.3	Stage 3 (WFD Impact Assessment)	17
2.3	Scope of this assessment	17
3	Stage 1: Screening	18
3.1	Construction	18
3.2	Maintenance	18
4	Stage 2: Scoping	19
4.1	Water Body Scoping	19
4.1.1	Identified Water Bodies	19
4.1.2	Potential Impact Pathways: Scoping In/Out of Waterbodies	20
4.1.3	Baseline WFD Status of Scoped-in Water Body	21
4.2	Habitats and Designated Sites	22
4.2.1	European Commission Protected Areas and Designated Sites	22

4.2.2	Other WFD Protected Areas and Sensitive Habitats	23
4.3	North Wales Coastal Water Body: Scoping In/Out of WFD Elements	24
5	Stage 3: Detailed Compliance Assessment	28
6	Outcomes and Conclusions	37
6.1	Assessment outcomes	37
6.1.1	Stage 1 – Screening	37
6.1.2	Stage 2 – Scoping	37
6.1.3	Stage 3 – Detailed Compliance	37
6.2	Marine Biodiversity Enhancement	38
6.3	Conclusions	38
A.	Red Line Boundary and Area of Permanent Construction Drawings	39
B.	Scheme Drawings	40
C.	Phase 1 Habitat Plan	41
D.	Biosecurity Risk Assessment	42
E.	HRA Screening Assessment	43

1 Introduction

1.1 Overview

This Water Framework Directive (WFD) Assessment has been prepared in support of an application by Conwy County Borough Council (CCBC) for a Marine Licence for marine works, as part of the Old Colwyn Coastal Defence and Active Travel Scheme (hereafter referred to as the “Scheme”). The Scheme, located in the Old Colwyn area of Colwyn Bay, North Wales, comprises coastal defence works in the form of a new rock revetment and promenade raising, in combination with promenade improvements to facilitate active travel.

The scope of this report is to identify potential WFD receptors that could be impacted by the works, assess the potential effects from the works, and to incorporate mitigation to minimise these potential effects (where required).

The report will describe any additional assessments required to ensure the proposed works are compliant with the WFD.

1.2 Background

The Victorian built coastal defences at Old Colwyn have suffered from undermining, corrosion, partial collapses and degradation with frequent overtopping events occurring at Spring Tides, especially if onshore westerly to north-westerly winds occur concurrently. The Promenade has to be closed during these events with the number of closures increasing in recent years – the promenade is now routinely closed whenever high tides coincide with forecast northerly or north-westerly winds.

The defences have been assessed as being at significant risk of “catastrophic failure”¹, which could lead to the loss of the pedestrian promenade and a section of National Cycle Route 5, along with the Promenade (highway) which would leave the main North Wales Coast (NWC) Railway Line (which connects London to Holyhead) highly vulnerable (and subsequently the A55 Expressway should the NWC Railway Line embankment fail).

The main trunk sewer that serves the whole of Old Colwyn is situated immediately behind the sea wall and could be lost should the defences fail catastrophically during a storm event. This would result in a discharge of significant quantities of untreated effluent directly onto the beach with associated severe environmental consequences. Other services are also present in this area.

To reduce the risk of damage to this infrastructure, starting in January 2020, the Splashpoint Project commenced comprising the construction of a 30m deep rock revetment against the sea wall at the location identified as being most vulnerable – the easternmost section of the promenade (where a revetment is currently absent). This was completed in July 2020.

Subsequent to this, CCBC are now seeking to provide a permanent upgrade of the coastal defences comprising a 32m deep 1.2km long rock revetment to protect the remainder of the Old Colwyn stretch of coastline from Porth Eirias to Splashpoint. The works are proposed to be completed concurrently with improvements to the Promenade to facilitate active travel. The

¹ Colwyn Bay Waterfront Project Phase 3 – Phasing Review, CCBC, August 2019

presence of the revetment would reduce the energy from storm waves reaching the promenade, providing passive resistance against the existing wall.

1.3 Scheme Location

The Scheme is located along the easternmost section of the promenade at Old Colwyn, from the eastern side of Porth Eirias in the west to Splashpoint in the east (see Figure 1.1). The Scheme footprint is divided into two principal areas:

- Area 1 – From the picnic area to the east of Porth Eirias car park (approximate National Grid Reference (NGR) 285822, 378870) to the east of Rotary Way (approximate NGR 286347, 378756) where the road currently reduces in height from the junction back down to promenade level; and
- Area 2 – From the eastern edge of Area 1 (approximate NGR 286347, 378756) to Splashpoint in the far east (approximate NGR 287029, 378701).

The red line boundary has been extended beyond the footprint as shown in Figure 1.1 to allow for access during construction.

Figure 1.1: Location of the Scheme



Source: Old Colwyn Coastal Defence and Active Travel Environmental Statement (ES) Volume1, August 2020

Scheme areas as shown on the Red Line Boundary Plan Drawing and Area of Permanent Construction Drawing located in Appendix A are summarised in Table 1.1.

Table 1.1: Approximate Scheme Areas

Area Boundary	Marine (north of sea wall) (ha)	Terrestrial (south of sea wall) (ha)	Grand Total (ha)
Area of Permanent Construction	3.6	3.0	6.6

Area Boundary	Marine (north of sea wall) (ha)	Terrestrial (south of sea wall) (ha)	Grand Total (ha)
Ecological Enhancements Only	0.3	0.7	1.0
Total	3.9	3.7	7.6
Red Line Boundary*	30.2	4.9	35.1

Source: Mott MacDonald Ltd, 2020 *Note: Other than a working buffer approximately 20m-30m north of the marine area of permanent construction (revetment area), the remainder of the intertidal area only needs to be accessed for revetment stone deliveries by sea (if revetment stone is to be delivered by barge) and for ecological enhancements.

1.4 Coastal Defences – Current Condition

The frontage at Old Colwyn covers around 1.2km of coastline and comprises a near vertical masonry sea wall that abuts a generally sandy foreshore, locally mixed, with natural gravels particularly along the toe of the wall.

The toe of the sea wall has been protected from erosion and undermining by a variety of defences. Across the first 750m west to east, rock armour has been placed directly in front of the wall (Photo 1.1, Photo 1.2), while over the remainder the toe has been protected either by reinforced concrete aprons or steel sheet piling (Photo 1.3).

Across the westernmost 200m of frontage the wall has a recurved section with the promenade lower to the rear. Over the remainder of the frontage there is no recurve and the crest level is the same as the promenade.

There are slipways located at Porth Eirias to the immediate west of the Scheme footprint and Splashpoint in the far east for beach access along with four sets of pedestrian access steps in various states of disrepair with some currently deemed unsafe and blocked-off. Rock groynes are present at four locations, outfalls are culverted beneath two groynes while other outfalls currently discharge directly to the beach (Photo 1.4).

Immediately landward of the wall is a part paved/part tarmac surfaced dual usage (pedestrian and cycle path) promenade, which adjoins the Promenade highway (Photo 1.5 and Photo 1.6). Moving west to east through Area 1, the Promenade highway increases in height to meet the incoming link road from Old Colwyn (Rotary Way) which provides access to the A55 (Junction 22) before dropping down to the same level in Area 2 as the top of the sea wall over the remainder of the length.

To the immediate west of the Scheme, a section of rock revetment approximately 30m wide with a 1:3 gradient has already been constructed against the sea wall in association with Phase 1 of the Colwyn Bay Waterfront Project and the Porth Eirias control structure as shown in Photo 1.7.

In addition, at the far eastern end of the Scheme, as part of the Splashpoint Project a rock revetment section of similar width with a 1:2.5 slope was constructed earlier in 2020 (Photo 1.8 **Error! Reference source not found.**) to curve around the eastern corner of the promenade highway to the point at which it makes a right angle turn southwards beneath the A55 Expressway and NWC Railway Line towards Beach Road/Cliff Gardens.

Within Area 2, overtopping of the promenade during storm events is a common occurrence which results in the closure of the highway and frequent (and increasing with deteriorating condition) damage to the sea wall, promenade and the NWC Railway Line embankment.

Photo 1.1: Looking North-West from Area 1 Promenade Across Old Colwyn Beach



Source: Mott MacDonald, 2020

Photo 1.2: Looking North-East from Area 1 Promenade Across Old Colwyn Beach



Source: Mott MacDonald, 2020

Photo 1.3: Looking West Along Sea Wall in Area 2 with Toe Protection Visible



Source: Mott MacDonald, 2020

Photo 1.4: Looking North-East At Splashpoint Nant y Fynnon Outfall During Revetment Construction



Source: Mott MacDonald, 2020

Photo 1.5: Looking West along Promenade South of Rotary Way



Source: Mott MacDonald, 2020

Photo 1.6: Looking East Along Promenade in Area 1



Source: Mott MacDonald, 2020

Photo 1.7: Looking North-East Across the Transition between the Existing Porth Eirias Revetment and the Scheme Area 1



Source: Mott MacDonald, 2020

Photo 1.8: Looking South-East Across the Transition between the Existing Splashpoint Revetment (Area 2) and the Area to the East of the Scheme



Source: Mott MacDonald, 2020

1.5 Current Overtopping Conditions and Storm Damage

As early as 1991, the Colwyn Borough Sea Defence Review identified that “*Overtopping, which occurs regularly when onshore winds coincide with spring tides, results in large quantities of shingle and cobbles being thrown over the wall. The road....is closed up to a dozen times a year for several days at a time while the shingle is cleaned back onto the beach*”². Conditions, which have continued to the present day with increasing frequency and severity³.

The impact of present day conditions is shown in visual and recorded evidence from more recent storm events (Figure 1.2), which confirms the overtopping behaviour and also identifies the following as taking place:

- Damage/Loss of Railings;
- Damage to promenade/highway surfacing and removal of fill behind the sea wall;
- Damage to boundary wall and erosion at toe of railway embankment;
- Lowering of beach levels in front of the sea wall;
- Undermining of the sea wall; and
- Removal of facing blocks to the sea wall.

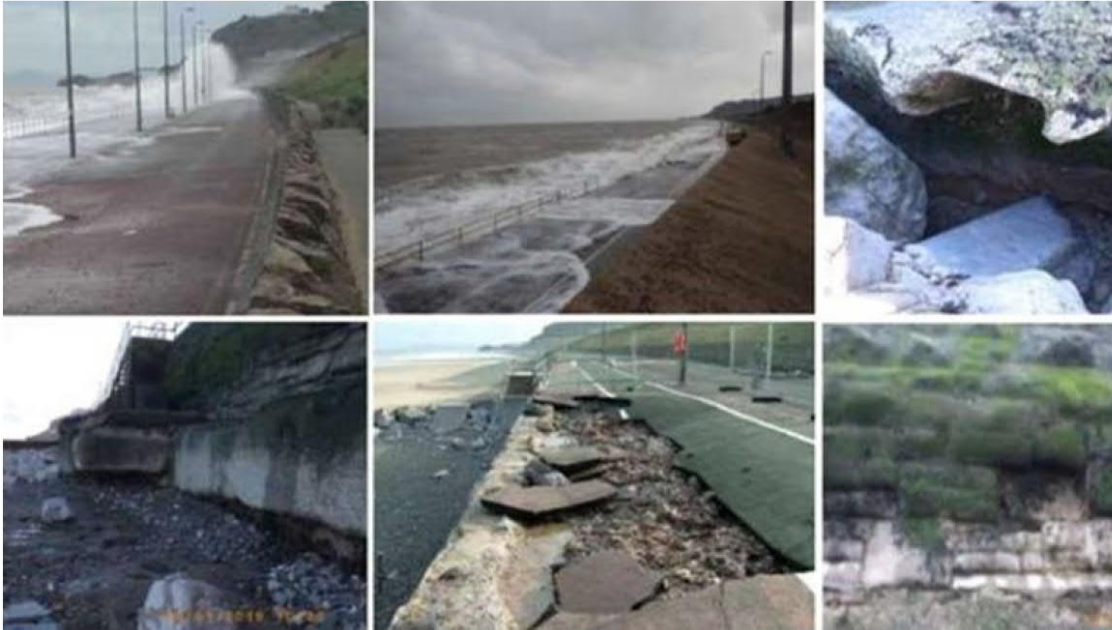
Examples of this damage are provided in Figure 1.2.

Furthermore, with sea levels predicted to rise in the future, due to anticipated climate change, by the end of the 21st century the tide is anticipated to reach approximately the crest of the current wall on each spring tide i.e. every 2 weeks. This means that the wall along the toe of the railway embankment would be impacted by waves rather than water that overtops the sea wall, as at present.

² Colwyn Bay Waterfront project Phase 3 – Phasing Review, Draft Report for Stakeholder Distribution, Coastal Engineering UK Ltd, August 2019

³ Discussions with CCBC 2020. No annual closure data available.

Figure 1.2: Examples of Old Colwyn Promenade Storm Damage



Source: CCBC records

1.6 Scheme Description

The proposed scope of work for the Scheme comprises a combination of coastal defence, promenade and active travel improvements. A series of Scheme detailed design drawings are included in Appendix B.

The coastal works design is summarised in Sections 1.6.1 to 1.6.7.

1.6.1 Rock Revetment Construction

The revetment would be approximately 32m in cross sectional width and 1.15km in length with an approximately 5m wide crest and a slope of 1:3 down to beach level. The revetment is required to protect the active travel routes along the promenade along with the Promenade highway, underground services, NWC Railway Line and A55 Expressway. The revetment would tie-in to the existing rock revetment east of Porth Eirias to the west and Splashpoint to the east – the toes and crests would merge as cross-sections are very similar.

1.6.2 Outfall Extensions and Groynes

Modifications to five existing outfalls would be required along the length of the revetment including extensions and protective slabs where necessary. The revetment toe would need to be widened locally to 7.2m (from typically 3.6m) at two locations. Stainless steel grills would be fixed to the end of each of the three culverts which are to be extended.

1.6.3 Access Build Out

A new access build out area would be constructed in the western half of Area 1, located between Porth Eirias and the first set of beach groynes. This build out would have numerous functions including:

- Providing a greater area for non-vehicular activity;

- Equality Act compliant access to the beach
- Stepped access to the beach; and
- Areas of landscaping and seating.

1.6.4 Beach Access Steps

New pedestrian accesses through the proposed revetment to comprise three sets of beach access steps perpendicular to the linear rock revetment, would be constructed at the location of each of the three longest groynes within the Scheme area to the west of Rotary Way, mid-way between Rotary Way and Splashpoint and at Splashpoint.

1.6.5 Existing Groynes and Slipway

The existing groynes present would be retained, maintained and enhanced ecologically through the installation of two ecological armouring units per groyne. Concrete access steps would be provided across the southernmost section of each groyne adjacent to the revetment.

The existing slipway at Splashpoint would be retained in its current location.

1.6.6 Fishing Platform

A fishing platform would be constructed in the Splashpoint area to ensure anglers do not block active travel routes (as is currently the case). The platform would be accessed from a pedestrian only area and extend out over the revetment with supporting steelworks to be pocketed into the raised sea wall structure at this location.

1.6.7 Promenade Raising

The raising of the promenade is required to permissible overtopping levels with consideration for climate change. The new promenade finished level is to be +7.0mOD directly behind the seawall, with the promenade slabs typically falling approximately 1:40 towards the seawall to allow over the edge drainage for surface water run-off. In Area 1 the promenade is to be raised above the levels of the Promenade highway and associated parking with a side retaining structure located along the rear of the promenade slabs (the Promenade highway would be maintained at approximately current levels). In Area 2, the promenade and highway would both be raised and the available promenade would be widened where it narrows between Rotary Way and Splashpoint.

1.7 Scheme Construction

1.7.1 Phasing

The Project has been divided into the two general sections for the purposes of planning and sequencing the works as follows:

- Construction Section 1: Splash Point to Rotary Way (Area 2); and
- Construction Section 2: Rotary Way to Porth Eirias (Area 1 and the westernmost section of Area 2).

In both Sections, the initial activity would comprise the delivery and placement of the rock revetment either by road or by barge and general site clearance of the promenade. Construction of the coastal defence elements would be completed before the promenade construction works commence.

1.7.2 Marine Construction Methodology

The marine works consist of constructing the rock revetment, drainage outfalls, access build-out, fishing platform and access steps of various configurations. The crest wall would form part of the highway works and support the end of the fishing platform. Access onto the beach would be via the slipways at either end.

Existing revetment rock present against the sea wall would be examined and if suitable, it would be removed and stockpiled on the beach. Piling activities would take place first (tubular steel piles driven into the underlying clay for the fishing platform and sheet piles for the access steps and access build-out structure) followed by the construction of the revetment.

Revetment construction would start from the toe. Core fill material would be delivered by road and stockpiled on the beach close to its final location within the revetment. Revetment rock would also be stockpiled on the beach following delivery, immediately seaward of where it is to be used. The core material would be placed against the existing sea wall to form the required profile with pipes/culverts for the outfall extensions placed within the core. The geotextile separation layer would then be placed over the core.

The revetment underlayer would need to be complete before the crest wall is constructed. In order to protect the underlayer the front face of the primary armour (3t-6t revetment rock) would be constructed as soon as possible. The construction of the outfall culverts through the armour layers would be coordinated with the revetment rock placing.

1.7.3 Rock Revetment Deliveries

Depending on funding and timing constraints, if revetment rock (particularly the 3t to 6t size) cannot be sourced from local quarries in sufficient quantities, bringing in some (or all) quarried rock from elsewhere by barge for direct delivery to the beach would be necessary. Revetment rock deliveries would be stockpiled on the beach, immediately seaward from where they are to be placed within the revetment.

For barge deliveries, the revetment rock would be transported on larger delivery vessels (anticipated to be ~6000t capacity) and then transferred onto smaller barges (~1,500t capacity) to be guided to shore by a tug at a designated (and rising) tidal state when access to the upper shore area is possible (understood to be approximately 2 hours either side of high tide). The revetment rock would be unloaded directly to shallow water. Land based plant would then move the unloaded revetment boulders to the designated stockpile locations along the beach at low tide.

Delivery by barge represents the worst case for potential impacts on the North Wales Coastal Water Body and therefore for the purposes of this assessment, it has been assumed that barge delivery of revetment will be the selected delivery method rather than by road.

Rock deliveries by barge would be likely to need 24/7 working patterns to allow the contractor to use the tides. Barge works are also very weather dependant and safe mooring locations inshore would be required in case of bad weather. These would be agreed before construction commenced.

Given the high costs of delays and standing time for barge deliveries combined with health and safety issues, delivery of materials by barge if transshipment is needed is not considered to be suitable for the winter months when the risk of storms is much higher. In addition, the Liverpool Bay SPA is designated for wintering birds and therefore barge deliveries would not be able to take place between March and October.

1.8 Scheme Operation

The Scheme also includes future management and maintenance actions. In addition to regular inspections, the following activities are of relevance to this assessment:

- Reactive maintenance and repair of revetment, structures, groynes access-build out, steps and fishing platform as required following routine inspections (this is anticipated to be minimal in the short-medium term);
- Routine maintenance and repair of promenade including pavement and drainage system;
- Cleaning and maintenance of slipways and flood gates (hinges and seals) with a suitable inspection regime; and
- Monitoring of beach levels at the toe of the revetment and along the beach: The revetment design has allowed for a 0.5m fall in beach levels. Should beach levels be noted to fall more than 0.5m following inspections, localised recycling of beach material would be required. Conversely should accretion of more than 1m be noted, this could be detrimental to access or ecological enhancements and some limited beach management may be required.

2 WFD Assessment Methodology

2.1 The Water Framework Directive

The Water Framework Directive (WFD) is a European Directive⁴ which aims to protect and improve the water environment. It became law in the UK in 2003. The current Regulations are the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017⁵.

The WFD requires the identification and setting of objectives for protecting and improving 'water bodies'. These include; rivers, streams, lakes, reservoirs, estuaries, coastal waters, canals and groundwaters.

The standard objective is to achieve 'good status', or 'good potential' (if the water body is artificial or has been extensively modified), and to protect the water body by preventing any deterioration in status. Good 'status' or 'potential' is made up of ecological and chemical components in surface waters. Ecological status consists of biological quality elements, physico-chemical supporting elements and hydromorphological supporting conditions. For groundwater, status consists of quantitative and qualitative elements. In this report for consistency, all the above components are referred to as 'WFD quality elements'.

2.2 Methodology of WFD assessment

The assessment has been completed in accordance with NRW guidance⁶, which provides guidance on assessing projects and activities for compliance with the WFD. This guidance recommends that WFD assessments are completed in a 3-stage approach:

2.2.1 Stage 1 (WFD Screening)

Stage 1 is an initial assessment to determine if there are any activities associated with the Scheme which have the potential to impact on waterbodies within the vicinity and to ensure that only those activities that may cause deterioration or prevent a water body from meeting its objectives are assessed further.

2.2.2 Stage 2 (WFD Scoping)

Stage 2 comprises a more detailed assessment to identify WFD water bodies and WFD quality elements that are at risk from the proposed activity. The aim of this assessment is to identify if any waterbodies would require further detailed assessment.

2.2.3 Stage 3 (WFD Impact Assessment)

Stage 3 is a detailed assessment of waterbodies and activities carried forward from the screening stage. It must include identification of waterbodies, description of the proposed development, methods used to determine impacts, risk of deterioration and mitigation required.

2.3 Scope of this assessment

This report covers the three stages of the assessment, as outlined above.

⁴ Water Framework Directive 2000/60/EC

⁵ Water Environment (Water Framework Directive) (England and Wales) Regulations 2017, 2017/407

⁶ Guidance for assessing activities and projects for compliance with the Water Framework Directive, OGN 72, 2018

3 Stage 1: Screening

This stage determines if there are any activities associated with the Scheme which have the potential to impact on water bodies within the vicinity (not listed within Appendix 2 or Table 5 or OGN72⁶).

3.1 Construction

The following aspects of the scheme have the potential to impact upon the water environment and have been screened into the assessment:

- Construction of 1.2km length of rock revetment connecting the existing Porth Eirias revetment in the west to the Splashpoint revetment in the east and associated extensions of outfalls through the revetment (including revetment deliveries by barge); and
- Construction of promenade access build out, associated fishing platform and access steps x3.

It is anticipated that the promenade works would be completed following the revetment construction and would be located above the levels of even the highest tides. Therefore, the promenade construction works have been screened out.

3.2 Maintenance

According to Appendix 2 of OGN72⁶ (activities that can be screened out from further assessment in the majority of cases), the following activities in the estuarine/coastal environment can be screened out:

- “*Minor Construction and Repairs*” including minor maintenance, resurfacing slipways and removal of marine growth; and
- “*Beach Management Activities*” including beach re-profiling, beach recycling, replacing or returning wind-blown sand and clearance/removal of beach material in and around outfalls to facilitate drainage.

It is considered that the standard maintenance anticipated to be required during operation of the Scheme would fall within those categories and in addition, maintenance requirements are anticipated to become much less frequent to the annual reactive repairs completed currently following regular storm damage. Therefore maintenance activities have been screened out from further assessment.

4 Stage 2: Scoping

This stage identifies water bodies and WFD quality elements that are at risk from the proposed activities and require further assessment.

4.1 Water Body Scoping

4.1.1 Identified Water Bodies

Information on WFD water bodies and associated data was obtained from the Water Watch Wales website⁷. The Western Wales River Basin Management Plan⁸ covering the study area was also used. A copy of the Water Watch Wales map is provided as Figure 4.1.

4.1.1.1 Coastal Water Bodies

The proposed works area predominantly falls within the North Wales Coastal Water Body (ID: GB 641011650000). The North Wales Coastal Water body starts at Great Orme's Head and continues eastwards along the Welsh coast and ends in the estuary of the River Dee.

4.1.1.2 Groundwater Bodies

Part of the Scheme works area also overlaps the Conwy Groundwater Body (ID: GB41002G2033000). This groundwater body extends across North Wales.

4.1.1.3 River Water Bodies

There are no WFD surface watercourses that drain via the Colwyn Bay waterfront area and the closest (the Ganol East (ID:GB 641011650000) is located over 3km distant to the west at its closest point).

There are three rivers discharging within and immediately adjacent to the Scheme area:

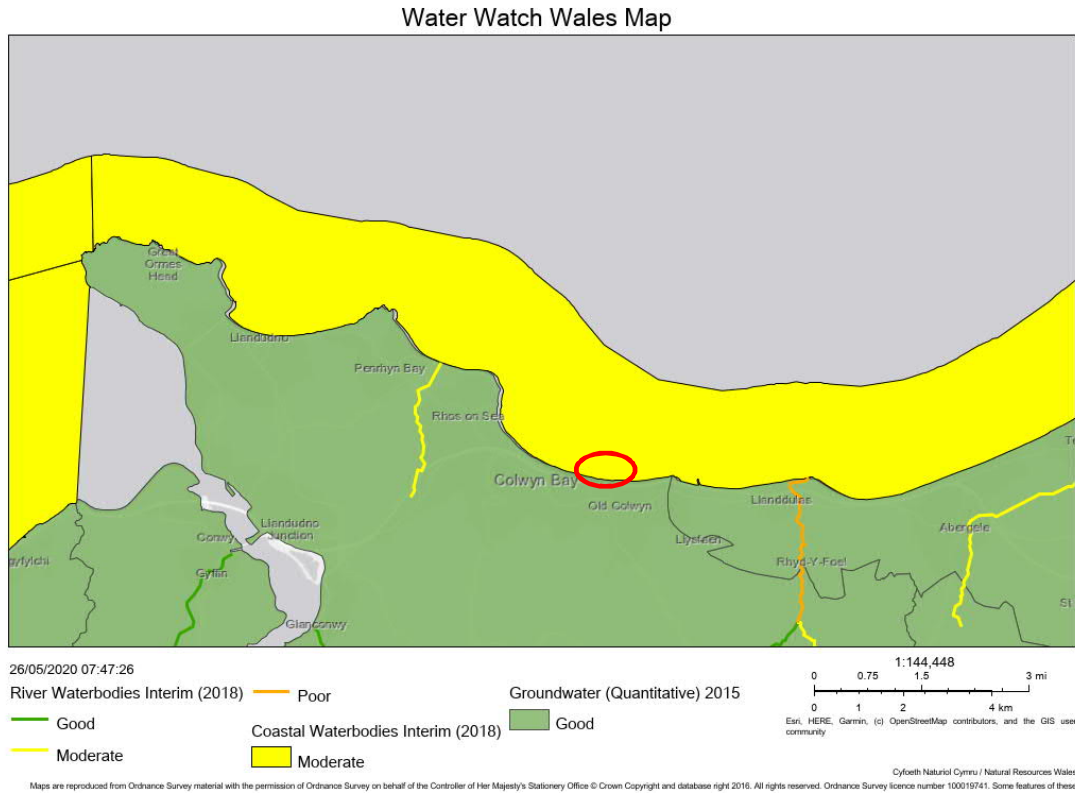
- The Nant-y-Groes (Main River) is present to the immediate west of the Scheme area, discharging to the beach via a culvert that passes beneath Porth Eirias at approximate NGR 285760, 378946;
- The Llwd (Main River) is culverted and is understood to discharge to the beach behind the existing revetment at approximate NGR 285877, 378888 within the Scheme area to the east of Porth Eirias. The culvert flows beneath a sports centre and recreational ground before discharging to the beach; and
- The Nant-y-Fynnon (Ordinary Watercourse) passes through Old Colwyn, flowing in an artificial channel down Beach Road and beneath the A55 Expressway before being culverted beneath the NWC Railway Line and outfalling directly onto the beach at Splashpoint at approximate NGR 287008, 378709.

As none of these watercourses are classified WFD waterbodies, they will be assessed as part of the downstream water body (North Wales Coastal Water Body).

⁷ Water Watch Wales website: <https://waterwatchwales.naturalresourceswales.gov.uk/en/>, accessed June 2020

⁸ Western Wales River Basin Management Plan: <https://naturalresources.wales/media/674895/ww-rbmp.pdf>, accessed June 2020

Figure 4.1: Map of WFD Water Bodies in the Vicinity of the Scheme



Source: Water Watch Wales website⁷

4.1.2 Potential Impact Pathways: Scoping In/Out of Waterbodies

Table 4.1 identifies which water bodies are considered to have a potential impact pathway with the Scheme and are therefore scoped in.

Table 4.1: Scoping In/Out of WFD Water Bodies

Water Body Name	WFD ID	Relationship to the Scheme	Potential Impact Pathway?	Scoped in?
<i>Coastal Waterbodies</i>				
North Wales	GB641011650000	<ul style="list-style-type: none"> Scheme is situated within coastal water body intertidal area, immediately adjacent to the Liverpool Bay SPA. Coastal waters also Bathing Waters within Scheme area and supporting sensitive habitats. 	Yes – scheme located within coastal water body.	✓
<i>Surface Waterbodies</i>				

Ganol East	GB641011650000	<ul style="list-style-type: none"> • Scheme is located ~3km east of the water body. • Water body flows into the North Wales Coastal Water body (it does not discharge into Colwyn Bay). 	No – water body is located over 2km distant from the Scheme at its closest point.	X
<i>Groundwaters</i>				
Conwy Groundwater Body	GB41002G203000	<ul style="list-style-type: none"> • Promenade aspects of Scheme are located above northern most edge of groundwater body in an area of saline intrusion. • Scheme includes raising of promenade with only shallow localised excavations. 	No – works are not anticipated to impact upon groundwaters.	X

Source: Water Watch Wales⁷

4.1.3 Baseline WFD Status of Scoped-in Water Body

- North Wales Coastal Water Body (ID: GB 641011650000).

The current (baseline) WFD status and objectives for the screened-in water body are summarised in Table 4.2. Status information has been obtained from the NRW Water Watch Website⁷, and from the Western Wales River Basin Management Plan⁸.

Table 4.2: Baseline WFD Status of Scoped-in Surface Water Body (RBMP 2018 Cycle 2 Interim Classification)

WFD Water body	North Wales
2018 Cycle 2 Interim Classification	
Water body ID	GB641011650000
River Basin District name	Western Wales
Water body type	Coastal
Water body total area (ha)	148.28km ²
Highly modified water body (HMWB) and use	Yes (for coastal protection)
Overall water body status (2018 interim)	Moderate
Ecological status	Moderate (phytoplankton blooms)
Chemical status	Fail
Invertebrates	Good
Phytoplankton	Moderate (blooms)
Dissolved Inorganic Nitrogen	Good
Dissolved Oxygen	High
Annex 8 chemicals, priority hazardous substances, priority substances and other pollutants	High (with exception of Moderate for Mercury)
Water body Objectives and Measures (2017)	
Failing WFD elements	Dissolved inorganic nitrogen, mercury
WFD overall objective	Good by 2021
WFD chemical objective	Good by 2021
WFD ecological objective	Good by 2021

Source: Water Watch Wales⁷

4.2 Habitats and Designated Sites

The WFD assessment considers the potential impact of an activity on other protected areas and sensitive habitats which may be considered as part of a designation for a Natura 2000 or SSSI protected site, be considered Features of Conservation Interest (FOCI) or be broad scale habitats which could be qualifying features for Marine Conservation Zones (MCZs).

4.2.1 European Commission Protected Areas and Designated Sites

There is one designated site within 2km of the works with the potential to be impacted:

- Liverpool Bay/ Bae Lerpwl Special Protected Area (SPA)⁹. The SPA is located immediately parallel to the north of the works extent straddling both Welsh and English territorial waters. It is designated a SPA supporting several wintering bird species, including five Annex II bird species and covers an area of ~252, 773 ha.

⁹ MAGIC map, DEFRA (N.D). Available at <https://magic.defra.gov.uk/magicmap.aspx>. Accessed on 01/04/2020

4.2.2 Other WFD Protected Areas and Sensitive Habitats

4.2.2.1 Shellfish Waters, Bathing Waters and Nutrient Sensitive Areas

Shellfish Waters

There are no Shellfish Waters within the Scheme area or within 2km of the red line boundary⁹. The closest are:

- Rhos-on-Sea 2.0km to the north-west; and
- Llanddulas 2.6km to the east.

Bathing Waters

The inshore waters at Colwyn Bay are classified as Bathing Waters which needs to be assessed for potential impacts under the WFD.

There are two Bathing Water Quality monitoring points in the wider Colwyn Bay area – to the west of Porth Eirias (approximate NGR 285566, 379291, around 500m north-west of the red line boundary) and further west again at Rhos-on-Sea (284634,380141, around 1.8km north-west), although there is no specific monitoring point within the Scheme area.

In 2019 the results of sampling and analysis of water quality at Porth Eirias (along with the sampling point at Rhos on Sea) against the revised Bathing Water Directive by NRW resulted in an Excellent classification¹⁰. Water quality at designated bathing water sites in Wales is assessed by NRW from May to September including testing the numbers of Intestinal enterococci and Escherichia coli present.

According to NRW “*there are no sewage treatment works that discharge directly into Colwyn Bay bathing waters. A major improvement scheme was completed by Welsh Water for Conwy, Deganwy, Llandudno and Colwyn Bay in 1999. The sewage from the immediate catchment of the Llandudno, Conwy, Deganwy and Colwyn Bay areas is now pumped to the Ganol Wastewater Treatment Works, at Llandudno Junction*”¹⁰.

Within the catchment there are a number of storm and surface water outfalls, that discharge to the rivers and streams. After periods of rainfall these discharges could have an adverse effect on bathing water quality. There are understood to be five active outfalls within the Scheme area.

Nutrient Sensitive Areas

There are no coastal/nutrient sensitive areas i.e. sensitive to nutrients and therefore eutrophication, in the Scheme area⁹.

4.2.2.2 WFD Sensitive Habitats

There are several ‘WFD sensitive habitats’ located within the Scheme area⁹ (see Appendix C for the Phase 1 Habitat Survey plan).

- Lower sensitivity habitats (medium to high resistance to, and recovery rate from, human pressures):
 - Subtidal soft sediment;
 - Intertidal soft sediment; and
 - Gravel and cobbles.

¹⁰ NRW Bathing Water data: <https://environment.data.gov.uk/wales/bathing-waters/profiles/profile.html?site=uk11301-40425>, accessed June 2020

- Higher Sensitivity Habitats (these have a low resistance to, and recovery rate from human pressures):
 - Blue Mussel beds:

The Preliminary Ecological Appraisal Report (PEAR)¹¹ describes the mussel beds as follows: *“Blue Mussel beds on sediment (within the survey area): The mussel beds within the survey area broadly meets the description for this priority habitat, in that Blue Mussel beds are present within the sand substrate. However, the beds are isolated areas of relatively sparse mussels (with areas that appeared to have previously been dense) in poor condition are now all that are present. Blue Mussel beds as a priority habitat is valued as having a role in coastal sediment dynamics, acting as a food source for overwintering waders and providing an enhanced area of biodiversity (typically associated with a range of organisms including furoids, barnacles, isopods and other fauna). The mussel beds within the survey area are small and in poor condition, whilst no evidence of any diverse assemblage of associated organisms was recorded during the surveys undertaken. On this basis, the habitats on site are considered to be poor examples of this priority habitat type and are not considered to be of any elevated ecological value in a local context.”*

In addition, (also as detailed in the PEAR) the following habitat within the survey area are considered to be of elevated value in the context of the site and could qualify as Priority Habitat (as listed under Section 7 of the Environment (Wales) Act):

- *Sabellaria alveolata* Reef patches along three groyne structures: *“The patches of Honeycomb Worm (Sabellaria alveolata)... could meet the description of the priority habitat Sabellaria alveolata Reefs. This priority habitat can typically be 30 to 50cm thick and form large expanses. However, the patches in the site were noted to be relatively small and isolated in extent (not reef forming) and so not a high quality example of this priority habitat.”*

4.3 North Wales Coastal Water Body: Scoping In/Out of WFD Elements

The Scheme may present potential risks to a number of receptors within the study area, based on the screened-in water body’s WFD quality elements. These include:

- Hydromorphology;
- Biology – habitats;
- Biology – fish;
- Protected areas;
- Water quality; and
- Invasive and non-native species.

Table 4.3 details the potential risk from the proposed scheme to each of these quality elements and determines which are at risk and require a full impact assessment (those activities determined not to constitute a risk have been shaded grey).

¹¹ Colwyn Bay Preliminary Ecological Appraisal Report (410895-MMD-N-R-00-XX-1701), Mott MacDonald 2020

Table 4.3: Scoping In/Out of WFD Quality Elements

WFD Quality Element	Consideration of Scheme Activity:	Potential Risk?	Stage 3 Assessment required?
Hydromorphology	Could impact on the hydromorphology (for example morphology or tidal patterns) of a water body at high status?	No. Overall status of water body is Moderate.	x
	Could significantly impact the hydromorphology of any water body (including morphological conditions and tidal patterns)?	No. Proposed scheme has potential to alter morphological conditions locally along the Old Colwyn frontage – however change in morphological conditions is not anticipated to be ‘significant’ in terms of water body as whole. There is currently extensive coastal protection along the frontage of the coastal water body (approximately 45km). Therefore, these works are considered to be relatively minor in the context of the entire water body, comprising approximately 2.5% of the length of frontage along the water body as a whole when considering the ~1.15km length, or approximately 0.8% when considering the 400m section without any revetment currently.	x
	Physical footprint is greater than 1% of surface area of water body or greater than 0.5km ² ?	No. Scheme physical footprint within coastal area ~3.9ha which is ~0.026% of the total water body surface area.	x
	Is in a water body that is heavily modified for the same use as the activity?	Yes. Water body is heavily modified for coastal protection	✓
Priority Habitats and Species	Physical footprint is greater than 1% of surface area of water body or greater than 0.5km ²	No. Scheme physical footprint within coastal area ~3.9ha which is ~0.026% of the total water body surface area.	x
	Is within 500m of any higher sensitivity habitat?	Yes. A single Blue Mussel bed (<i>Mytilus edulis</i>) and intermittent patches of Honeycomb Work (<i>Sabellaria alveolata</i>), although they are sparse and poor quality examples of these habitats and are not considered to be critical to the health of the water body.	✓

WFD Quality Element	Consideration of Scheme Activity:	Potential Risk?	Stage 3 Assessment required?
	1% or more of any lower sensitivity habitat?	No. Lower sensitivity habitats in question are very common along 45km frontage of water body ¹² .	x
Biology - fish	Will impact on normal fish behaviour like movement, migration, spawning; species composition and abundance; or mechanical injury?	No. No physical barriers, chemical changes, habitat changes, significant changes to water quality or quantity, no changes to depth or flow and no possibilities of entrainment/impingement.	x
	Is in a transitional water body and could affect fish?	No	x
	Is outside of a transitional water body and could impact upon migratory fish?	No	x
Water Quality	Could affect water clarity, temperature, salinity, oxygen levels, nutrients or microbial patterns continuously for longer than a spring neap tidal cycle (about 14 days)	No. Majority of works are to be undertaken at low tide on the upper shore area, minimising the potential for the generation of suspended solids; if the 3-6t revetment stone is to be delivered by barge, this would increase turbidity levels, however only intermittently during unloading, not continuously and any impact would be temporary and limited to the construction period.	x
	Is in a water body with a phytoplankton status of moderate, poor or bad	Yes (Moderate)	✓
	Is in a water body with a history of harmful algae	No	x
	Puts water quality at risk from your activity through the use, release or disturbance of chemicals	No. Chemical use or release is not anticipated. Ground investigation and associated sediment quality testing has not yet been completed, however sediments not in a historically contaminated area and there is no evidence that elevated contaminant levels would be present.	x

¹² NRW online mapping: <https://naturalresources.wales/evidence-and-data/maps/wales-environmental-information/?lang=en>, accessed June 2020

WFD Quality Element	Consideration of Scheme Activity:	Potential Risk?	Stage 3 Assessment required?
		An Outline Environmental Management Plan (OEMP) ¹³ has been produced for the Scheme. This would be updated to a Construction EMP when a Contractor is appointed.	
Protected areas	Within 2km of any WFD protected area	Yes. Scheme is immediately adjacent to a SPA and within a Bathing Water area.	✓
Invasive and non-native species (INNS)	Introduce or spread INNS (including materials or equipment that have come from, had use in or travelled from other water bodies; or activities that help spread INNS).	No. Introduction of alien species is not seen as a significant risk. Measures to prevent the import of INNS are included in the Biosecurity Risk Assessment, Appendix D.	x

¹³ Old Colwyn Coastal Defence and Active Travel Scheme, Outline Environmental Management Plan, 417437-MMD-00-XX-RP-N-1728, Mott MacDonald Ltd, July 2020

5 Stage 3: Detailed Compliance Assessment

This stage considers the potential impacts of an activity, identifies ways to avoid or minimise impacts, and concludes if the activity may prevent any WFD quality element within any WFD water body achieving good status/potential or may cause deterioration.

Four receptors were identified as being at risk from the Scheme:

- Hydromorphology (development for coastal protection);
- Priority habitats and species (higher sensitivity habitat: Blue Mussel and Honeycomb Worm reef patches within red line boundary);
- Water quality (phytoplankton status of Moderate); and
- Protected areas (Liverpool Bay SPA, Colwyn Bay Bathing Waters).

In addition in-combination and cumulative effects have been considered.

A WFD compliance assessment has been completed for each receptor, as shown in Table 5.1.

Table 5.1: Potential Impacts on WFD status of the North Wales Coastal Water body

WFD Quality Element	Construction of Rock Revetment and Associated Beach Access Structures – Potential Impacts (taking into account mitigation measures identified during the EIA process) For more information see the Old Colwyn Coastal Defence and Active Travel Scheme Environmental Statement Volume 1 (Report No. 415437-MMD-00-XX-RP-N-1719), Mott MacDonald, August 2020,	Will the Scheme Result in Deterioration of WFD Quality Element (when the status of at least one quality element reduces by one class or more)?
Hydro-morphology: Development for coastal protection	<p>Overview</p> <p>This water body is currently heavily modified due to ‘coastal protection’, which is also the purpose of the proposed works as supported by the Shoreline Management Plan policy to ‘Hold the Line’¹⁴. A total of ~1.15km of rock revetment would be constructed along the coastline, which provides an impact pathway to coastal morphology. However, all bar the 400m immediately west of Splashpoint is already defended by smaller scale rock revetment which is to be upgraded with the proposed larger-scale revetment. Extension of rock revetments would affect coastal morphology but only in the locality of the scheme. There is currently extensive coastal protection along the frontage of the coastal water body (approximately 45km). Therefore, these works are considered to be relatively minor in the context of the entire water body, comprising approximately 2.5% of the length of frontage along the water body as a whole when considering the ~1.15km length, or approximately 0.8% when considering the 400m section without any revetment currently.</p> <p>Potential Impacts</p> <ul style="list-style-type: none"> • The construction of the revetment would require excavation of beach material and glacial till to provide a solid foundation. During the construction phase, machinery would need to track along the foreshore to excavate existing material and to place new materials. This could result in the loosening of beach material, making it more available for transporting along the frontage and to be suspended into the water column. However, works are to be undertaken at low water, reducing the potential for resuspension. • Material from the excavation would be evenly distributed along the foreshore following the construction of a section of revetment that was excavated. This would allow the material to remain in the system and maintain the sediment balance. • The construction phase may lead to short term adverse impacts on sediment transport through the temporary placement of rock used for revetment construction in the intertidal zone prior to re-location to its final location within the new revetment structure. It is assumed that revetment rock would be 	No – Residual effects of the Scheme on coastal hydromorphology are not considered to result in a deterioration of this WFD quality element when considering the mitigation already allowed for as discussed in the Environmental Statement (ES) ¹⁶ .

¹⁴ North West England and North Wales Shoreline Management Plan SMP2, Halcrow Group Ltd, February 2011

¹⁶ Old Colwyn Coastal Defence and Active Travel Scheme, Environmental Statement Volume 1: Main Text, 415437-MMD-00-XX-RP-N-1719, Mott MacDonald Ltd, July 2020

stockpiled immediately seaward of its eventual location within the revetment. This temporary storage of materials may affect current localised sediment transport patterns, leading to settling-out of materials in the vicinity of the stockpiled materials and the reduction in sediment transported along the frontage. It is considered that once the stockpiles have been removed the beach would return to its current state.

- It is likely that in the long term there would be some accumulation of sediment material at the toe of the new revetment, as has been recorded along the revetment currently in place along the Colwyn Bay frontage. The modelling that was previously undertaken for the Colwyn Bay Phase Waterfront Project¹⁵ (of which this Scheme is equivalent to Phase 3 of) indicated that with control structures in place, erosion of the wider beach area still occurred in the long term. Although this scenario has not been modelled, it can be assumed that the wider beach would continue to erode in the longer term as per the Waterfront Project model. Taking the 15 year monitoring of beach levels into account, the Scheme has been designed to include a beach lowering of 0.5m to account for any longer term sediment movement at the toe of the structure.
- The revetment in front of the existing sea wall may result in the alteration of waves incident at the sea wall. This would provide a less reflective surface and as such would be expected to reduce scour and thus reduce further erosion and lowering of the beach along the frontage. However, with time beach levels are anticipated to reach equilibrium levels.

Mitigation Measures

- In general, with the exception of minor ecological enhancement works to the groynes, the majority of construction plant movements would be within a primary working area 20-30 m from the toe of the revetment (50-60m from the sea wall). The exception to this would be if 3-6t revetment stone is to be delivered by barge. Barge deliveries would be made at high tide. Following the appointment of a Contractor, and the selection of a delivery method for the 3-6t rock revetment (barge or road), the CEMP would be updated to outline the routes where the construction vehicles can travel to minimise the area of beach affected. These routes would be finalised in agreement with CCBC and NRW, but as a minimum would exclude the Blue Mussel bed, and areas of Honeycomb Worm which has been identified on sand/gravel substrate. The existing rock groyne areas where Honeycomb Worm has been identified would also be disturbed, other than for ecological enhancement works – placement of ecological armouring units). A site walkover by a marine ecologist 6 weeks prior to works commencing would be completed to make any necessary changes to plant movement routes. Where material is disturbed localised reinstatement of the beach would be undertaken.
- Stockpile locations would be agreed in advance with CCBC and NRW once a Contractor has been appointed (to be recorded in the CEMP) and the 3-6t revetment delivery method has been selected. During construction, to reduce short term negative impact on hydrodynamics and the sediment transport regime, materials, such as rock armour used for revetment construction, would be stored as

¹⁵ Detailed Modelling Studies for Colwyn Bay Coastal Defence Scheme, Royal Haskoning, July 2010

high up the beach as practicable, close to the working area. Where this is not possible, the size of the stockpile would be assessed to ensure that changes to the current flows are not creating areas of scour. Monitoring of the beaches around the stockpile would be undertaken and the beach levels reinstated should beach lowering be recorded. A Contractor-led beach inspection scheme would be agreed in advance with CCBC and NRW and detailed in the CEMP. Stockpiles would only be temporary and would not be permitted to remain beyond the end of the construction phase.

- Any barge delivery of revetment is also proposed to be undertaken in the months of least storm activity which would reduce the impact on sediment and water quality in relation to plant movements on the lower beach area.
- Excavation of waste materials would be kept to the minimum required in order to allow a solid founding for new structures without the removal and disturbance of excess materials. This would minimise displacement of removed sediments onto the foreshore that might be dispersed leading to an increase in suspended sediments.
- For rock delivered by barge, the Contractor would produce a Transshipment Management Plan in consultation with CCBC, NRW and other local stakeholders prior to construction. It is proposed that this plan would include the identification of the transshipment locations offshore and a bathymetric survey of the area prior to works commencing. The plan would also include shipping corridors to the frontage, along with bathymetric surveys of these areas. The methodology for transferring rocks between barges would also be included to minimise the loss of rocks overboard. A plan for recovering any lost rocks off the seabed would also be included should this be required by NRW.
- Regular beach monitoring would be undertaken along this section of the frontage and a beach monitoring regime would need to continue throughout the life of the coastal defence works to record how the beach is evolving in front of the new rock revetment, enabling any remedial action to be planned if required. Should the beach level drop below 0.5m CCBC would be required to undertake localised beach recycling and if it should rise by over 1m, localised beach management may be required to ensure ecological enhancement and outfalls remain operational.

Priority habitats and species

Overview

Blue Mussel (*Mytilus edulis*) beds: A small, poor quality Blue Mussel bed is present within the red line boundary area in the far east of the Scheme to the immediate north of Splashpoint and east of the Splashpoint groyne. The mussel bed is not located beneath the revetment footprint and is separated from the base of the existing Splashpoint revetment by an approximately 15m strip of beach and shingle where no mussels are present, providing an access around the base of the proposed revetment.

Honeycomb Worm (*Sabellaria alveolata*) reef: Poor quality and sparse patches of *Sabellaria alveolata* have been noted intermittently along the northern third to half of the groynes present (with the exception of the Splashpoint groyne where the environment appears to be too muddy). They were observed approximately ~60m north of the sea wall at their closest point however these examples were very sparse – the conditions

No – Residual effects of the Scheme on priority habitats and species are not considered to result in a deterioration of this WFD quality element when considering the mitigation already allowed for as discussed in the ES⁶.

within the northernmost 50m of the longer groynes provided more favourable conditions with more patches noted along the eastern side of the groynes rather than the west. There was also a very small area of *Sabellaria alveolata* reef located within the intertidal sediment to the immediate east of the westernmost of the three longer groynes (approximately 200m north of the sea wall).

Potential Impacts – Mussel Beds

Both dense and sparse mussel bed habitats are present within the eastern end of the Site, although it is noted that these are considered to be in poor condition. Mussel beds present on site are likely to be susceptible to direct effects from:

Physical damage – the Scheme would result in the tracking of plant, machinery and personnel across the site area in order to undertake construction. It is unlikely that the entire mussel bed would be able to be avoided by tracking plant, however limiting the area for tracking to the sparse sections and avoiding dense areas would lead to minimal temporary impacts on the mussel bed only. The use of the barge in the intertidal area and stockpiling, along with necessary marine support vessels provides the potential for physical damage to the mussel beds.

Acoustic underwater noise and vibration (piling) – the Scheme would involve piling within the intertidal area at low tide. Vibration when not properly mitigated can propagate through the bedrock and sediment and has been found to impact on shellfish species (both the fitness of individuals and mussel beds of *Mytilus edulis* due to disruption of natural valve movements¹⁷).

The potential for indirect effects on Blue Mussel beds include:

- Water pollution – given the nature of works, there is a risk of oil and fuel spills into the environment from machinery and vehicles in, and adjacent to, the intertidal habitats, as well as from the barge and associated vessels should this be required. This release of pollutants could prove toxic to this shellfish species, resulting in the loss and degradation of this habitat type.
- Changes in turbidity & impacts on coastal water quality – it is possible for sediment to be disturbed and released through construction activities and deliveries of material to site (e.g. dropping of rocks onto beach via barge). Despite *Mytilus edulis* being a species relatively tolerant to high levels of turbidity¹⁸, large increases in turbidity can reduce the levels of dissolved oxygen in the water column, resulting in decreases in respiration rate and the eventual closing of valve systems which can lead to mussel death¹⁹. It is unlikely that the proposed works would result in sediment disturbance large enough to impact on the *Mytilus edulis* present and any impact would be temporary, short-term and is not anticipated to cause any WFD quality element deterioration.

¹⁷ Roberts, et al., 2015. *Sensitivity of the mussel Mytilus edulis to substrate-borne vibration in relation to anthropogenically-generated noise*. Marine Ecology Progress (538).

¹⁸ Mainwaring, et al., 2014. *Assessing the sensitivity of Blue Mussels (Mytilus edulis) to pressures associated with human activities*. Joint Nature Conservation Committee.

¹⁹ Tang, B., & Riisgard, H.U., 2018. *Relationship between oxygen concentration, respiration and filtration rate in Blue Mussel Mytilus edulis*.

Potential Impacts – Construction Honeycomb Worm

These segments of reef structure are likely to be susceptible to direct effects from:

- Physical damage – the Scheme would result in the tracking of plant, machinery and personnel across the Site area in order to undertake construction. The use of the barge in the intertidal area and rock stockpiling provides the potential for physical damage to the *Sabellaria alveolata*. Additionally, under the Scheme modular ecological armouring units would be installed on the groyne structures to enhance the area for biodiversity. In order to install these structures approximately 1m³ of groyne structure would be required to be removed from the two central larger groynes. This would likely result in the permanent loss of some small patches of *Sabellaria alveolata* reef.

The potential for indirect effects on the reef structures include:

- Water pollution – given the nature of works, there is a risk of oil and fuel spills into the environment from machinery and vehicles in, and adjacent to the intertidal habitats, as well as from the barge and associated vessels. This release of pollutants could prove toxic to the polychaete worm that builds these honeycomb reef structures, resulting in the further loss and degradation of this habitat type.

Other than bioblock installation, the only works which would require plant to travel further north down the beach would be if the rock revetment delivery by barge with revetment deposited into shallow water at high tide. During barge delivery periods it is anticipated that there would be an increase in turbidity however this would be temporary and of short duration. Additionally the rock delivery would be made at high tide, reducing the distance plant or machinery would have to track across the intertidal area.

Mitigation Measures

- The core wintering bird season (October to March inclusive) would be avoided for the delivery of revetment rock via barge. This would avoid disturbance to SPA bird species and also would minimise the risk of standing time due to storms and safety/delay risks for moving boulders between barges by transshipment in bad weather.
 - Vessels present in the intertidal area of the Site at high tide (for the unloading of rock via barge) would not be allowed to drop anchor and instead barges would be guided and positioned by tugs or small support vessels. This would avoid any potential impact on mussel bed or Honeycomb Worm habitat as a result of coming into contact with anchors.
 - Delivery via barge and stockpiling would not be permitted in the area of the Blue Mussel bed or isolated patches of Honeycomb Worm located on intertidal sands/gravels.
 - Tracking of plant for the rock revetment construction would be undertaken within an approximate working buffer of 20-30m from the base of the proposed 30m deep revetment (approximate maximum of 50-60m from the sea wall), with tracking to occur only over the sparse section of mussel bed is absolutely unavoidable and avoidance of the dense section.
-

- A site walkover would be completed 6-8 weeks prior to construction by a marine ecologist to ensure any changes in area of mussel bed and Honeycomb Worm are recorded, the site environmental constraints plan is updated, and a suitable approach to tracking plant over the mussel bed is agreed.
- Toolbox talks with site workers and copies of the site environmental constraints plan to be made available.
- Vibropiling with a variable frequency control would be used and higher frequencies would be adhered to in order to reduce vibration effects;
- The unloading of rocks from the barge would be undertaken at high tide to reduce vibration effects; and
- Pollution prevention measures and contingency planning would be implemented through the CEMP to ensure these features are safeguarded during the works.

Habitats in the area would have adapted to the presence of rock revetments, which are present along much of the coastal frontage and would further adapt to additional revetments being proposed, which are on a small scale in the context of the entire water body. In addition, a number of ecological enhancements are proposed as part of the scheme which would have a beneficial impact on the habitats present.

Protected areas –
Bathing Waters

Overview

The Scheme is located within a Bathing Water area, which is sensitive to changes in water quality and a Bathing Water quality monitoring point is located to the immediate west of the red line boundary at Porth Eirias.

Potential Impacts

The revetment construction works would be completed at low tide, meaning that there would be limited potential for the generation of suspended sediments in relation to this activity.

The Scheme would not increase within the water body:

- Concentrations of pollution from sewage (specifically Intestinal enterococci and Escherichia coli as monitored by NRW throughout the Bathing Water season);
- Quantities or concentrations of water draining from populated areas;
- Concentration of domestic sewage; or
- Animals on beaches (during construction access to the beach would be prohibited for the general public including dog owners) which would result in a decrease in dog faeces deposition throughout construction within the Scheme area.

For rock revetment barge deliveries deposited into shallow water at high tide there would be a localised increase in turbidity at the time of delivery. However this would be temporary, intermittent and of short duration. Additionally, the long shore drift in this area would result in the movement of sediments to the east, away from Old Colwyn.

No – Residual effects of the Scheme on Bathing Waters are not considered to result in a deterioration of this WFD quality element when considering the mitigation already allowed for as discussed in the ES⁶.

	<p>Mitigation Measures</p> <ul style="list-style-type: none"> • Chemicals used for cleaning of the beach access points (stairs and slipways) must be specified to be non-hazardous to ensure that there is no adverse impact on sediment and water quality. • All necessary pollution prevention measures would be detailed in a CEMP during the construction phase to minimise potential adverse impacts on water quality. This detailed CEMP would be produced by the Contractor detailing the practical and necessary measures required during construction to prevent the pollution of the surrounding environment. • It should also be noted that there are a number of major Welsh Water sewers which run beneath the promenade. Without the Scheme, if the promenade should suffer severe damage during an extreme storm event, there is the risk that one of these services could rupture which would result in a major release of raw sewage directly onto the intertidal area (the Scheme would defend these assets). • The Contractor would produce a Transshipment Management Plan in consultation with CCBC, NRW and other local stakeholders prior to construction. This plan would detail any additional measures necessary. 	
Protected areas – Liverpool Bay SPA	<p>Overview Liverpool Bay SPA is designated for the wintering and breeding bird assemblages it supports.</p> <p>Impacts Impacts have been assessed in full in the HRA Screening Assessment (Appendix E).</p> <p>Mitigation Measures Mitigation has been proposed during the construction phase to avoid or minimise risk of impacts as follows:</p> <ul style="list-style-type: none"> • The CEMP would include best practice pollution prevention measures to minimise risk of habitat degradation through oil spills and increased turbidity; • Delivery of revetment by barge would be outside of October - March (the most sensitive period for wintering birds); and • Measures to minimise disturbance during works (directional lighting, vibropiling, toolbox talks to contractors, etc) would minimise disturbance from on-shore works. <p>Further enhancement measures are proposed to raise awareness of the importance of birds.</p>	No – Impacts of the Scheme on the SPA are not considered to be significant when considering the mitigation already allowed as discussed in the HRA Screening (Appendix E). A deterioration of this WFD quality element is not anticipated.
Water Quality - Phytoplankton	<p>According to NRW, blooms of the algae <i>Phaeocystis</i> do occur along this coastline during warm and calm weather in May and June. This typically produces a cream or brown coloured scum along the water's edge, but is otherwise harmless.</p> <p>The Scheme would not result in an increase in the amount of organic material being deposited into the water body and is not anticipated to result in any impact upon phytoplankton. The Biosecurity Risk Assessment (Appendix D) covers the import of materials from other sites into the intertidal area.</p> <p>A detailed CEMP would be produced by the Contractor detailing the practical and necessary measures required during construction to prevent the pollution of the surrounding environment.</p>	No – Residual effects of the Scheme on phytoplankton are not considered to result in a deterioration of this WFD quality element when considering the mitigation already allowed as discussed in the ES ⁶ .

Cumulative Effects

A full assessment of in-combination and cumulative effects has been completed as part of the Old Colwyn Coastal Defence and Active Travel Scheme Environmental Statement Volume 1 Chapter 16¹⁶. One development (not yet in planning but well defined and likely to proceed) has been identified:

- Colwyn Bay Waterfront project Phase 2b: Not yet in the planning system but known to be at outline design stage). This project forms part of the wider Colwyn Bay Waterfront Project for coastal defence remediation (repairs to the sea wall), beach recharge (understood to be from the location of Horizon Shine kiosk (approximate NGR 284880, 379374) westward to Rhos-on-Sea Harbour (approximate NGR 284253, 380450) and promenade enhancements for the western third of Colwyn Bay (approximately 1.3km in length in total of which ~850m comprise the sea wall and promenade improvements). The plans for this scheme are yet to be finalised and the construction timetable would be determined by availability and grant of funding. On this basis, it is assumed that there could be some overlap in the construction period between the Phase 2b scheme and the Scheme.

Potential Cumulative Construction Impacts and Additional Mitigation

- Cumulative effects from disturbance have been assessed under the HRA as no likely significant effect, following implementation of mitigation measures.
- If construction periods for both the Scheme and Phase 2b overlap, there is the potential for the increased generation of suspended solids and increased turbidity from the beach recharge Scheme which has the potential to affect Bathing Waters within Colwyn Bay. However the cumulative effects in relation to the Scheme are considered to be negligible given that Bathing Water areas within the respective red line boundaries would be closed to the public for the duration of works and long-shore drift is to the east away from the Old Colwyn Bathing Water area. The majority of impacts would result from the Phase 2b Scheme on the central (Phase 1 area) in isolation rather than in combination. The Phase 2b works would need to be designed to minimise and mitigate effects through the use of appropriate construction method statements and measures contained within the CEMP.

Potential Cumulative Operational Impacts and Additional Mitigation

- The Phase 2b scheme is proposed to have beach recharge as part of the outline design. It is considered that material from this scheme could be transported eastwards in line with the sediment transport patterns onto the Old Colwyn Coastal Defence and Active Travel scheme. This would be beneficial to maintaining existing beach levels along the frontage.
 - The combined Scheme would protect the wider promenade and vastly reduce the risks of severe damage and associated pollution events.
-

No – Residual cumulative effects of the Scheme when considered in combination with the Phase 2b scheme are not considered to result in a deterioration of this WFD quality element when considering the mitigation already allowed as discussed in the ES⁶.

6 Outcomes and Conclusions

6.1 Assessment Outcomes

In accordance with the NRW document “Guidance for assessing activities and projects for compliance with the Water Framework Directive” (OGN 72, 2018), the 3-Stage approach to Water WFD Assessment has been completed for the Scheme.

6.1.1 Stage 1 – Screening

The Stage 1 assessment determined that there are activities associated with the Scheme which have the potential to impact on water bodies within the vicinity, specifically the:

- Construction of 1.2km length of rock revetment connecting the existing Porth Eirias revetment in the west to the Splashpoint revetment in the east and associated extensions of outfalls through the revetment (including revetment deliveries by barge); and
- Construction of promenade access build out, associated fishing platform and access steps.

6.1.2 Stage 2 – Scoping

The Stage 2 assessment identified the North Wales Coastal Water body to be the only one likely to be impacted as a result of the scheme. The remaining water bodies considered were scoped out of the assessment at this stage. It was acknowledged that the North Wales Coastal Water Body is currently classified as ‘Heavily Modified’ as a result of existing coastal defences. Stage 2 also identified quality elements that are at risk from the proposed activities and required further assessment.

It was recognised that the Scheme could potentially impact upon WFD quality elements associated with the North Wales Water Body. Four quality elements were shortlisted as being at risk from the Scheme:

- Hydromorphology (further development for coastal protection);
- Priority habitats and species (higher sensitivity habitat: Blue Mussel and Honeycomb Worm reef patches within red line boundary);
- Water quality (phytoplankton status of Moderate); and
- Protected areas (Liverpool Bay SPA, Colwyn Bay Bathing Waters).

6.1.3 Stage 3 – Detailed Compliance

The Stage 3 assessment considered the potential impacts of the Scheme activities on the WFD quality elements, identified ways to avoid or minimise impacts, and concluded if the activity may prevent any WFD quality element within any WFD water body achieving good status/potential or may cause deterioration.

The assessment found that given:

- The mitigation already incorporated into the Scheme for hydromorphology; and
- The relatively small scale of works in the context of the WFD water body as a whole;

Residual effects on the WFD water body were not considered to cause deterioration of the WFD water body status.

Mitigation measures already incorporated into the Scheme also resulted in effects relating to priority habitats and species and Bathing Waters being assessed as not causing deterioration. A separate HRA Screening Assessment determined that there would be no significant adverse effects on the effects on the features of the Liverpool Bay SPA. No phytoplankton effects were found to be associated with the Scheme. The assessment of cumulative effects also concluded no deterioration when considering the combined effects of the Scheme alongside the proposed Colwyn Bay Waterfront Project Phase 2b works.

6.2 Marine Biodiversity Enhancement

The Scheme has been identified as having potential for ecological enhancement which has been integrated into Scheme design from the earliest opportunity.

Two key areas of ecological enhancement have been chosen through discussions between Mott MacDonald marine biologists and ornithologists in consultation with CCBC as being of optimum value given the locations of bird species and the potential for ecological connectivity. The first is located between Porth Eirias and the access build out and the second to the immediate west of Splashpoint (this area also has the advantage of providing links with improved fish habitat for local anglers). Each of the two areas would include:

- Placement of 3 clusters of 3 tidal pools; and
- Localised enhancement of approximately 80m of enhanced rock revetment (25-30% enhanced rock) in the lower intertidal revetment area (around 3.6m width). The rock enhancement would comprise adding areas of rock with more complex surfacing to encourage colonisation.

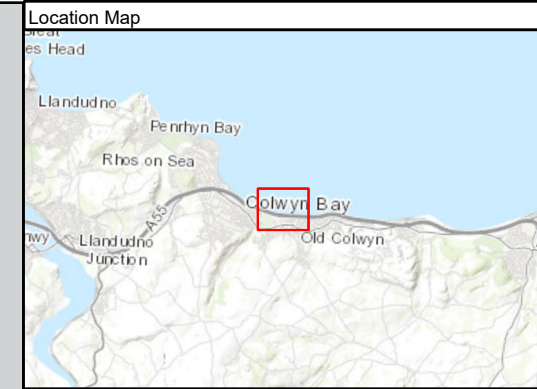
In addition the following would also be implemented:

- Enhancement of the three longer groyne structures with the placement of two ecological armouring unit habitats (bioblocks or similar) per groyne close to the low tide mark;
- The installation of 'Vertipool' features to retain water on vertical surfaces at lower tidal states at the south walls of the stepped access points and the north face of the ramp at the access build-out; and
- The enhancement of outer wall finishes along the intertidal sections of the perpendicular access steps and outer walls of the access buildout to provide greater complexity and improved potential for colonisation.

6.3 Conclusions

This WFD Assessment has found that, when considering the mitigation already proposed, the Scheme is very unlikely to affect the WFD status or cause any deterioration of the WFD quality elements for the North Wales Coastal Water Body. The potential for marine biodiversity enhancement has been identified and built into the Scheme design.

A. Red Line Boundary and Area of Permanent Construction Drawings



Key to Symbols

Red line boundary

Notes

- 1. For information only, not for construction.
- 2. Contains Ordnance Survey data © Crown copyright and database rights 2019 Ordnance Survey. All rights reserved.
- 3. Contains OS data © Crown Copyright and database right 2020 Contains data from OS Zoomstack, Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

P1	23/07/20	MH	For information	NS	CW
Rev	Date	Drawn	Description	Ch'k'd	App'd

M M
MOTT MACDONALD

Mott MacDonald House
 5 Woodland Road West
 Colwyn Bay
 LL29 7DH
 T +44 (0)2920 467800
 W www.mottmac.com

Client

CONWY
 CYNOR IWRDISTREF SIROL
 COUNTY BOROUGH COUNCIL

Conwy County Borough Council

Title
 Old Colwyn Coastal Defence and Active Travel Scheme
 Anticipated principal working area buffer (approximate only)
 Red Line Boundary

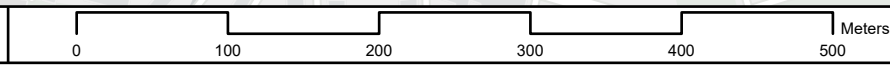
Designed	N Spofforth	NS	Eng. Check	N Spofforth	NS
Drawn	M Hayward	MH	Coordination	N Spofforth	NS
GIS Check	G O'Donovan	GO	Approved	C Williams	CW

Scale at A3	Status	Rev	Security
1:5,000	INF	P1	STD

Drawing Number
415437-MMD-00-XX-DR-N-1707



© Mott MacDonald Ltd.
 This document is issued for the party which commissioned it and for specific purposes connected with the captioned project only. It should not be relied upon by any other party or used for any other purpose.
 We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.





Key to Symbols

- Red line boundary
- Area of permanent construction
- Ecological enhancements only

Notes

1. For information only, not for construction.
2. Contains Ordnance Survey data © Crown copyright and database rights 2019 Ordnance Survey. All rights reserved.
3. Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

P1	23/07/20	SA	For information	NS	CW
Rev	Date	Drawn	Description	Ch'k'd	App'd

M MOTT MACDONALD

Mott MacDonald House
5 Woodland Road West
Colwyn Bay
LL29 7DH
T +44 (0)2920 467800
W www.mottmac.com

Client

CONWY
CYNOR IWRDREISTREF SIROL
COUNTY BOROUGH COUNCIL

Conwy County Borough Council

Title Old Colwyn Coastal Defence and Active Travel Scheme
Area of Permanent Construction

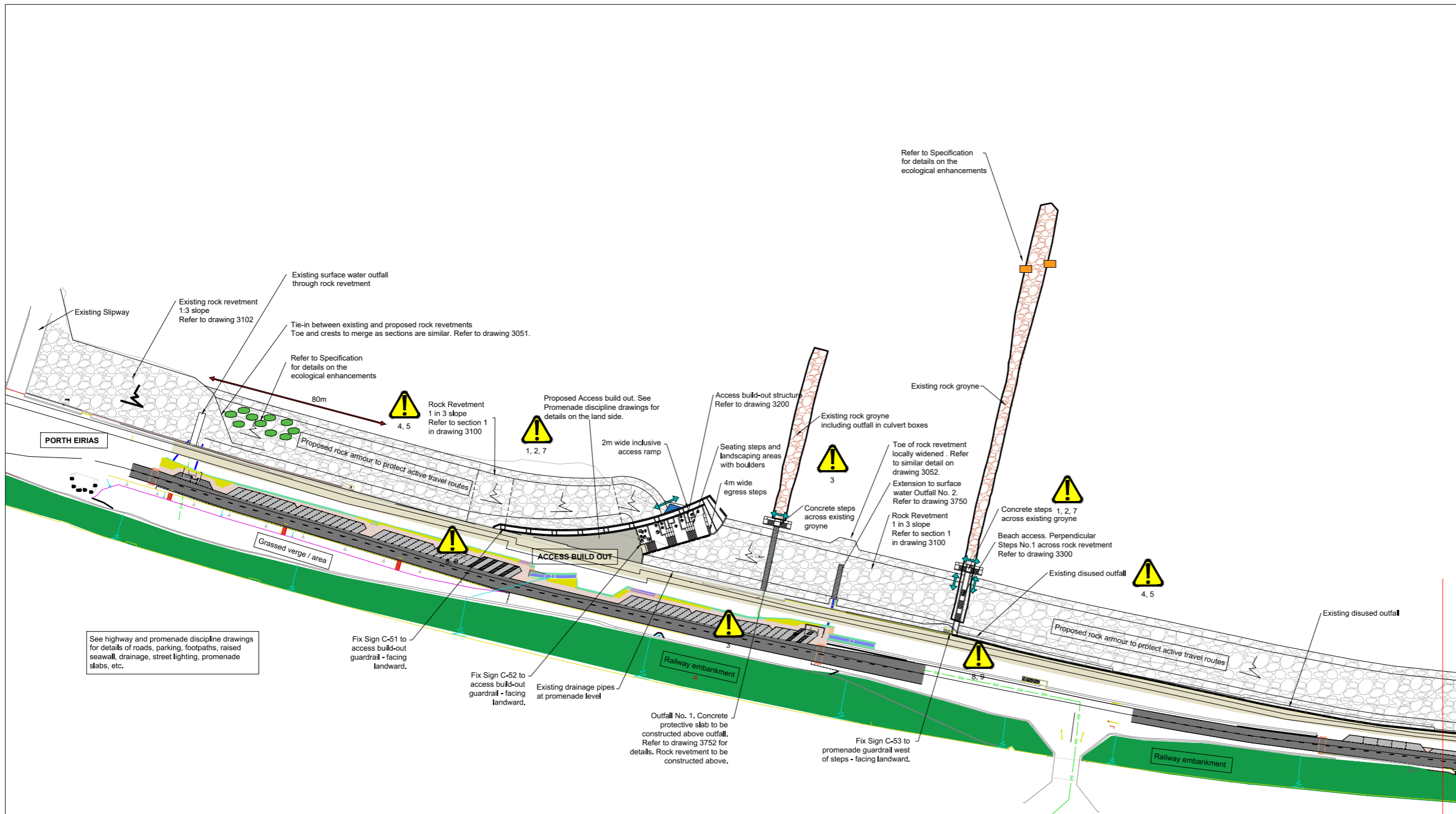
Designed	N Spofforth	NS	Eng. Check	N Spofforth	NS
Drawn	S Anstice	SA	Coordination	N Spofforth	NS
GIS Check	G O'Donovan	GO	Approved	C Williams	CW

Scale at A3	Status	Rev	Security
1:5,000	INF	P1	STD

Drawing Number
415437-MMD-00-XX-DR-N-1708



B. Scheme Drawings



Location Plan - Area 1
1:1000

Safety, Health & Environmental Information

It is assumed that all works will be carried out by a competent contractor working, where appropriate, to an approved method statement.

⚠ In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following risks and information:

CONSTRUCTION

- 1 Depth and full extent of existing seawall foundations are unknown. Existing seawall becomes destabilised (DHER Ref. 19 & 23).
- 2 Unforeseen ground conditions/obstructions prevent sheet piles being driven (DHER Ref. 20).
- 3 The status (i.e. disused or live) and precise positions of some outfalls are unknown (DHER Ref. 21).
- 4 Falling from height. Falling objects from promenade (DHER Ref. 22).
- 5 Working in tidal zone (DHER Ref. 27).
- 6 Presence of Unexploded ordnances (UXOs). Site area categorised as low risk. (DHER Ref. 30).

OPERATION AND MAINTENANCE

- 7 Beach levels to be reinstated to existing levels or higher after completion of works. Beach levels shall be monitored at regular intervals including before and after storms and at least once a year in spring (DHER Ref. 4).
- 8 Marine growth to be removed periodically from pedestrian access surfaces (DHER Ref. 5).

- Notes**
1. This drawing is to be read in conjunction with all discipline drawings, specifications and standards.
 2. Unless otherwise noted (UNO), all dimensions are in millimetres, all levels are in meters above ordnance datum (AOD), and all setting-out points in millimeters to the British National Grid (OSGB36). Do not scale from drawing, if in doubt ask.
 3. All relevant setting-out points, dimensions & levels are to be checked by Contractor on-site prior to commencement of the works.
 4. The onshore topographical survey was supplied by Survey Operations Ltd in April 2008. The offshore topographical (beach) survey was supplied by Environmental & Engineering Services in 2019. The CCTV survey was supplied by Invek Surveys Ltd in May 2020.
 5. Drawings show approximate position of known services. See Site Information for further information. Further unknown services maybe present. Contractor to undertake survey to determine full extent of services present within working area. Results to be forwarded to the Structural Design Engineer 2 week prior to commencement of works, or ordering of materials, whichever occurs first.
 6. See 415437-MMD-00-XX-DR-C-2000 series drawings for the proposed promenade works. See 415437-MMD-00-XX-DR-D-0000 to 1399 series drawings for the proposed highway & drainage works.
 7. Refer to Appendix 12/1 of the Works Specification for all the sign details.

Key to symbols

	Existing railway embankment		Rock structures
	Proposed extent of highway		Fishing platform
	Group of 5 Vertipools fixed to wall		Outfall extension/protection
	Textured outer walls		Tidal pools
	Enhancement of rocks		Ecological Armouring unit

- Reference drawings**
- 415437-MMD-00-XX-DR-C-3051 - Plan at Porth Eirias End
 - 415437-MMD-00-XX-DR-C-3052 - Plan at Splash Point End
 - 415437-MMD-00-XX-DR-C-3100 - Retevment Cross Sections - Sheet 1 of 3
 - 415437-MMD-00-XX-DR-C-3102 - Retevment Cross Sections - Sheet 3 of 3
 - 415437-MMD-00-XX-DR-C-3200 - Access Build-Out Plan
 - 415437-MMD-00-XX-DR-C-3300 - Perpendicular Steps No.1 Plan
 - 415437-MMD-00-XX-DR-C-3750 - Outfall Extensions and Culvert Cross Sections
 - 415437-MMD-00-XX-DR-C-3752 - Outfall No. 1 Protection Details
 - 415437-MMD-00-XX-DR-C-2000 series - Promenade Works
 - 415437-MMD-00-XX-DR-D-0000 to 1399 series drawings - Highway and Drainage Works
 - 19.537 - 100 Old Colwyn GA Landscape Drawing

Rev	Date	Drawn	Description	Ch'k'd	App'd
P05	17/07/20	AA	Construction Issue for Client Approval	AD	ZH
P04	26/06/20	AA	Construction Issue for Client Approval	AD	ZH
P03	27/04/20	ZD	Tender Issue for Client Comments	AD	ZH
P02	25/03/20	ZD	Second Issue for Internal Comments	AD	ZH
P01	12/03/20	ZD	First Issue for Comments	AD	ZH

Status Stamp

MOTT MACDONALD

Mott MacDonald House
5 Woodland Road West
Colwyn Bay
LL29 7DH
United Kingdom
T +44 (0)1492 534601
F +44 (0)1492 533063
W www.mottmac.com

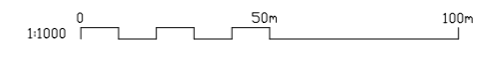
Client

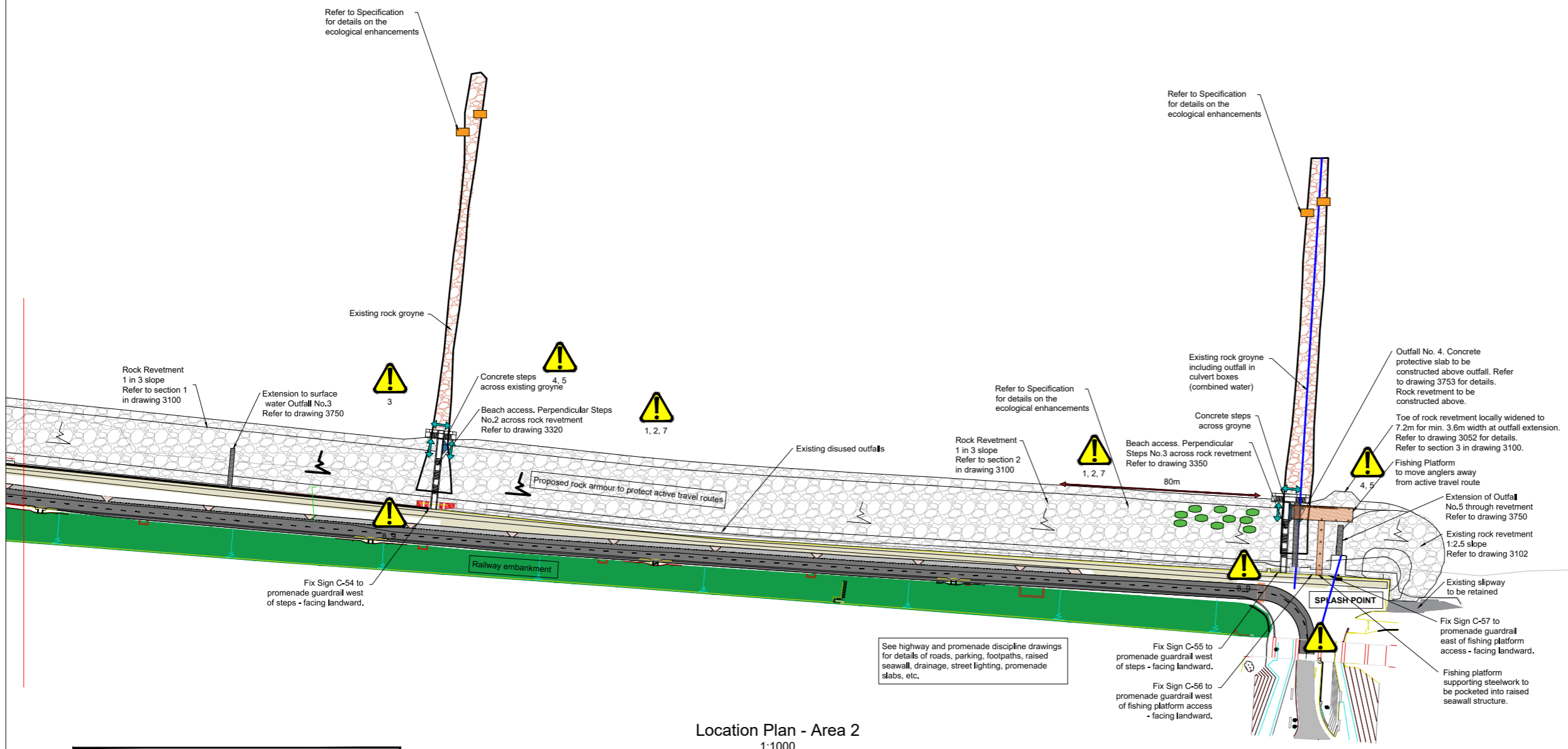
Title

Old Colwyn Promenade Coastal Defence & Active Travel Improvements

General Arrangement Plan - Area 1
Sheet 01 of 02

Designed	P. Kacperek	PK	Eng check	A Douglas	AD
Drawn	A. Al-Abdullah	AA	Coordination	F. Loy	FL
Dwg check	D. Sciuto	DS	Approved	Z. Hutchison	ZH
MMD Project Number	Scale at A1			Security	
415437	1:1000			STD	
Suitability Description	Issue for Construction Approval			Suit. Code	S4
Drawing Number	415437-MMD-00-XX-DR-C-3001			Revision	P05





Location Plan - Area 2
1:1000

Safety, Health & Environmental Information

It is assumed that all works will be carried out by a competent contractor working, where appropriate, to an approved method statement.

⚠ In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following risks and information:

CONSTRUCTION

- Depth and full extent of existing seawall foundations are unknown. Existing seawall becomes destabilised (DHER Ref. 19 & 23).
- Unforeseen ground conditions/obstructions prevent sheet piles being driven (DHER Ref. 20).
- The status (i.e. disused or live) and precise positions of some outfalls are unknown (DHER Ref. 21).
- Falling from height. Falling objects from promenade (DHER Ref. 22).
- Working in tidal zone (DHER Ref. 27).
- Presence of Unexploded ordnances (UXOs). Site area categorised as low risk. (DHER Ref. 30).

OPERATION AND MAINTENANCE

- Beach levels to be reinstated to existing levels or higher after completion of works. Beach levels shall be monitored at regular intervals including before and after storms and at least once a year in spring (DHER Ref. 4).
- Marine growth to be removed periodically from pedestrian access surfaces (DHER Ref. 5).

- Notes**
- This drawing is to be read in conjunction with all discipline drawings, specifications and standards.
 - Unless otherwise noted (UNO), all dimensions are in millimetres, all levels are in meters above ordnance datum (AOD), and all setting-out points in millimeters to the British National Grid (OSGB36). Do not scale from drawing, if in doubt ask.
 - All relevant setting-out points, dimensions & levels are to be checked by Contractor on-site prior to commencement of the works.
 - The onshore topographical survey was supplied by Survey Operations Ltd in April 2008. The offshore topographical (beach) survey was supplied by Environmental & Engineering Services in 2019. The CCTV survey was supplied by Invek Surveys Ltd in May 2020.
 - Drawings show approximate position of known services. See Site Information for further information. Further unknown services maybe present. Contractor to undertake survey to determine full extent of services present within working area. Results to be forwarded to the Structural Design Engineer 2 week prior to commencement of works, or ordering of materials, whichever occurs first.
 - See 415437-MMD-00-XX-DR-C-2000 series drawings for the proposed promenade works. See 415437-MMD-00-XX-DR-D-0000 to 1399 series drawings for the proposed highway & drainage works.
 - Refer to Appendix 12/1 of the Works Specification for all the sign details.

Key to symbols

Existing railway embankment	Rock structures
Proposed extent of highway	Fishing platform
Group of 5 Vertipools fixed to wall	Outfall extension/protection
Textured outer walls	Tidal pools
Enhancement of rocks	Ecological Armouring unit

- Reference drawings**
- 415437-MMD-00-XX-DR-C-3052 - Plan at Splash Point End
 - 415437-MMD-00-XX-DR-C-3100 - Revetment Cross Sections - Sheet 1 of 3
 - 415437-MMD-00-XX-DR-C-3102 - Revetment Cross Sections - Sheet 3 of 3
 - 415437-MMD-00-XX-DR-C-3320 - Perpendicular Steps No. 2 Plan
 - 415437-MMD-00-XX-DR-C-3350 - Perpendicular Steps No. 3 Plan
 - 415437-MMD-00-XX-DR-C-3450 - Fishing Platform Plan
 - 415437-MMD-00-XX-DR-C-3750 - Outfall and Culvert Cross Sections
 - 415437-MMD-00-XX-DR-C-3753 - Outfall No.4 Protection Details
 - 415437-MMD-00-XX-DR-C-2000 series - Promenade Works
 - 415437-MMD-00-XX-DR-D-0000 to 1399 series drawings - Highway and Drainage Works
 - 19.537 - 100 Old Colwyn GA Landscape Drawing

Rev	Date	Drawn	Description	Ch'k'd	App'd
P05	17/07/20	AA	Construction Issue for Client Approval	AD	ZH
P04	26/06/20	AA	Construction Issue for Client Approval	AD	ZH
P03	28/04/20	ZD	Tender Issue for Client Comments	AD	ZH
P02	13/04/20	ZD	Second Issue for Internal Comments	AD	ZH
P01	12/03/20	ZD	First Issue for Comments	AD	ZH

Status Stamp

MOTT MACDONALD

Mott MacDonald House
5 Woodland Road West
Colwyn Bay
LL29 7DH
United Kingdom
T +44 (0)1492 534601
F +44 (0)1492 533063
W www.mottmac.com

Client

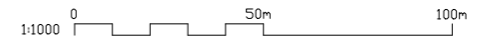
CONWY
CYNGOR BWRDEISTREF SIROL
COUNTY BOROUGH COUNCIL

Title

Old Colwyn Promenade Coastal Defence & Active Travel Improvements General Arrangement Plan - Area 2

Sheet 02 of 02

Designed	P. Kacperek	PK	Eng check	A. Douglas	AD
Drawn	A. Al-Abdullah	AA	Coordination	F. Loy	FL
Dwg check	D. Sciuto	DS	Approved	Z. Hutchison	ZH
MMD Project Number	Scale at A1			Security	
415437	1:1000			STD	
Suitability Description	Issue for Construction Approval				Suit. Code
					S4
Drawing Number	415437-MMD-00-XX-DR-C-3002				Revision
					P05



C. Phase 1 Habitat Plan



Key to Symbols

- Target note
- Phase boundaries
- Trees with low bat potential
- Honeycomb Worm Reef - sparse (approximate location)
- A3.1 - Broadleaved parkland/scattered trees
- A2.1 - Scrub - dense/continuous
- A3.1 - Broadleaved parkland/scattered trees
- B6 - Poor semi-improved grassland
- C1.1 - Bracken - continuous
- G1.6 - Standing water - brackish
- H1.1 - Intertidal - mud (approximate location)
- H1.1 - Intertidal - sand
- H1.2 - Intertidal - shingles/cobbles (approximate location)
- H1.3 - Intertidal - boulders/rocks (Groynes and man-made features)
- J1.2 - Cultivated/disturbed land - amenity grassland
- J3.5 - Artificial sea wall
- J3.6 - Buildings & infrastructure
- J5 - Hardstanding
- Mussel bed - dense (approximate location)
- Mussel bed - sparse (approximate location)

Notes

1. For information only, not for construction.
2. Contains Ordnance Survey data © Crown copyright and database rights 2019 Ordnance Survey. All rights reserved. Mott Macdonald OS License: 0100026791.
3. Contains public sector information licensed under the Open Government Licence v3.0.
4. Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
5. Phase 1c beach recharge extended into the Phase 2b area while transitioning back to existing beach levels and Phase 2a promenade improvements straddled the Phase1 and Phase2 boundary.

P5	23/07/20	SA	For information	NsS	JB
Rev	Date	Drawn	Description	Ch'k'd	App'd

MOTT MACDONALD

Mott MacDonald
2 Callaghan Square
Cardiff
CF10 5BT
T +44 (0)2920 467800
W www.mottmac.com

Client

CONWY
CYNGOR BWRDEISTREF SIRIOL
COUNTY BOROUGH COUNCIL

Conwy County Borough Council

Title Old Colwyn Coastal Defence and Active Travel Scheme
Phase 1 Habitat Survey

Designed	L Woolley	LW	Eng. Check	N Spofforth	NS
Drawn	S Anstice	SA	Coordination	L Woolley	LW
GIS Check	H Wheldon	HW	Approved	J Bates	JB

Scale at A3	Status	Rev	Security
1:10,000	INF	P5	STD

Drawing Number
415437-MMD-00-XX-DR-N-1713



D. Biosecurity Risk Assessment



Old Colwyn Coastal Defence and Active Travel Scheme

Bio-Security Risk Assessment

July 2020

Mott MacDonald
Mott MacDonald House
5 Woodland Road West
Colwyn Bay LL29 7DH
United Kingdom

T +44 (0)1492 534601
mottmac.com

Conwy County Borough
Council Environment,
Roads & Facilities
Swyddfeydd Mochdre,
Ffordd Conway,
Mochdre,
Bae Colwyn,
LL28 5AB

Old Colwyn Coastal Defence and Active Travel Scheme

Bio-Security Risk Assessment

July 2020

Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
P01	23/07/2020	E. Haggett	R. Byrne N. Spofforth	C. Williams	First issue

Document reference: 417437-MMD-00-XX-RP-N-1722

Information class: Standard

This document is issued for the party which commissioned it and for specific purposes connected with the above-captioned project only. It should not be relied upon by any other party or used for any other purpose.

We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

This document contains confidential information and proprietary intellectual property. It should not be shown to other parties without consent from us and from the party which commissioned it.

Contents

1	Introduction	3
1.1	Overview	3
1.2	Terrestrial INNS	3
1.3	Marine INNS	3
1.3.1	High Risk INNS	4
1.3.2	Medium Risk INNS	4
2	Bio Security Risk Assessment	1
A.	Bio-Security Risk Assessment Scoring Matrix	1

1 Introduction

1.1 Overview

This Bio Security Risk Assessment (BSRA) document has been produced in support of the Old Colwyn Coastal Defence and Active Travel Scheme (hereafter referred to as “the Scheme”).

This BSRA outlines the potential hazards relating to the introduction and spread of invasive and non-native species (INNS) on site for the Scheme. The Scheme will involve working on land, within the intertidal zone and it also may require the delivery of revetment rock by ship and barge. As a result, INNS relating to the terrestrial and marine environments have been considered.

Prior to implementing this risk assessment on site, a site briefing and a toolbox talk should be provided to all site workers regarding the importance of bio security. The required inspection, preventative and management techniques for personnel should be outlined and pest/containment identification should also be explained to ensure rapid and appropriate responses to any INNS present, (if INNS are found on site, the Ecological Clerk of Works (ECoW) should be notified and guidance should be sought with statutory agencies). An ecological walkover survey should be undertaken on site approximately 6-8 weeks prior to the construction phase commencing. This will provide an opportunity to confirm any new occurrences of INNS on site and for these to be managed suitably prior to works starting.

Formal standardised reporting to Natural Resources Wales (NRW) should be implemented on site throughout the duration of the works regarding the presence of INNS should any be discovered.

1.2 Terrestrial INNS

A Preliminary Ecological Appraisal Report has been produced for the Scheme¹, along with other subsequent assessments (both terrestrial and intertidal) for which a number of field surveys were undertaken from December 2019 to June 2020. During these surveys no invasive plant species were discovered on site. However, it is noted that INNS can be introduced into the site through poor bio-security protocols and construction practice, so a precautionary approach for the management of terrestrial INNS on site is outlined in Section 2.

1.3 Marine INNS

It should be noted that to date no site visit has been undertaken by a marine ecologist (visits were planned but these had to be cancelled due to the Covid-19 pandemic). Instead comprehensive high definition (HD) photographic evidence taken by an experienced local environmental consultant has been reviewed by a qualified marine ecologist to establish marine species present on site. It was not possible to confirm the presence/absence of marine INNS from these photographs. However, due to the potential delivery of revetment rock to the site via barge, precautionary measures to manage potential INNS within the marine environment need to be outlined.

The Marine Strategy Framework Directive (MSFD) (2008) outlines a monitoring list for INNS. These INNS listed by the MSFD are further outlined within the “Priority Monitoring and Surveillance List of Marine INNS for Wales”² and have been categorised into “High Risk” and “Medium Risk”

¹ Colwyn Bay Preliminary Ecological Appraisal Report (Ref: 410895-MMD-N-R-00-XX-1701), Mott MacDonald Ltd, 2020.

² Gov.Wales (2017). *Marine Invasive Non-Native Species Priority Monitoring and Surveillance List for Wales*. [Online] Available at: <https://gov.wales/sites/default/files/publications/2018-02/invasive-aquatic-species-priority-marine-species.pdf>

INNS. A “Low Risk” category also exists, but there are not INNS considered to require monitoring by the MSFD.

The “High” and “Medium” risk INNS listed by the MSFD have been reviewed and INNS from these categories that are believed to have the potential to interact with the site as a result of the delivery of revetment rock via barge have been considered for this BSRA. These species considered for this risk assessment are outlined below:

1.3.1 High Risk INNS

- Compass sea squirt (*Asterocarpa humilis*) – potential for introduction through fouling;
- Carpet sea squirt (*Didemnum vexillum*) – potential for introduction through fouling;
- Chinese mitten crab (*Eriocheir sinensis*) – potential for introduction through ballast water; and
- Red ribbon bryozoan (*Watersipora subatra*) – potential for introduction through fouling.

1.3.2 Medium Risk INNS

- Bonnemaison’s hook weed (*Bonnemaisonia hamifera*) – potential for introduction through fouling and ballast water;
- Japanese skeleton shrimp (*Caprella mutica*) – potential for introduction through fouling;
- Orange striped anemone (*Diadumene lineata*) – potential for introduction through fouling;
- Japanese wireweed (*Sargassum japonica*) – potential for introduction through fouling;
- Leathery sea squirt (*Styela clava*) – potential for introduction through fouling; and
- Wakame, Asian kelp (*Undaria pinnatifida*) – potential for introduction through fouling.

2 Bio Security Risk Assessment

The BSRA scoring methodology is presented in Appendix A

The risk assessment in **Error! Reference source not found.** outlines the potential hazards of the Scheme associated with the introduction, transfer and spread of INNS. This risk assessment should be included within the Construction Environmental Management Plan (CEMP). As outlined above, this risk assessment is precautionary as it relies upon records of INNS within and near to the site.

Table 2.1: BSRA for the Scheme (risk is the transfer and introduction of INNS)

Hazard	Who or What Might be Affected?	Initial Assessment			Risk Control Measures	Residual Risk		
		Severity	Likelihood	Assessed Risk		Severity	Likelihood	Assessed Risk
Land Based Plant								
Machinery access	Where access points are varied and/or used on a number of occasions, the risk of pathogen transfer/introduction will increase.	4	H	JA	The number of vehicles used on site and the frequency at which they enter the intertidal area should be limited (vehicles should only enter the intertidal area on an ebb tide when there is a suitable dry area available for working). Tracking of vehicles across the intertidal zone will remain within a strict working buffer of 20m from the rock revetment (which is 30m wide, so in total a buffer of 50m from the seawall will be adhered to).	2	L	A
Use of land-based plant on the foreshore	Heavy lifting plant will be used in the intertidal zone to collect revetment rock delivered by the barges once the tide has receded. This provides the opportunity for the spread of INNS across the intertidal area.	4	M	AR	Sections of the plant that would come into direct contact with the intertidal area (track/wheels) should be thoroughly cleaned before and after use to avoid the spread of any INNS. This will also prevent potential spread from the Scheme's site area into other sites that may be used after the Scheme's construction is completed.	3	L	A

Hazard	Who or What Might be Affected?	Initial Assessment			Risk Control Measures	Residual Risk		
		Severity	Likelihood	Assessed Risk		Severity	Likelihood	Assessed Risk
Machinery origins/ previous works	Machinery travelling or having previously worked on different sites has the potential to introduce non-native or non-localised species to site.	4	H	JA	A stringent system of vehicle maintenance and cleanliness should be implemented during construction works, including frequent vehicle washing between road and beach access. A CEMP should be adhered to and available on site and NRW Pollution Prevention Guidelines should be followed.	3	M	AR
Promenade works	Material used to raise and widen the promenade may introduce alien species or spread existing species and/or pathogens on site.	3	H	AR	Existing material will be reclaimed as far as possible, therefore the risk of introduction of invasive species is considered low.	2	L	A
PPE – contractor staff, operatives and sub-contractors	PPE can collect contaminants including mud, seeds, pathogens etc. which can easily be transferred to and between sites.	4	VH	JA	All PPE especially footwear, Velcro closures, gloves, etc. should be thoroughly inspected and cleaned and inspected before arrival on site. Boot washing as well as equipment cleaning facilities (with a biocide such as Virkon) should be provided and carried out when entering and exiting site. Ideally equipment should then be allowed to dry for 48 hours before it is used elsewhere (a different site). Transfer between work areas on site should be avoided and minimised where possible.	3	M	AR
Marine Vessels / Marine Plant								
Ballast water	It is currently anticipated that the rocks required for the construction of the revetment on site may be transported by ship from Norway. There may be a requirement for these ships to take on board ballast waters from seas of different nations and to then dispose of these in	4	H	JA	All vessels and associated staff must ensure adherence to the Ballast Water Management Convention, 2017 for each vessel required for the works. This legislation outlines the requirements for each vessel to have a ballast water management plan, a ballast water record book and an international ballast water management certificate. Vessels should have a on-board ballast water treatment system, if this is not possible then ballast water should be	3	L	A

Hazard	Who or What Might be Affected?	Initial Assessment			Risk Control Measures	Residual Risk		
		Severity	Likelihood	Assessed Risk		Severity	Likelihood	Assessed Risk
	UK waters (and vice versa). This could result in the spread of INNS in the form of marine microbes, plants and animals (such as Carpet sea squirt (<i>Didemnum vexillum</i>) larvae).				exchanged mid-ocean and not near the shoreline of the site.			
Anchorage	Anchors used for the mooring of vessels pose the opportunity for bio-fouling and introduction of INNS to the site when lowered to the seabed.	3	L	A	Only the larger ships that contain the delivery of the revetment rock will be allowed to drop anchor. These ships will be moored off-site, outside of the site boundary. Barges will be held in place by tugs which are self-propelled and so these will not require anchorage within the intertidal zone. Anchors for vessels used on site should be cleaned when the opportunity arises (e.g. at port or when refuelling) to minimise cross contamination between sites. It should be noted that the anchor will provide a relatively small opportunity for cross site contamination in comparison to other hazards listed in this risk assessment.	2	L	A
Bio-fouling of revetment rock	If revetment rocks delivered on site have been reused from other projects or have spent prolonged periods of time in the marine environment, they may already be colonised to marine INNS which would then be introduced to the site.	4	M	AR	Revetment rock delivered to site should preferably be virgin material and not consist of rocks used for previous coastal defence schemes that may have spent prolonged periods of time in coastal waters. Rocks should also be clean prior to introduction into the intertidal zone on site.	2	L	A
Bio-fouling (ships, barges and tugs used)	It is possible for the hulls of ships, barges and tugs used on site to be fouled by INNS such as algae,	4	M	AR	All vessels used on site should ensure they have a copy of their Bio-fouling Management Plan on board with clear information outlining efforts to reduce bio-fouling of the vessel, e.g.	4	L	AR

Hazard	Who or What Might be Affected?	Initial Assessment			Risk Control Measures	Residual Risk		
		Severity	Likelihood	Assessed Risk		Severity	Likelihood	Assessed Risk
for revetment deliveries).	barnacles, sea squirts. This presents an opportunity to introduce INNS to site and to other waters (e.g. from UK waters at Colwyn Bay to Norwegian waters where revetment rock is obtained).				through anti-fouling treatments or use of biocides.			
Bio-fouling of groynes	It should be noted that in order to install the ecological armouring units (ecological enhancements for the Scheme), sections of the existing groyne structures will be required to be removed to fit these in place. It is possible that if these sections of removed groyne are re-used on other projects, there could be a cross contamination of INNS from the Scheme area to other locations as the groyne structures could be fouled.	3	M	AR	Once removed, the sections of groyne should be disposed of suitably on land and should not be disposed of or reused within the marine environment.	3	VL	A

A. Bio-Security Risk Assessment Scoring Matrix

Table A.1: Bio-Security Risk Assessment Scoring Matrix

Biosecurity Severity or Consequence					
1 = Slight – no measurable consequence					
2 = Minor – slight impact, small scale, easily contained					
3 = Moderate – damage recoverable, moderate impact					
4 = Permanent – considerable damage, long term impacts on native flora and/or fauna					
5 = catastrophic – major damage, threat to species					
Likelihood					
VL = Improbable – unlikely to occur					
L = Remote – unlikely but possible					
M = Occasional – possible at some time					
H = Probable – likely to occur several times					
VH = Frequent – likely to occur many times					
Acceptability of assessed risks					
UA = Unacceptable (action essential)					
AR = Action required (if reasonably practical)					
A = Acceptable (manage risk)					
N = Negligible					
Assessed risk					
	Severity				
Likelihood	1	2	3	4	5
VL	N	N	A	A	A
L	N	A	A	AR	AR
M	A	A	AR	AR	UA
H	A	AR	AR	UA	UA
VH	A	AR	UA	UA	UA

Source: Mott MacDonald, 2015



E. HRA Screening Assessment



Old Colwyn Coastal Defence and Active Travel Scheme

Habitats Regulations Assessment - Report to
Inform an Appropriate Assessment

July 2020

Mott MacDonald
Mott MacDonald House
5 Woodland Road West
Colwyn Bay LL29 7DH
United Kingdom

T +44 (0)1492 534601
mottmac.com

Conwy County Borough
Council: Environment,
Roads & Facilities
Swyddfeydd Mochdre
Ffordd Conway
Mochdre
Bae Colwyn
LL28 5AB

Old Colwyn Coastal Defence and Active Travel Scheme

**Habitats Regulations Assessment - Report to
Inform an Appropriate Assessment**

July 2020

Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
A	23/07/2020	L Woolley	N Shelton	C Williams	First Issue

Document reference: 417437-MMD-00-XX-RP-N-1726

Information class: Standard

This document is issued for the party which commissioned it and for specific purposes connected with the above-captioned project only. It should not be relied upon by any other party or used for any other purpose.

We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

This document contains confidential information and proprietary intellectual property. It should not be shown to other parties without consent from us and from the party which commissioned it.

Contents

1	Introduction	1
1.1	Background and Site Location	1
1.2	Purpose and Structure of this Report	2
1.3	Ecologist Qualifications	3
2	Project Description	4
2.1	Scheme Description	4
2.2	Proposed Works Methodology and Programme	4
2.2.1	Construction	4
2.2.2	Operation	5
2.2.3	Decommissioning	5
3	HRA Framework and Study Area	6
3.1	HRA Framework	6
3.2	Study Area	7
4	Ecology Baseline	8
4.1	Site Description and Context	8
4.2	Assessment of Bird Assemblage	9
4.2.1	Common Scoter	9
4.2.2	Red-throated Diver	12
4.2.3	Little Gull	12
4.2.4	Common and Little tern	13
4.2.5	Waterbird assemblage	13
5	Screening Assessment	16
5.1	Identification of Sites	16
5.2	Assessment of Impact Pathways	16
5.3	Screening Assessment	17
6	Mitigation	21
6.1	Embedded Mitigation Measures	21
6.2	Secondary (Additional) Mitigation	21
7	Appropriate Assessment	22
7.1	Appropriate Assessment	22
7.1.1	Assessment of the Project Alone	22
7.1.2	In-combination Assessment	22

8	Conclusions	25
9	References	26
A.	International Designations within 2.0km	27
B.	HRA Process	29
C.	WeBS Raw Data	30
D.	Distribution Maps (JNCC Report Extracts)	37

[Click or tap here to enter text.](#)

1 Introduction

1.1 Background and Site Location

Mott MacDonald Limited is advising on ecology matters relating to the proposed 'Old Colwyn Coastal Defence and Active Travel Scheme' in Colwyn Bay (see Figures 1.1 and 1.2 for Site Location).

Figure 1.1: Overview Site location



Source: DigitalGlobe, Microsoft, Earthstar Geographics | Esri UK, Esri, HERE, Garmin, METI/NASA, USGS

The Victorian built coastal defences around Colwyn Bay from Rhos-on-Sea in the west to Old Colwyn in the east have suffered from undermining, corrosion, partial collapses and degradation with frequent overtopping events occurring at Spring Tides. Phase 1abc and 2a of the Colwyn Bay Waterfront Project have already been completed which included the construction of a 150m groyne and Porth Eirias, beach recharge and promenade improvements in the central Colwyn Bay area. Subsequent to this, CCBC are now seeking to provide a permanent upgrade of the coastal defences to protect the western and eastern areas of the bay concurrently with improvements to the promenade to facilitate active travel and regeneration. The proposed works will include upgrades to the promenade, new coastal defences and beach recharge. These will be referred to as the Scheme within this report.

The Scheme is located along the easternmost section of the Promenade at Old Colwyn, from the eastern side of Porth Eirias in the west to Splashpoint in the east. The Scheme footprint is divided into two principal areas:

- Area 1 – From the picnic area to the east of Porth Eirias car park (approximate National Grid Reference (NGR) 285822, 378870) to the east of Rotary Way (approximate NGR 286347, 378756) where the road currently reduces in height from the junction back down to Promenade level; and
- Area 2 – From the eastern edge of Area 1 (approximate NGR 286347, 378756) to Splashpoint in the far east (approximate NGR 287029, 378701).

The red line boundary has been extended beyond the footprint as shown in Figure 1.2 to allow for access during construction. For the purposes of this report, the site refers to everything within the redline boundary.

Figure 1.2: Location of the Scheme



Source: Adapted from Red Line Boundary Plan Drawing 415437-MMD-00-XX-DR-N-1707

The Scheme is located immediately adjacent to Bae Lerpwl / Liverpool Bay inshore Special Protection Area (SPA), which is also an Important Bird Area (IBA), designated for a number of breeding and wintering bird species (see Appendix A for location). Notably wintering common scoter (*Melanitta nigra*), red-throated diver (*Gavia stellata*), little gull (*Hydrocoloeus minutus*) and breeding little tern (*Sternula albifrons*) and common tern (*Sterna hirundo*). It is also designated for its overwintering waterbird assemblage (over 60,000 birds).

Mott MacDonald Limited has therefore been commissioned by Conwy County Borough Council (CCBC) to prepare a report to inform a Habitats Regulations Assessment (HRA) in relation to the proposed works. Based on an initial assessment, avoidance and mitigation measures have already been proposed as part of the scheme to avoid adverse effects on wintering birds using the SPA. On this basis this report has been prepared to inform an Appropriate Assessment (Stage 2) to consider the effectiveness of applied mitigation measures.

1.2 Purpose and Structure of this Report

This document has been prepared document the assessment of the proposed coastal defence improvement works in relation to the potential for effects on European Sites as required by Regulation 63(1) of the Conservation of Habitats and Species Regulations 2017 (the Habitats Regulations). The HRA process is described Section 3 and in Appendix B.

The structure of this report can be summarised as:

- Sections 1-4 provide the context and baseline information (including an ecology baseline for SPA features of interest abundance and distribution) to inform the screening and appropriate assessment;
- Section 5 provides the information to inform a screening assessment; and
- Sections 6-8 provide information to inform an appropriate assessment.

1.3 Ecologist Qualifications

Table 1.1: Ecologist Qualifications

Name and Role	Qualifications	Experience
Clive Williams Approver	BSc (Hons), MSc, FGS, CGeol	23 years' environmental consultancy experience preparing Environmental Statements and HRA for various projects.
Nigel Shelton Checker	BA(Hons) MSc, MIFM	Over 25 years' experience in ecology with 15 years in national government agency and consultancy, with a specialism in ornithology, advising on ecological matters in relation to legislation, licensing and impact assessment, including review of HRA's for the competent authority.
Lorraine Wooley Author	MA (Oxon), MRes, CEcol, CEnv, MCIEEM	Over 10 years' experience in consultancy, advising on ecological matters including HRA and EclA

Source: Mott MacDonald Ltd

2 Project Description

2.1 Scheme Description

The Scheme comprises a combination of coastal defence, promenade and active travel improvements.

Coastal defence improvements include:

- The construction of a rock revetment approximately 32m in cross-sectional width and 1.15km in length, with associated modifications to existing surface water outfalls on the beach to extend them through the new revetment;
- A new access build-out area to be constructed in the western half of the Scheme area which would have several functions, including providing a greater area for pedestrian access; Equality Act compliant ramp access and stepped access to the beach, along with landscaped seating steps at varying levels, to the beach access;
- New pedestrian accesses through the proposed revetment to comprise three sets of beach access steps perpendicular to the linear rock revetment;
- A dedicated fishing platform in the Splashpoint Area to keep anglers at a safe distance from active travel routes: and
- The raising of the Promenade to the west of Rotary Way and the raising of the Promenade and highway to the east of Rotary Way with associated access provision.

Active Travel improvements, to include new cycleway layouts, improved pedestrian access areas, improved lighting, new handrailing, improved picnic and outdoor spaces, improved signage and landscaping.

In addition, a series of ecological and educational enhancements have been incorporated into the proposals including new intertidal habitat creation, classification of the beach as a plastic free zone, incorporation of wildflower grassland into new amenity areas and enhancements to the network rail embankment.

2.2 Proposed Works Methodology and Programme

2.2.1 Construction

As funding is yet to be secured for Scheme construction, the programme has not yet been confirmed. Due to the scale and funding requirements of the Scheme, the construction process may need to be split into several phases. However, it is anticipated that works would be undertaken over a period of approximately 20 months and would be split into at least two phases for areas 1 and 2.

The construction phase will involve construction of the above listed works. It is anticipated that construction would require the following elements (of key relevance to this assessment) and would be subject to tidal working:

- Import of rock revetment by barge or by road:
 - Import by barge would be undertaken outside of the period October to March only. For this method of delivery, the delivery barge would be guided to shore by a tug at a designated (and rising) tidal state when access to the upper shore area is possible. The rock armour would be unloaded directly to shallow water on the beach. The window for this operation would be relatively small (considered likely to be limited to 2 hours either side of high tide only) and therefore 24 hour working (requiring artificial lighting) may be

required. Rock armour would be stockpiled immediately seaward from where it is to be placed within the revetment; and

- Import by lorry would be undertaken throughout the year, as required, and would involve a large number of lorries offloading directly onto the foreshore. Storage of revetment would either be on the upper beach or on the promenade (awaiting transfer to the beach);
- Extensive and prolonged periods of piling along the existing promenade and revetment (tubular steel piles driven into the underlying clay for the fishing platform and sheet piles for the access steps and access build-out structure) (anticipated at least 12-14 weeks); and
- Vehicular movements on the beach and promenade as well as increased presence of construction personnel.

Construction compound locations are not yet finalised but will be located within the red line boundary. The existing groynes would be retained, maintained and enhanced.

2.2.2 Operation

Once constructed, the sea defences will work in a similar way to the current sea wall. However, maintenance requirements are anticipated to be reduced compared with the existing situation as fewer emergency repairs (often required in winter) would be needed.

2.2.3 Decommissioning

It is considered highly unlikely that the proposed coastal defences would be decommissioned as this would pose a safety and environmental hazard. These works are proposed as a long-term solution.

3 HRA Framework and Study Area

3.1 HRA Framework

National Site Network (formerly known as European or Natura 2000) sites form a network protected sites, designated for their rare, vulnerable and/or endangered species and habitats. National Site Network sites include Special Areas of Conservation and Special Protection Areas (SPA). HRAs are also required, as a matter of UK Government policy, for potential SPAs (pSPA), candidate SACs (cSAC) and wetlands of international importance (Ramsar sites) for the purposes of considering plans and projects, which may affect them. Hereafter all of the above designated nature conservation sites are referred to as “National Site Network sites

Part 6 of the Conservation of Species and Habitats Regulations 2017 (as amended) transpose the requirements of Article 6 paragraphs (3) of Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (the Habitats Directive) into UK law. These Regulations require that the competent authority undertakes and appropriate assessment of implications of a project for a National Site Network site, where this is likely to have a significant effect on any sites under that designation.

The regulations also require a person, or organisation, applying for a consent to undertake an activity to provide the competent authority with sufficient information to inform its assessment. This process of assessment has become known as a Habitat Regulations Assessment (HRA)

The HRA process consists of four stages;

Table 3.1: HRA Stages

Stage	Description
Screening (Stage One)	This is the process which identifies the potential effects upon the National Site Network sites and considers if the effects are likely to be significant. A significant effect or impact on a National Site Network site is that which could undermine the conservation objectives or/and management of the site. The likelihood of it occurring is judged on a case-by-case basis, taking account of the precautionary principle and the local circumstances of the site. The judgment of 'likelihood' is, in turn conducted in a very precautionary manner, taking account of the ecological circumstances of the National Site Network site. This is an iterative process and before moving to Stage Two it can be repeated if required. Proposals to mitigate any significant effects are no longer allowed to be considered at the screening stage, only features which are considered to be integral to the scheme and not those designed to avoid or mitigate for any negative effects on the National Site Network site, are included in the screening assessment. The competent authority must consult with the appropriate nature conservation body (in this case Natural Resources Wales (NRW)) and have regard to any representations made by that body.
Appropriate Assessment (Stage Two)	If the Stage One Screening identifies that the project or plan, alone or in combination, may have significant effects on a National Site Network site, or if there is uncertainty, the competent authority must undertake an Appropriate Assessment of the implications for that site in view of that site's conservation objectives. This step involves the consideration of the predicted adverse effects of the project or plan either alone or in combination with other projects or plans, on the integrity of the National Site Network site with respect to the site's structure and function and conservation objectives. Additionally, where there are adverse impacts, an assessment of the potential mitigation of those impacts is also required.
Assessment of Alternative Solutions (Stage Three)	If the mitigation measures prescribed at Stage Two cannot avoid adverse effects on the integrity of a National Site Network site, this process examines alternative ways of achieving the objectives of the project or plan that avoid adverse impacts on the integrity of the National Site Network site.
Assessment where no alternative solutions exist and where adverse	If no suitable alternative solutions are available, Stage Four requires an assessment of compensatory measures where, in the light of an assessment of Imperative Reasons of Overriding Public Interest (“IROPI”), it is deemed that the project or plan should proceed.

Stage	Description
impacts remain (Stage Four)	In making this assessment, it is important to recognise that it will be appropriate to the likely scale, importance and impact of the proposed project.

Each stage determines whether further stages in the process are required.

If the conclusion of Stage 1 is that there will be no significant effects on the National Site Network site, there is no requirement to undertake further stages.

All the Stages of the HRA process, including those beyond appropriate assessment are shown in Appendix B.

3.2 Study Area

The proposed coastal defence project has the potential to impact on ecological features such habitats and/or species beyond the confines of the working area itself. The potential impacts on the SAC are defined as:

- Areas where there will be land take and habitat removal for the works;
- Areas where there is a risk of altering the hydrodynamic regime;
- Areas where there is a risk of an increase in air, noise and light pollution;
- Areas where there is a risk of a reduction in water quality; or
- Areas where there is physical disturbance to international designated sites and/or their designated interest features.

Taking the above into consideration, for the proposed Scheme, a zone of influence (Zol) of 2.0km (10.0km for SACs designated for bats or marine mammals) has been used to define the study area for this screening assessment.

4 Ecology Baseline

4.1 Site Description and Context

The site comprises approximately 1.2km stretch of intertidal habitats, including sandy beach, areas of gravel, rocky groynes and associated habitats as well as existing coastal defence, promenade and adjacent grassy verges. The beach is well used throughout the year for recreational use, including water sports (outside of winter), whilst the existing coastal defences are also subject to regular maintenance including frequent emergency works (often in winter) due to their poor state of repair.

The inshore area of Colwyn Bay lies within the boundary of Bae Lerpwl / Liverpool Bay SPA.

The wintering bird survey data is also presented for Colwyn Bay Phase 1abc (west of the site, comprising a stretch of sandy beach recently subject to recharge) and Colwyn Bay Phase 2b (west of Phase 1abc, comprising similar habitats to the site). These areas are indicated within Figure 4.1 below.

Figure 4.1: Detailed site location



Source: 'ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community'. Note The completed Colwyn Bay Waterfront Phase 2a Scheme area straddles the Phase 1 and Phase 2 areas.

4.2 Assessment of Bird Assemblage

Given the proximity of the site to Liverpool Bay SPA, in order to understand the local waterbird assemblage present, wintering bird surveys of the site and the adjacent areas (Phase 2b and Phase 1abc as shown in Figure 1.2) were undertaken in November 2019 to January 2020 (Mott MacDonald, 2020). In addition, Wetland Bird Survey (WeBS) data has also been sourced from the BTO for the count sectors covering the area (Colwyn Bay to Rhos Point and Abergele to Llandulais) for the most recent five-year period (2014 to 2019; see Appendix C for full records).

Liverpool Bay SPA regularly supports more than 1% of the British populations of red-throated diver (*Gavia stellata*), 1% of the biogeographical population of common scoter (*Melanitta nigra*) and more than 60,000 waterfowl during the non-breeding season. Within the entire SPA, peaks of common scoter can reach up to 29,000 birds (60% of total population) and up to 1000 (5%) of the UK red-throated diver population during October to March. The SPA is also designated for non-breeding little gull (*Hydrocoloeus minutus*) and breeding common tern (*Sterna hirundo*) and little tern (*Sternula albifrons*). The baseline survey results are therefore summarised below with particular reference to these interest features of the Liverpool Bay SPA. As common scoter were recorded in far larger numbers than other species, more detail from the WeBS counts and wintering bird surveys has been included in respect of this species than for the others.

4.2.1 Common Scoter

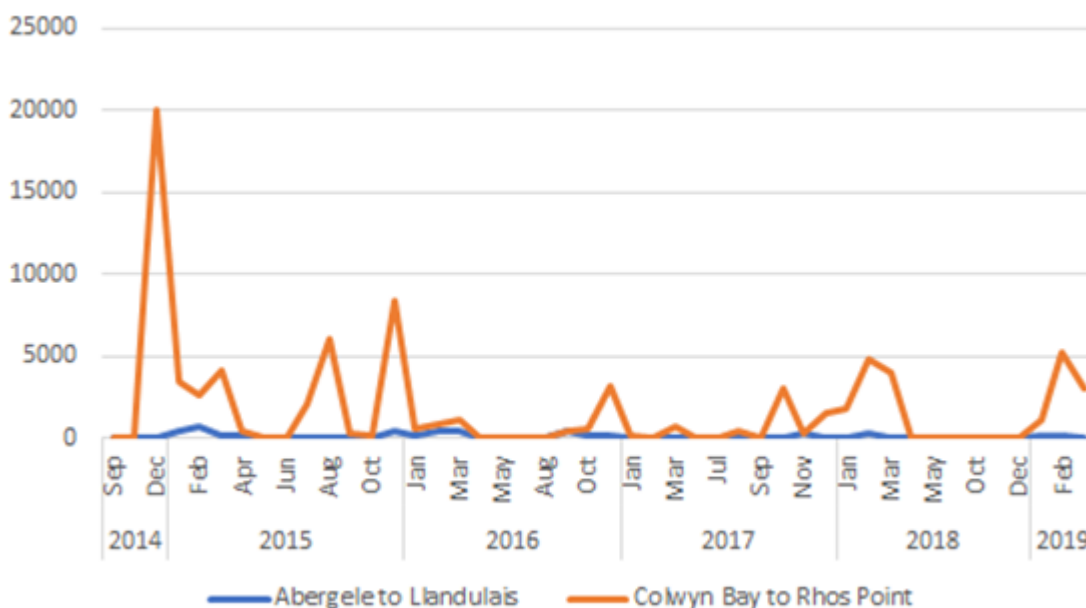
4.2.1.1 WeBS data (2014 – 2019)

The WeBS sector counts from the last five years is plotted in Figure 4.2 whilst the counts recorded for different months is summarised in Table 4.1. Raw data is provided in Appendix C.

This data shows that common scoter are present over winter in both the Abergele to Llandulais and the Colwyn Bay to Rhos Point sectors, with the latter supporting large numbers (typically 5,000 – 8,000, with a peak of 20,000 in December 2014). This is consistent with the wintering bird survey results from 2019 – 2020 (see next section) which also recorded large rafts of thousands of common scoter offshore from Colwyn Bay.

The trends in bird numbers vary between years but the majority of high bird counts appear between October and March, with the notable exception of a peak in August 2015 which is atypical for the species (a winter resident) and so not considered relevant to this analysis.

Figure 4.2: Common scoter



Source: WeBS data (BTO, 2020)

Table 4.1: Common scoter WeBS counts per month

Month	Abergele to Llandulais							Colwyn Bay to Rhos Point						
	2014	2015	2016	2017	2018	2019	Average	2014	2015	2015	2017	2018	2019	Average
Jan		415	200	0		200	204	3000	350	200	1800	1000	1270	
Feb		710	461	6	386	230	359	2000	400	5	4500	5000	2381	
Mar		206	505		0	4	179	4000	600	730	4000	3000	2466	
Apr		203	0	0			68	300	0	1	0		75	
May		4					4	0	101		4		35	
Jun								0	0				0	
Jul								2100		0			1050	
Aug								6000	0	400			2133	
Sep	51	0	420		0		118	300	4	0			101	
Oct	53	0	161	0	0		43	200	400	3000	1		900	
Nov				268	52		160							
Dec		401	220	0	44		166	20000	8000	3000	1500		8125	

Source: Summarised from WeBS data (BTO, 2020)

4.2.1.2 Wintering Bird Surveys (2019-2020)

The wintering bird surveys recorded observations of common scoter on all four site visits. The common scoter observations from the wintering bird surveys are summarised in Table 4.2 below whilst full results are available in the wintering bird survey report (Mott MacDonald, 2020).

Table 4.2: Field survey results (2019/2020) – common scoter

Site	Date	Overall Count	Summary of Observations
Colwyn Bay Coastal Defence and Active Travel	22 Nov 2019	c.2000	<ul style="list-style-type: none"> Scattered medium to large rafts of birds (50-500) were visible from the coastal footpath, up to 1.0km-3.0km out to sea; and Two small rafts of 13-20 birds were recorded within 500m of the coastline for short periods* before returning to the larger groups.
	09 Dec 2019	c. 2000	<ul style="list-style-type: none"> Large rafts of birds (approximately 1,000 individuals) were visible from coastline, approximately 1.5-2.0km out to sea; Small rafts of birds (3 and 23 individuals) were observed within 0.5km of the bay for short periods* of time before returning to the larger groups.
	06 Jan 2020	c. 1000	<ul style="list-style-type: none"> Large rafts of birds (approximately 1,000 individuals) were visible from coastline, approximately 2.0-3.0km out to sea; Small rafts of birds (approximately 6 - 21 individuals) were observed within 0.5km of the bay for short periods* of time before returning to the larger groups.
	16 Jan 2020	c. 1300	<ul style="list-style-type: none"> Scattered medium to large rafts of birds (40-300) were visible from the coastal footpath. The closest of these (40 individuals) was recorded approximately 0.5km from shore but did not drift closer during the time observed.
Colwyn Bay Waterfront Phase 2b	06 Dec 2019	c. 700	<ul style="list-style-type: none"> Scattered medium to large rafts of birds (50-300) were visible, at least 1.0km out to sea.
	09 Dec 2019	c. 1200	<ul style="list-style-type: none"> Large scattered raft (1200) visible, at least 1.0km out to sea.
	06 Jan 2020	c. 800	<ul style="list-style-type: none"> Scattered medium to large rafts of birds (50-300) were visible from the coastal footpath, at least 1.0km out to sea; and One small rafts of 3 birds was recorded approximately 0.5km from the coastline but did not drift closer during the time observed.
	16 Jan 2020	c. 800	<ul style="list-style-type: none"> Large raft (800) visible, at least 1.0km out to sea.
Colwyn Bay Phase 1abc**	22 Nov 2019	c. 2000	<ul style="list-style-type: none"> Scattered medium to large rafts of birds (50-500) were visible from the coastal footpath, up to approximately 1.0km – 3.0km out to sea.

Source: Mott MacDonald Limited (2020); * typically 5 to 15 minutes; ** supplementary data from one visit only

In summary, the key findings from the wintering bird surveys are:

- Common scoter were consistently present in large rafts over 1.0km from shore during every visit;
- The largest numbers recorded were from the November and December visits (rafts of approximately 2,000 individuals);
- Smaller rafts (ranging from between 50-500 individuals) were observed between 0.5km – 1.0km from shore but did not drift closer; and
- Small numbers of individuals (typically up to 20) were observed within 0.5km for periods of 5 to 15 minutes before re-joining the larger rafts offshore.

4.2.1.3 Conclusions

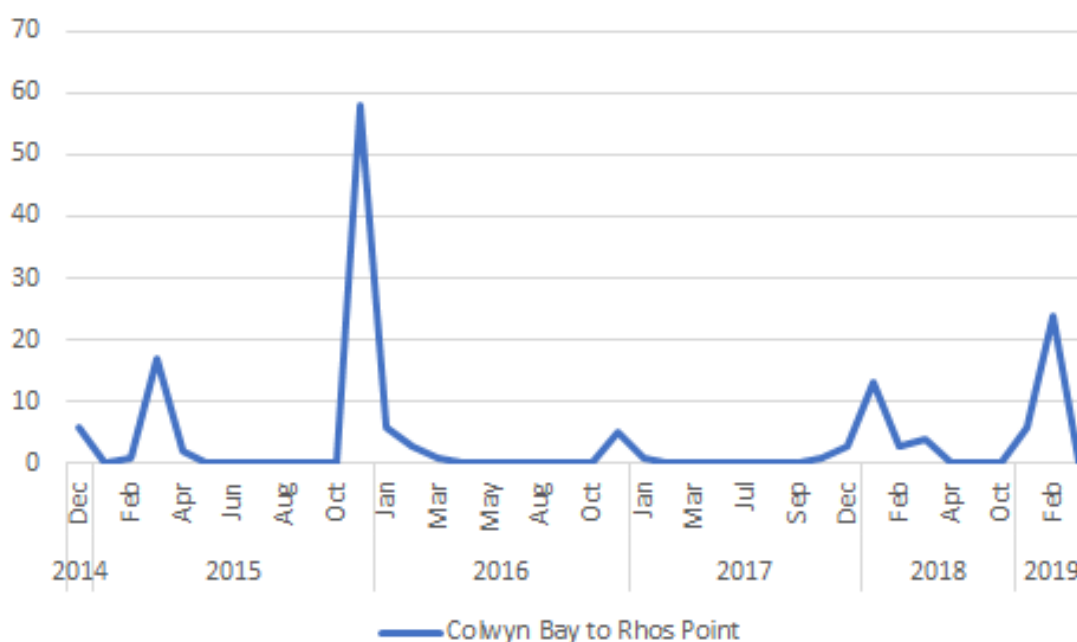
On the basis of the WeBS sector counts and field observations it is clear that common scoter use Colwyn Bay in large numbers over winter, with the key period appearing to be October to March. This is consistent with other research of common scoter in the local area which also concluded October to March as being the key period for this species (Kaiser *et al.*, 2002). The most important area appears to be approximately 1.0km offshore where large rafts of birds gather to rest and forage. Areas within approximately 0.5km appear to be used infrequently and only by very small numbers of individuals in short duration, so are unlikely to be of significant importance to the population.

4.2.2 Red-throated Diver

4.2.2.1 WeBS data (2014 – 2019)

Red-throated diver was only recorded within the Colwyn Bay to Rhos Point sector during October to March. The WeBS sector counts from the last five years are plotted in Figure 4.3 below. Raw data is provided in Appendix C.

Figure 4.3: Red-throated diver



Source: WeBS data (BTO, 2020)

In summary, red-throated diver was only recorded during the period October to March and numbers appear inconsistent between years. The peak counts returned are 58 and 24 from December 2015 and February 2019 respectively.

4.2.2.2 Wintering Bird Surveys (2019-2020)

The wintering bird surveys undertaken only recorded red-throated diver during one survey visit, on 6 December 2019, where two individuals were recorded within approximately 0.8km offshore in the Colwyn Bay Phase 2b survey area.

4.2.2.3 Conclusions

Red-throated diver has been confirmed as present in the Colwyn Bay area over winter (strictly between October and March) but in low numbers, indicating that this is unlikely to be a key area of importance for this species. This is consistent with distribution maps shown in Lawson *et al.* (2016) (see Appendix D) which show Colwyn Bay to be located outside of the main hotspots for this species.

4.2.3 Little Gull

No records of Little Gull were returned from the WeBS sector counts nor was this species recorded during any of the survey visits.

WeBS data online for little gull presents the annual peaks for this species for Colwyn Bay and North Clwyd Coast for the last five years. The peak count for this species was one bird for 2015/2016. The JNCC report (Lawson *et al.*, 2016; Appendix D) which assessed numbers and distribution of wintering waterbirds and seabirds to inform the SPA citation indicates that this species is largely associated with the areas further offshore from the Dee and Ribble Estuaries. For the purposes of this assessment, this species is considered likely to be a passage species migrating through in Autumn.

4.2.4 Common and Little tern

No records of any common or little terns were returned from the WeBS sector counts, whilst these species were not recorded during the wintering bird surveys (as anticipated). Common and little tern are known to be summer breeding species in the SPA.

Common terns are known to breed on shingle beaches and gravelly areas, which are notably absent from the Site, whilst only one known little tern breeding colony is known in Wales at Gronant Dunes (approximately 24.0km north east).

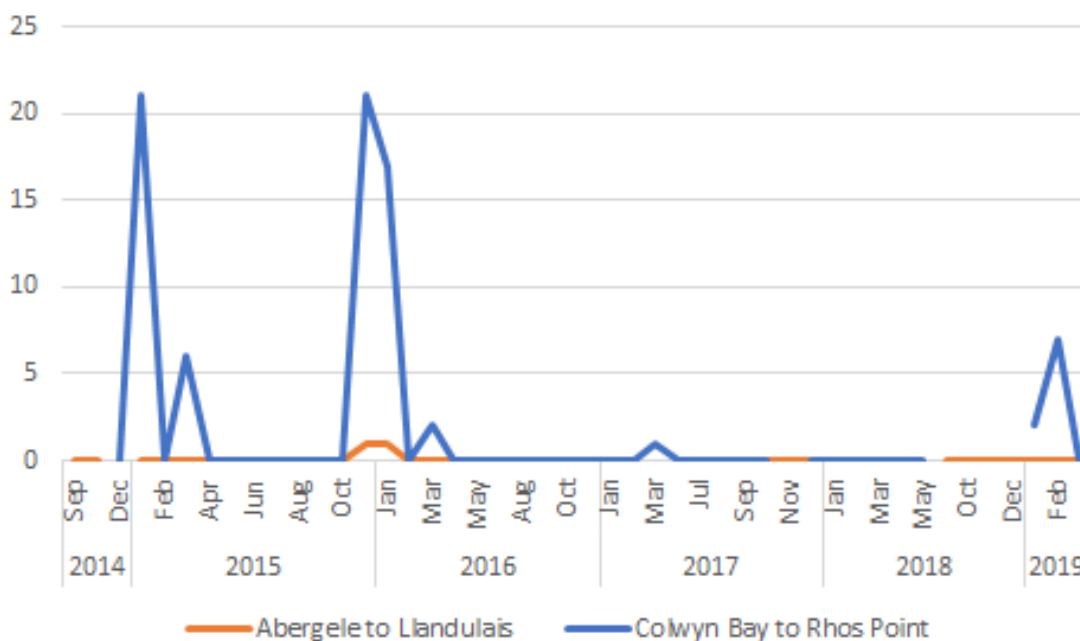
4.2.5 Waterbird assemblage

The waterbird assemblage is specifically noted to include common scoter, red-throated diver and little gull, discussed above, as well as red-breasted merganser and great cormorant as being present in greater numbers.

4.2.5.1 Red-breasted merganser

Red-breasted merganser was not recorded during the wintering bird surveys undertaken at the site, whilst only low numbers of this species were returned from WeBS sector counts from winter months (peak count of 21; see Figure 4.4 below).

Figure 4.4: Red-breasted merganser

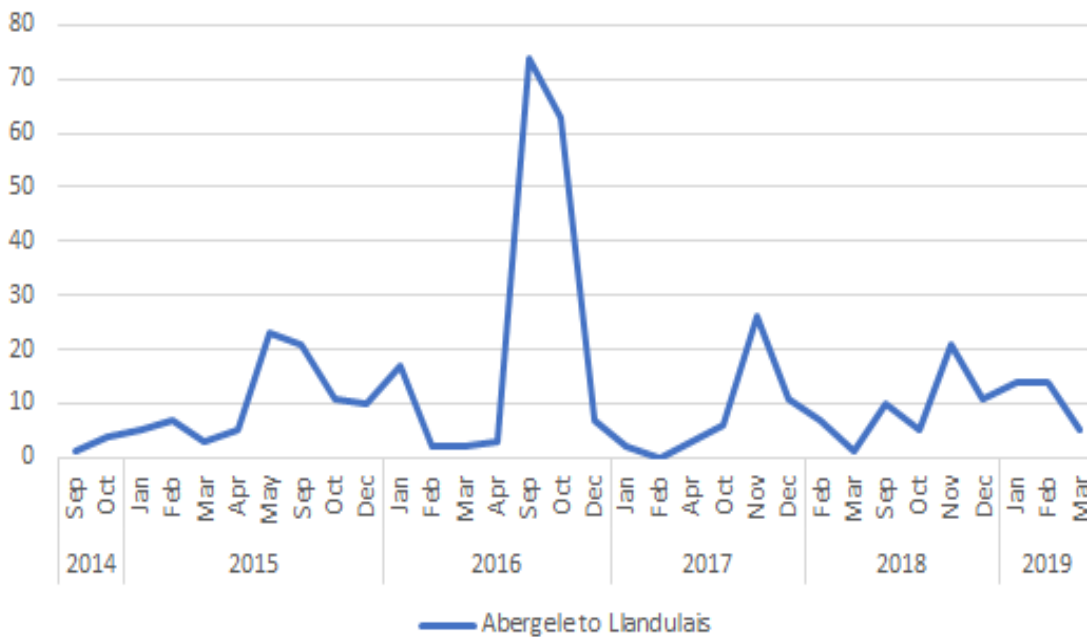


Source: WeBS data (BTO, 2020)

4.2.5.2 Cormorant

Cormorant appears to be present in small numbers throughout the year from the WeBS sector counts (see Figure 4.5), with larger numbers present in winter months, although given the small numbers present it is difficult to accurately draw out any trends in this data.

Figure 4.5: Cormorant



Source: WeBS data (BTO, 2020)

The wintering bird surveys did record this species consistently across the survey period, loafing on manmade structures along the bay as well as feeding both close to shore (within 0.1-0.4km) and out at sea amongst common scoter. The largest counts were recorded in the November and December surveys within the vicinity of the Colwyn Bay Coastal Defence and Active Travel survey area (104 and 86 respectively), before dropping to 18 and 1 individuals observed in the January visits. Similar trends were observed for the Phase 2b area.

Survey results for cormorant are summarised in Table 4.3 below.

Table 4.3: Field survey results (2019/2020) – cormorant

Site	Date	Overall Count	Summary of Observations
Colwyn Bay Coastal Defence and Active Travel	22 Nov 2019	104	<ul style="list-style-type: none"> Majority of birds observed day roosting / loafing on manmade structures in the bay; and Several individuals observed feeding at sea (close to common scoter) and inshore (within 100m of the bay).
	09 Dec 2019	86	<ul style="list-style-type: none"> Majority of birds observed day roosting / loafing on manmade structures in the bay; and A few individuals observed feeding at sea.
	06 Jan 2020	18	<ul style="list-style-type: none"> Majority of birds observed basking on rocks or feeding inshore (within 400m of the bay).
	16 Jan 2020	1	<ul style="list-style-type: none"> Flying at sea.
	06 Dec 2019	46	<ul style="list-style-type: none"> Majority of birds observed day roosting / loafing on manmade structures in the bay; and

Site	Date	Overall Count	Summary of Observations
Colwyn Bay Waterfront Phase 2b	09 Dec 2019	42	<ul style="list-style-type: none"> ▸ A few individuals observed flying and feeding at sea. ▸ Majority of birds observed day roosting / loafing on manmade structures in the bay; and ▸ A few individuals observed feeding at sea.
	06 Jan 2020	16	<ul style="list-style-type: none"> ▸ Majority of birds observed day roosting / loafing on manmade structures in the bay; and ▸ A few individuals observed feeding at sea.
	16 Jan 2020	16	<ul style="list-style-type: none"> ▸ All birds observed day roosting / loafing on manmade structures in the bay.
Colwyn Bay Phase 1abc**	22 Nov 2019	5	<ul style="list-style-type: none"> ▸ Flying overhead.

Source: Mott MacDonald Limited (2020); * typically 5 to 15 minutes; ** supplementary data from one visit only

4.2.5.3 Conclusions

These results indicate that Colwyn Bay is unlikely to be of key importance for red-breasted merganser but does appear to be more well used by cormorant, albeit still in relatively low numbers in the context of the SPA population. Considering the distances and behaviour observed during surveys cormorant appear to have a considerable degree of habituation to any existing disturbance from the shore.

5 Screening Assessment

5.1 Identification of Sites

The only internationally designated site within 2.0km is Liverpool Bay SPA, located immediately north of the Scheme. No additional SACs designated for bats or marine mammals have been identified from within 10.0km.

As set out in Section 3.2, based on the project scope and assessment potential impact pathways, no designations outside of this distance are considered likely to be affected.

5.2 Assessment of Impact Pathways

Potential impact pathways and sources of disturbance from construction include:

- Pollution event – resulting from an oil spill or other pollution sources (from the barge or from machinery) which could damage habitats (reducing prey availability) as well as cause harm to birds directly;
- Noise and vibration disturbance – resulting from piling works (anticipated to last a number of weeks and which could be undertaken over winter), machinery, vehicle movements (including barge and transshipment vehicles if required) and personnel. Any such sources of disturbance close to the shoreline could disturb or displace individuals using these areas to forage, whilst disturbance out at sea from a barge and associated transshipment could disrupt any larger rafts of birds (if present outside October to March);
- Visual disturbance – from increased human activity and machinery along the promenade and intertidal area, which could disturb and displace birds foraging closer to shore;
- Artificial lighting disturbance – there is a requirement to use artificial lighting at night if the delivery of rocks via barge is required to be undertaken during hours of darkness to make use of the periods of high tide. This could which could disturb and displace birds using areas closer to shore or, for lighting associated with barges and transshipment, could affect larger rafts of birds out at sea (if present outside October to March); and
- Changes in turbidity – it is possible for sediment to be disturbed and released through construction activities and deliveries of material to site (e.g. dropping of rocks onto beach via barge). This could adversely impact submerged seaweeds/plants and filter feeding organisms which provide prey for birds, as well as affecting diving bird species using sight to feed/hunt close to the coast.

Disturbance impacts can affect birds directly, by displacing them away from key foraging grounds and causing swimming or flight flee responses. Fleeing from a disturbance event can also indirectly reduce food availability by displacing birds, directing them to less favourable habitats which can subsequently affect energy budgets and survival rates, thus impacting the overall population numbers.

Displacement from preferred feeding areas may have an adverse effect by being energetically expensive to individuals, particularly diving birds, where the feeding activity is physically depleting. Birds displaced from preferred feeding areas may need to swim against currents in order to stay in an area where prey species are present (Hawkins et al. 2000).

As set out above in respect of operational and decommissioning stages of the project, the operational stage is considered to be an improvement to the baseline in terms of potential disturbance to birds (with less maintenance required and therefore fewer emergency repairs), whilst no decommissioning is anticipated. As such, no potential impact pathways from these phases have been identified.

5.3 Screening Assessment

The following Tables 5.1 to 5.3 document the screening exercise to assess if the project, alone or in combination with other projects, will have an impact on Liverpool Bay SPA.

Table 5.1: Liverpool Bay SPA – Citation Details and Conservation Status

National Site Network Site(s)	Bae Lerpwl/ Liverpool Bay SPA	
Distance from the National Site Network Site(s)	Immediately adjacent	
Description of the site(s)		
Key Qualifying features		
Annex I habitats or species	Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site	No Annex I habitats that qualify for the primary reason for the designation
	Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site	No Annex I habitats present as a qualifying feature
Annex II habitats or species	Annex II species that are a primary reason for selection of this site	Red throated diver (<i>Gavia stellata</i>) Little gull (<i>Larus minutus</i>) Common Scoter (<i>Melanitta nigra</i>) Little tern (<i>Sterna albifrons</i>) Common tern (<i>Sterna hirundo</i>)
	Annex II species present as a qualifying feature, but not a primary reason for site selection	No Annex II species present as a qualifying feature
Assemblage qualification	An internationally important assemblage of birds present as a qualifying feature	In the non-breeding season, the site regularly supports at least 69,687 (2004/05 -2010/11) individual waterbirds. The main components of the assemblage include all of the non-breeding qualifying features listed above and red breasted merganser (<i>Mergus serrator</i>) and great cormorant (<i>Phalacrocorax carbo</i>).
Management of the site		
Vision of the site(s)	<p>The stated objectives are to ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring;</p> <ul style="list-style-type: none"> • The extent and distribution of the habitats of the qualifying features; • The structure and function of the habitats of the qualifying features; • The supporting processes on which the habitats of the qualifying features rely; • The population of each of the qualifying features; and • The distribution of the qualifying features within the site. 	
Current status of species or habitats and vulnerabilities		
Site	Species	Status and vulnerabilities
Bae Lerpwl/ Liverpool Bay	Red-throated diver (wintering)	The increase in numbers may be the result of i) a proportion of the biogeographic population moving further west from Baltic wintering grounds, ii) a change in survey method i.e. visual aerial to digital aerial where there is greater confidence in the estimate or iii) a combination of the two. Known vulnerabilities including physical loss or damage of supporting habitat, disturbance (from certain sources noise or movement), toxic and non-toxic (turbidity) contamination and biological disturbance. Disturbance was noted to be the highest vulnerability for this species.
	Common scoter (wintering)	The significant change in numbers may be the result of i) a proportion of the biogeographic population moving from Baltic wintering grounds, ii) a change in survey method i.e. visual aerial to digital aerial where there is greater confidence in the estimate or iii) a combination of the two. Known vulnerabilities including physical loss or damage of supporting habitat, disturbance (from certain sources noise or movement), toxic and non-toxic (turbidity) contamination and biological disturbance. Disturbance was noted to be the highest vulnerability for this species.

National Site Network Site(s)	Bae Lerpwl/ Liverpool Bay SPA
Little Gull	NOT AVAILABLE
Little tern	NOT AVAILABLE
Common tern	NOT AVAILABLE
Waterbird assemblage	Common scoter are noted to be the dominant species in this feature and so the current status and vulnerabilities has been taken from this species.

Source: Natural England (October 2012)

Table 5.2: Liverpool Bay SPA – Screening Assessment

Screening Qualifying Feature	Assessment of significance	Likely significance effect of the project during:		
		Construction	Operation	Decommissioning
Common scoter (wintering)	<p>Construction</p> <p>Effects are considered in respect of the impact pathways above:</p> <ul style="list-style-type: none"> ● Oil Spills: In the absence of mitigation, a pollution event from oil spills from the barge, transhipment or machinery cannot be ruled out. Such a pollution event would degrade habitat quality, foraging availability and injure birds; ● Disturbance: Common scoter can be sensitive to disturbance. Due to lack of research of construction disturbance in relation to overwintering common scoter, recommended safe working distances during the breeding season (sensitive period) have been used as a broad guidance for the proposed works. Recommended safe working distances for nesting common scoter during construction is 300-800m (although reference is also included to 300-500m as an upper estimate). Survey work undertaken on site indicated only small numbers of individuals appeared to come within c.500m of shore (<25 individuals or small rafts) whilst a few rafts of approximately 40 birds were recorded to rest within offshore areas (c.500m-1.0km). The majority of birds rested further offshore (approximately 1.0km-3.0km). On this basis, the key sources of disturbance are considered below: <ul style="list-style-type: none"> – <i>Barge movements:</i> Delivery of revetment by barge would be within close proximity of large rafts of birds out to sea and so could cause significant disturbance at a population level; – <i>Piling:</i> Piling onshore is anticipated for extended time periods and, in the absence of mitigation, could result in propagation of noise and vibration through the water column (where this is required for the fishing platform) as well as the air which could affect benthic fauna (prey for scoter) as well as potentially disturbing birds themselves (albeit in small numbers) such that effects from piling cannot be ruled out; and – <i>Other onshore disturbance:</i> Other disturbance from construction, such as additional human presence, noise, artificial lighting, represent an increase to the existing baseline but are not new sources of disturbance for the area. Such effects would be temporary and are considered unlikely to affect birds beyond the above 500m threshold referenced above. Based on survey work this would result in temporary displacement to small numbers of individuals. The total length of shoreline (measured as the coast itself) within the SPA is approximately 125km, of which only approximately 1.5km (1.2% falls within the Site), such that there remains a large area of shoreline habitat (i.e. habitat within 500m of the coast where waters are shallower) available for foraging birds within the SPA. Such effects would therefore be considered <i>de-minimis</i> and not anticipated to significantly affect the population integrity. ● Changes in turbidity: Changes in turbidity would be localised and mostly associated with the shoreline (i.e. unloading rocks from the 	Yes	None	None

Screening

	<p>transshipment), such that they are likely to disperse and attenuate before affecting foraging for this species. As such, these temporary affects are considered unlikely to significant affect the population integrity.</p> <p>On the basis of the above, a LIKELY SIGNIFICANT EFFECT cannot be ruled out during construction as a result of the risk of pollution (oil spills) and disturbance to birds from the barge movements and piling.</p> <p><u>Operation and Decommissioning</u></p> <p>As set out above, no impact pathways during operation or decommissioning have been identified.</p>			
Red-throated diver (wintering)	<p><u>Construction</u></p> <p>Effects are considered in respect of the impact pathways above:</p> <ul style="list-style-type: none"> ● Oil Spills: In the absence of mitigation, a pollution event from oil spills from the barge, transshipment or machinery cannot be ruled out. Such a pollution event would degrade habitat quality, foraging availability and injur birds; ● Disturbance: Red-throated diver can be sensitive to disturbance. Due to lack of research of construction disturbance in relation to over wintering common scoter, recommended safe working distances during the breeding season (sensitive period) have been used as a broad guidance for the proposed works. Recommended safe working distances for nesting red-throated diver during construction is 500-750m. Survey work identified only identified two individuals within this distances whilst the WeBS sector counts indicate that relatively low numbers are present in this area (key areas of importance being further north along the coast, offshore from the Dee and Ribble Estuaries). On this basis, displacement of individuals to other areas is considered unlikely to significantly affect the integrity of the SPA population. However, delivery of revetment by barge could affect larger numbers of birds which could be using offshore habitats such that significant effects from barge movements cannot be ruled out; and ● Changes in turbidity: Changes in turbidity would be localised and mostly associated with the shoreline (i.e. unloading rocks from the transshipment), such that they are likely to disperse and attenuate before affecting foraging for this species. As such, these temporary affects are considered unlikely to significant affect the population integrity. <p>On the basis of the above, a LIKELY SIGNIFICANT EFFECT cannot be ruled out during construction as a result of the risk of pollution (oil spills) and disturbance to birds from the barge.</p> <p><u>Operation and Decommissioning</u></p> <p>As set out above, no impact pathways during operation or decommissioning have been identified.</p>	Yes	None	None
Little Gull	<p>The SPA is designated for non-breeding use by little gull, which were not recorded during the wintering bird species or WeBS sector counts. No likely significant effect on the integrity of the population from works is anticipated.</p>	None	None	None
Little tern	<p>The SPA is designated for summer use by little tern but this species was not recorded in the WeBS sector counts indicating this area is unlikely of importance to the SPA population. The upper shore habitats within the Scheme footprint do not offer any particular breeding opportunities for these species and the site is approximately 24.0km from the known breeding colony (Gronant Dunes). At this distance, no direct or indirect effects on breeding sites are anticipated as a result of the works, whilst any disturbance of foraging individuals (if present) would be low numbers and considered unlikely to significant affect the population.</p>	None	None	None
Common tern	<p>The SPA is designated for summer use by common terns. The upper shore habitats within the Scheme footprint do not offer any particular breeding opportunities for these species. Common terns are known to breed on shingle beeches and gravelly areas, which are notably absent from the Site. On this basis, no direct or indirect effects on breeding sites are anticipated as a result of the works, whilst any disturbance of foraging individuals (if present) would be low numbers and considered unlikely to significant affect the population.</p>	None	None	None
Waterbird assemblage	<p>Natural England advice (2002) on the vulnerability of this feature specifically cites that the most sensitive species, upon which the feature vulnerability is based, is common scoter. Disturbance effects on common</p>	Yes	None	None

Screening

scoter are set out above, which conclude that likely significant effects cannot be ruled out for these species during construction, so a likely significant effect is also concluded for the waterbird assemblage in respect of oil spills, barge movements and piling.

Other species listed as part of the Waterbird assemblage include red-breasted merganser, recorded in extremely low numbers (and not observed during the surveys) and cormorant, which was recorded using manmade features close to shore and appeared to be well acclimatised to disturbance. It is therefore anticipated that this species would either readily habituate to increased shoreline disturbance or would be displaced to similar features in the wider surrounds. Given the numbers and activity recorded (largely loafing and foraging), no significant effects on the integrity of the SPA population would be anticipated.

As set out above, no impact pathways during operation or decommissioning have been identified.

Source: Mott MacDonald Limited

Table 5.3: Liverpool Bay SPA – Screening (In-combination Assessment)

Screening Qualifying Feature	Assessment of significance	Likely significance effect of the project during:		
		Construction	Operation	Decommissioning
Red-throated diver (wintering)	Potential impact pathways from this project have only been identified from the construction stage, where waterbirds could be disturbed by works and displaced away from key foraging grounds or expend energy to flee. It is therefore considered that appropriate to consider only projects nearby (therefore likely affecting the same population / group / rafts of birds) during the same or consecutive construction periods as likely to result in in-combination effects. Colwyn Bay Waterfront Phase 2b project is proposed along the same stretch of bay (approximately 1.0km northwest of the site), the scope of works for which also includes coastal and promenade improvements along with beach recharge. The construction period for this project is anticipated to coincide with the Colwyn Bay Coastal Defence and Active Travel scheme. On this basis, a LIKELY SIGNIFICANT EFFECT from the two projects cannot be ruled out. No other projects have been identified, on the basis of the above criteria, that are considered likely to have an in-combination effect.	Yes	None	None
Common scoter (wintering)		Yes	None	None
Waterbird assemblage		Yes	None	None
Little Gull	As set out in Table 5.2, the survey area is not considered to be of key importance for these species such that no significant impact pathways have been identified and any disturbance to individuals would be negligible. Given the extremely low numbers anticipated, no likely significant effects in-combination with any the Colwyn Bay Phase 2b scheme are anticipated.	None	None	None
Little tern		None	None	None
Common tern		None	None	None

Source: Mott MacDonald Limited

6 Mitigation

A description of all of the mitigation measures proposed under the Scheme in respect of biodiversity is included within the EIA, Chapter 8 - Biodiversity. The mitigation of relevance to the SPA and designated interest features is set out below.

6.1 Embedded Mitigation Measures

The following mitigation measures have been embedded into the Scheme design in order to avoid impacts on wintering birds and as part of best practice:

- The core wintering bird season (October to March, based on the data in Section 4) would be avoided for the delivery of revetment rock via barge. This activity would require the delivery barge to be moored offshore with smaller barges taking transhipped loads of rock to the shore, resulting in high levels of noise and movement in the zone where the wintering features of interest have been recorded. Timing delivery of revetment rock outside this period would avoid disturbance to SPA bird species;
- Piling works associated with the installation of fishing platforms would be undertaken at low tides. This would avoid piling within the marine waterbody, therefore avoiding the propagation of underwater noise through the water column. The tide cycle would also mean that birds would be further offshore and disturbance activities greatly reduced by the increased distance;
- Throughout the construction and operational phases, best practice guidance in reference to pollution prevention will be followed; and
- Pollution prevention measures and contingency planning would be implemented through the CEMP and during operational phases to ensure the marine environment and associated species/features are safeguarded during the works in line with CIRIA (Construction Industry Research and Information Associated) (2015).

6.2 Secondary (Additional) Mitigation

Given the nature of the works, which are highly constrained by tidal patterns and cannot be flexible in programme or location, mitigation options are limited. In particular, screening or stopping works is not feasible without compromising delivery of the repair works. On this basis, the additional measures proposed are as follows:

- Use of vibro piling instead of percussive piling;
- Toolbox talks will be undertaken with site staff prior to works commencing to highlight the importance of the SPA habitat and wintering birds, particularly their sensitivity to disturbance and what types of activities can disturb the birds, in order to minimise the disturbance as much as possible from construction as well as reduce the risk of pollution;
- Best practice measures under the CEMP to reduce noise;
- Avoidance of excessive working hours on site (save for where barge unloading is required); and
- Use of directional lighting, hoods and cowls to reduce light spill onto marine habitats.

7 Appropriate Assessment

7.1 Appropriate Assessment

7.1.1 Assessment of the Project Alone

The Stage 1 assessment screened in the following designated interest features:

- Common scoter;
- Red-throated diver; and
- Waterbird assemblage (of notable importance for the above species as well as red-breasted merganser and cormorant).

Likely significant effects were anticipated from the construction phase only. Impact pathways during construction were identified as follows:

- Damage to habitat and birds from oil spills / pollution;
- Disturbance to large rafts of birds offshore and out to sea from delivery of revetment by barge; and
- Disturbance to birds closer to shore from piling.

Following implementation of the mitigation set out in Section 6, the following table documents the assessment of significant effects on Liverpool Bay SPA, in respect of the above impact pathways, in line with Stage 2 of the HRA process.

Table 7.1: Liverpool Bay SPA – Appropriate Assessment

Designated Interest Feature	Assessment of Effects	Significance of Effect
Common Scoter	Oil Spills	Negligible
Red-throated Diver	The CEMP and best practice pollution safeguards are proposed to reasonably avoid or significantly minimise the risk of pollution events (oil spills) and potential degradation of foraging grounds. Following these measures, the likelihood of such an event occurring is considered extremely low.	Negligible
Water Bird Assemblage	<p>Disturbance</p> <p>No disturbance from the rock revetment delivery by barge is anticipated as this will be undertaken outside of the wintering bird season.</p> <p>Mitigation for piling includes undertaking works at low tides to avoid any piling within the water column (for the fishing platform) as well as use of vibropiling instead of percussive piling, which will reduce the disturbance to benthic fauna. Combined with other best practice measures to reduce disturbance levels, any impacts on birds, particularly at a population level, are considered <i>de-minimis</i> and not anticipated to significantly affect the population integrity.</p>	Negligible

Source: Mott MacDonald Limited

7.1.2 In-combination Assessment

As set out in the Stage 1 screening assessment, no likely significant effects are anticipated from the operation or decommissioning phases of the project. As such, only cumulative effects from the construction phases, where these construction periods overlap or are consecutive, are considered. The only such project identified is:

- Colwyn Bay Waterfront project Phase 2b:** Not yet in the planning system but known to be at outline design stage). This project forms part of the wider Colwyn Bay Waterfront Project for coastal defence remediation (repairs to the sea wall), beach recharge (understood to be from the location of Horizon Shine kiosk (approximate NGR 284880, 379374) westward to Rhos on Sea Harbour (approximate NGR 284253, 380450) and promenade enhancements for the western third of Colwyn Bay (approximately 1.3km in length in total of which ~850m comprise the sea wall and promenade improvements). The plans for this scheme are yet to be finalised and the construction timetable will be determined by availability and grant of funding. On this basis, it is assumed that there could be some overlap in the construction period between this Phase 2b scheme and the Scheme (Colwyn Bay Coastal Defence and Active Travel).

Cumulative impacts from this project with the proposed Scheme are considered in Table 7.2 below in respect of the designated interest features identified in the screening assessment (Table 5.3).

Table 7.2: Assessment of in-combination effects with Colwyn Bay Waterfront Phase 2b

Impact Pathway	Assessment of in-combination effects	Assessment of Significant Effects		
		Common Scoter	Red throated Diver	Waterbird assemblage
Oil Spills	<p>The CEMP and best practice pollution safeguards are proposed to reasonably avoid or significantly minimise the risk of pollution events (oil spills). It is anticipated that similar best practice measures would be required for Colwyn Phase 2b.</p> <p>Following these measures, the likelihood of such an event occurring is considered extremely low.</p>	Negligible	Negligible	Negligible
Disturbance <ul style="list-style-type: none"> Noise and vibration Visual disturbance Artificial lighting 	<p>The construction periods of both schemes are likely to either overlap or occur consecutively. Disturbance could result from construction activities (e.g. piling works or machinery) as well as barge delivery of revetment and sand. Barge deliveries from Colwyn Phase 2b are anticipated to be subject to the same timing restrictions as this scheme (e.g. outside of October to March), whilst mitigation to reduce construction disturbance would also be anticipated to be consistent with this scheme. On this basis, disturbance would be anticipated to be of a similar nature to that described above and would only affect small numbers of birds during winter from works on the shore.</p> <p>In line with the assessment set out above, given the numbers of and distribution of birds recorded and the abundant alternative opportunities elsewhere in the SPA, such effects are considered unlikely to significantly affect the SPA population integrity of these features.</p>	Negligible	Negligible	Negligible
Changes in turbidity	<p>The beach recharge associated with Colwyn Phase 2b could result in increased turbidity changes in addition to localised and temporary effects from unloading of revetment or vehicle movements. However, it is anticipated that best practice measures to contain and minimise these effects would be implemented during construction, whilst effects would be temporary in nature.</p> <p>As described above, the bay represents a small proportion of the foraging habitat available for designated species, with abundant and more</p>	Negligible	Negligible	Negligible

Impact Pathway	Assessment of in-combination effects	Assessment of Significant Effects		
		Common Scoter	Red throated Diver	Waterbird assemblage
	important foraging grounds available elsewhere. Given the relatively low numbers of designated interest features recorded inshore during surveys and from WeBS count data, any effects from changes in turbidity would be unlikely to affect the SPA population integrity of these features.			

Source: Mott MacDonald Limited

In summary, no significant adverse effects are anticipated on the designated interest features of Liverpool Bay SPA as a result of the project in combination with any other plans or projects.

8 Conclusions

This report to inform an Appropriate Assessment provides evidence that, following the implementation of mitigation, any adverse effects on Liverpool Bay SPA and its designated interest features alone or in combination with other projects are considered to be *de-minimis* such that no adverse effect on the integrity of the Liverpool Bay Special Protection Area is anticipated.

No impact pathways to any other internationally designated sites have been identified.

This report is provided to inform the competent authority in completing their Appropriate Assessment of the project.

9 References

Degraer, S., Vincx, M., Meire, P. and Offringa, H., 1999. The macrozoobenthos of an important wintering area of the common scoter (*Melanitta nigra*). *Journal of the Marine Biological Association of the United Kingdom*, 79(2), pp.243-251.

Hawkins, P.A.J., Butler, P.J., Woakes, A.J. & Speakman, J.R. 2000. Estimation of the rate of oxygen consumption of the common eider duck (*Somateria mollissima*) with some measurements of heart rate during voluntary dives. *J. Exp Biol.* 203: 2819–2832.

Kaiser, M.J., Galanidi, M., Showler, D.A., Elliott, A.J., Caldow, R.W., Rees, E.I.S., Stillman, R.A. and Sutherland, W.J., 2006. Distribution and behaviour of Common Scoter *Melanitta nigra* relative to prey resources and environmental parameters. *Ibis*, 148, pp.110-128.

Kaiser, M.J., *et al.* 2002. Predicting the displacement of common scoter *Melanitta nigra* from benthic feeding areas due to offshore windfarms. COWRIE funded project under BEN-03-2002. Centre for Applied Marine Sciences, School of Ocean Sciences, University of Wales, Bangor; NERC Centre for Ecology and Hydrology; School of Biological Sciences, University of East Anglia.

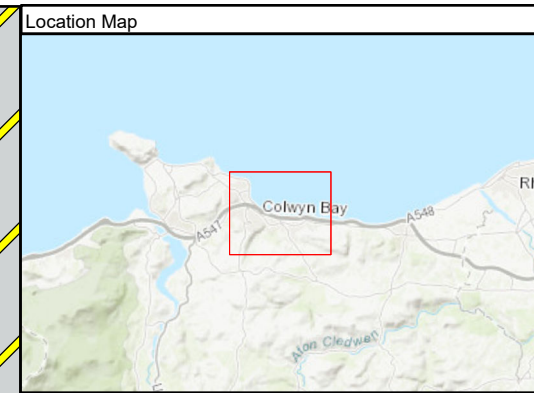
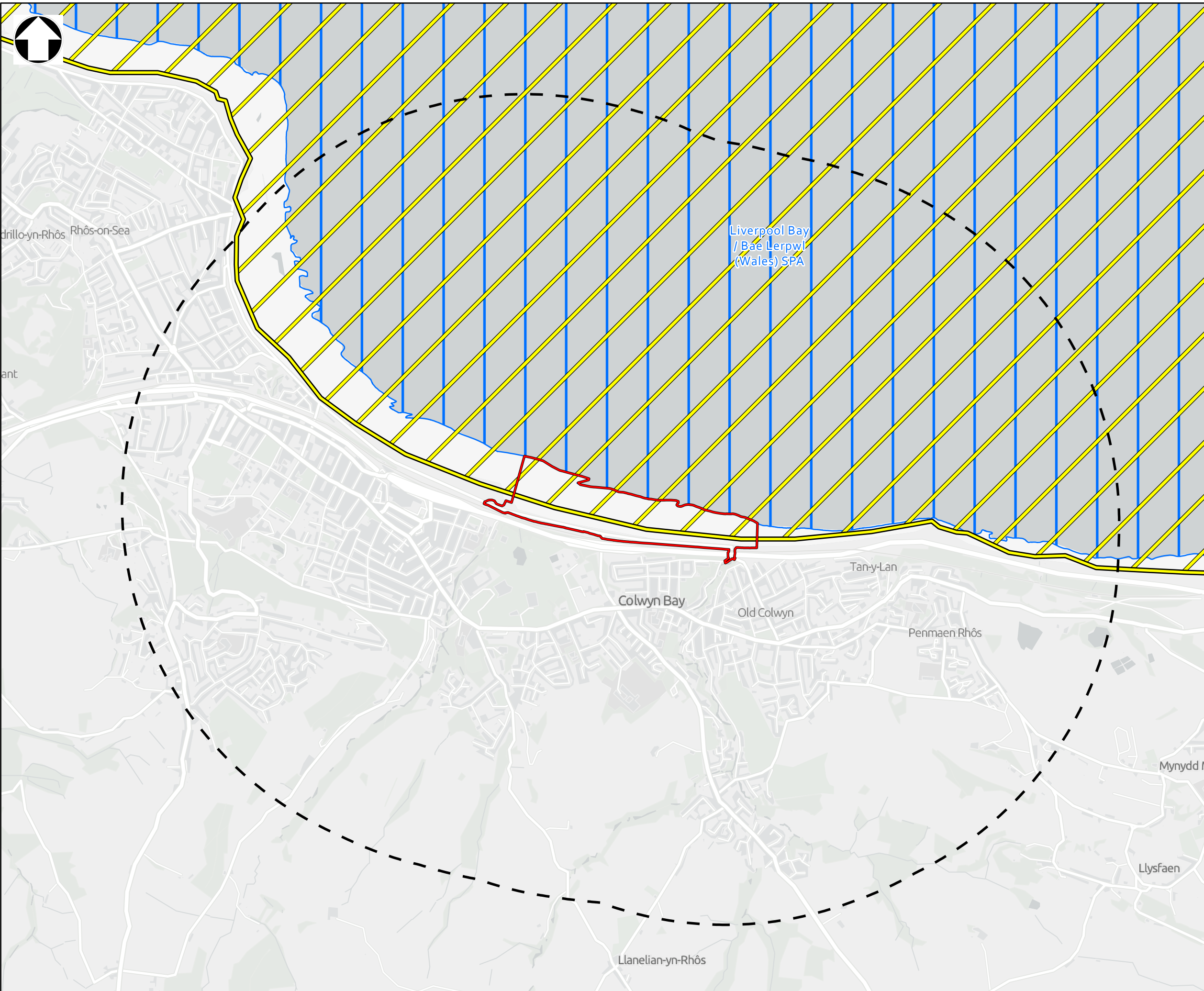
Lawson, J., Kober, K., Win, I., Allcock, Z., Black, J., Reid, J.B., Way, L. and O'Brien, S.H. (February 2016) An assessment of the numbers and distributions of wintering waterbirds and seabirds in Liverpool Bay/Bae Lerpwl area of search. JNCC Report No. 576.

Mott MacDonald (February 2020) Colwyn Bay: Over Wintering Bird Survey Report. Ref: 410895-MMD-N-R-00-XX-1700

Natural England (October 2012) Liverpool Bay / Bae Lerpwl Special Protection Area – Advice under Regulation 35(3) of The Conservation of Habitats and Species Regulations 2010 (as amended). Version 6.5.

Ruddock, M. and Whitfield, D.P., 2007. A review of disturbance distances in selected bird species. *A report from Natural Research (Projects) Ltd to Scottish Natural Heritage*, p.181.

A. International Designations within 2.0km



Key to Symbols

- Red line boundary
- 2km buffer of red line boundary
- Important Bird Area (IBA)
- Special Protection Area (SPA)

Notes

1. For information only, not for construction.
2. Contains Ordnance Survey data © Crown copyright and database rights 2019 Ordnance Survey. All rights reserved.
3. Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.
4. Data reproduced with the permission of RSPB. © Crown Copyright. Ordnance Survey licence number 100021787 (2020).
5. Contains OS data © Crown Copyright and database right 2020 Contains data from OS Zoomstack, Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	23/07/20	SA	For information	LW	CW

MOTT MACDONALD

Mott MacDonald House
5 Woodland Road West
Colwyn Bay
LL29 7DH
T +44 (0)2920 467800
W www.mottmac.com

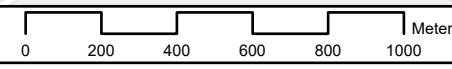
Client

Conwy County Borough Council

Title
Old Colwyn Coastal Defence and Active Travel Scheme
International designations within 2.0km

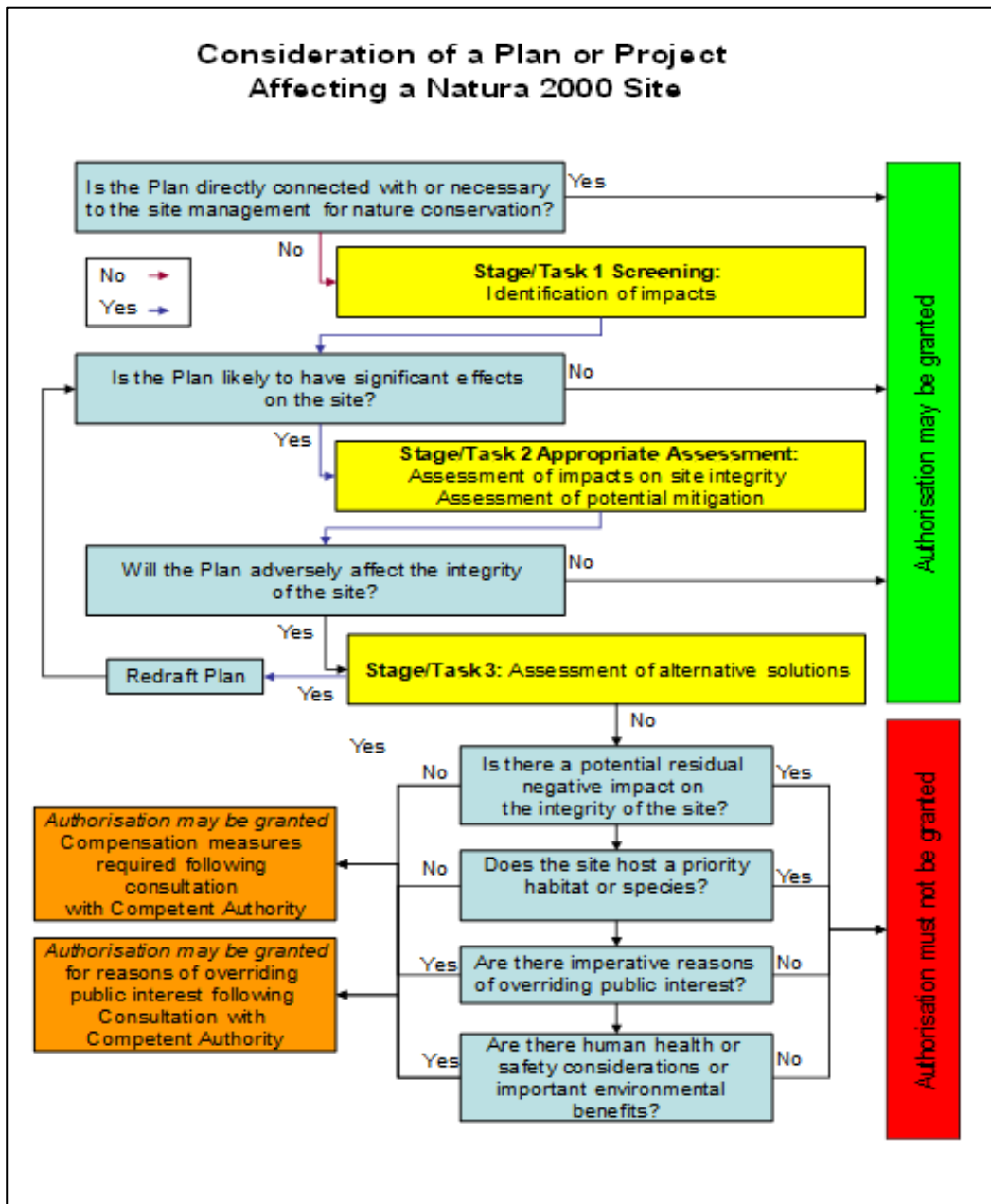
Designed	L Woolley	LW	Eng. Check	N Spofforth	LW
Drawn	S Anstice	MH	Coordination	L Woolley	LW
GIS Check	G O'Donovan	GO	Approved	C Williams	CW

Scale at A3	Status	Rev	Security
1:20,000	INF	P1	STD



B. HRA Process

Figure A.1: The Habitats Regulations Assessment Process



The term 'Task' is used in reference to an HRA of a plan and the term 'Stage' in reference to an HRA of a project.

C. WeBS Raw Data

The raw data has been curtailed to only show the species considered in this report, namely common scoter, common tern, red-throated diver, red-breasted merganser and cormorant. Full information is available on request.

Table 9.1: WeBS sector counts (2014-2019)

Species Code	Species	Taxon Sort	Visit	Count	Species Cover	Location
CX	Common Scoter	5810	Sep-14	51	Good	Abergele to Llandulais
CX	Common Scoter	5810	Oct-14	53	Good	Abergele to Llandulais
CX	Common Scoter	5810	Jan-15	415	Good	Abergele to Llandulais
CX	Common Scoter	5810	Feb-15	710	Good	Abergele to Llandulais
CX	Common Scoter	5810	Mar-15	206	Good	Abergele to Llandulais
CX	Common Scoter	5810	Apr-15	203	Good	Abergele to Llandulais
CX	Common Scoter	5810	May-15	4	Good	Abergele to Llandulais
CX	Common Scoter	5810	Sep-15	0	Good	Abergele to Llandulais
CX	Common Scoter	5810	Oct-15	0	Good	Abergele to Llandulais
CX	Common Scoter	5810	Dec-15	401	Good	Abergele to Llandulais
CX	Common Scoter	5810	Jan-16	200	Good	Abergele to Llandulais
CX	Common Scoter	5810	Feb-16	461	Good	Abergele to Llandulais
CX	Common Scoter	5810	Mar-16	505	Good	Abergele to Llandulais
CX	Common Scoter	5810	Apr-16	0	Good	Abergele to Llandulais
CX	Common Scoter	5810	Sep-16	420	Good	Abergele to Llandulais
CX	Common Scoter	5810	Oct-16	161	Poor	Abergele to Llandulais
CX	Common Scoter	5810	Dec-16	220	Good	Abergele to Llandulais
CX	Common Scoter	5810	Jan-17	0	Good	Abergele to Llandulais
CX	Common Scoter	5810	Feb-17	6	Good	Abergele to Llandulais
CX	Common Scoter	5810	Apr-17	0	Poor	Abergele to Llandulais
CX	Common Scoter	5810	Oct-17	0	Good	Abergele to Llandulais
CX	Common Scoter	5810	Nov-17	268	Good	Abergele to Llandulais
CX	Common Scoter	5810	Dec-17	0	Poor	Abergele to Llandulais
CX	Common Scoter	5810	Feb-18	386	Good	Abergele to Llandulais
CX	Common Scoter	5810	Mar-18	0	Good	Abergele to Llandulais
CX	Common Scoter	5810	Sep-18	0	Good	Abergele to Llandulais
CX	Common Scoter	5810	Oct-18	0	Good	Abergele to Llandulais
CX	Common Scoter	5810	Nov-18	52	Good	Abergele to Llandulais
CX	Common Scoter	5810	Dec-18	44	Good	Abergele to Llandulais
CX	Common Scoter	5810	Jan-19	200	Good	Abergele to Llandulais
CX	Common Scoter	5810	Feb-19	230	Good	Abergele to Llandulais
CX	Common Scoter	5810	Mar-19	4	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Sep-14	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Oct-14	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Jan-15	0	Good	Abergele to Llandulais

Species Code	Species	Taxon Sort	Visit	Count	Species Cover	Location
RM	Red-breasted Merganser	6030	Feb-15	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Mar-15	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Apr-15	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	May-15	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Sep-15	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Oct-15	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Dec-15	1	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Jan-16	1	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Feb-16	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Mar-16	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Apr-16	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Sep-16	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Oct-16	0	Poor	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Dec-16	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Jan-17	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Feb-17	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Apr-17	0	Poor	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Oct-17	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Nov-17	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Dec-17	0	Poor	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Feb-18	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Mar-18	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Sep-18	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Oct-18	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Nov-18	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Dec-18	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Jan-19	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Feb-19	0	Good	Abergele to Llandulais
RM	Red-breasted Merganser	6030	Mar-19	0	Good	Abergele to Llandulais
CA	Cormorant	25040	Sep-14	1	Good	Abergele to Llandulais
CA	Cormorant	25040	Oct-14	4	Good	Abergele to Llandulais
CA	Cormorant	25040	Jan-15	5	Good	Abergele to Llandulais
CA	Cormorant	25040	Feb-15	7	Good	Abergele to Llandulais
CA	Cormorant	25040	Mar-15	3	Good	Abergele to Llandulais
CA	Cormorant	25040	Apr-15	5	Good	Abergele to Llandulais
CA	Cormorant	25040	May-15	23	Good	Abergele to Llandulais
CA	Cormorant	25040	Sep-15	21	Good	Abergele to Llandulais
CA	Cormorant	25040	Oct-15	11	Good	Abergele to Llandulais
CA	Cormorant	25040	Dec-15	10	Good	Abergele to Llandulais
CA	Cormorant	25040	Jan-16	17	Good	Abergele to Llandulais
CA	Cormorant	25040	Feb-16	2	Good	Abergele to Llandulais
CA	Cormorant	25040	Mar-16	2	Good	Abergele to Llandulais
CA	Cormorant	25040	Apr-16	3	Good	Abergele to Llandulais

Species Code	Species	Taxon Sort	Visit	Count	Species Cover	Location
CA	Cormorant	25040	Sep-16	74	Good	Abergele to Llandulais
CA	Cormorant	25040	Oct-16	63	Poor	Abergele to Llandulais
CA	Cormorant	25040	Dec-16	7	Good	Abergele to Llandulais
CA	Cormorant	25040	Jan-17	2	Good	Abergele to Llandulais
CA	Cormorant	25040	Feb-17	0	Good	Abergele to Llandulais
CA	Cormorant	25040	Apr-17	3	Poor	Abergele to Llandulais
CA	Cormorant	25040	Oct-17	6	Good	Abergele to Llandulais
CA	Cormorant	25040	Nov-17	26	Good	Abergele to Llandulais
CA	Cormorant	25040	Dec-17	11	Poor	Abergele to Llandulais
CA	Cormorant	25040	Feb-18	7	Good	Abergele to Llandulais
CA	Cormorant	25040	Mar-18	1	Good	Abergele to Llandulais
CA	Cormorant	25040	Sep-18	10	Good	Abergele to Llandulais
CA	Cormorant	25040	Oct-18	5	Good	Abergele to Llandulais
CA	Cormorant	25040	Nov-18	21	Good	Abergele to Llandulais
CA	Cormorant	25040	Dec-18	11	Good	Abergele to Llandulais
CA	Cormorant	25040	Jan-19	14	Good	Abergele to Llandulais
CA	Cormorant	25040	Feb-19	14	Good	Abergele to Llandulais
CA	Cormorant	25040	Mar-19	5	Good	Abergele to Llandulais
CN	Common Tern	46930	Sep-14	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Oct-14	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Jan-15	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Feb-15	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Mar-15	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Apr-15	0	Good	Abergele to Llandulais
CN	Common Tern	46930	May-15	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Sep-15	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Oct-15	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Dec-15	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Jan-16	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Feb-16	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Mar-16	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Apr-16	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Sep-16	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Oct-16	0	Poor	Abergele to Llandulais
CN	Common Tern	46930	Dec-16	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Jan-17	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Feb-17	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Apr-17	0	Poor	Abergele to Llandulais
CN	Common Tern	46930	Oct-17	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Nov-17	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Dec-17	0	Poor	Abergele to Llandulais
CN	Common Tern	46930	Feb-18	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Mar-18	0	Good	Abergele to Llandulais

Species Code	Species	Taxon Sort	Visit	Count	Species Cover	Location
CN	Common Tern	46930	Sep-18	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Oct-18	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Nov-18	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Dec-18	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Jan-19	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Feb-19	0	Good	Abergele to Llandulais
CN	Common Tern	46930	Mar-19	0	Good	Abergele to Llandulais
CX	Common Scoter	5810	Dec-14	20000	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Jan-15	3000	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Feb-15	2000	Poor	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Mar-15	4000	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Apr-15	300	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	May-15	0	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Jun-15	0	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Jul-15	2100	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Aug-15	6000	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Sep-15	300	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Oct-15	200	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Dec-15	8000	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Jan-16	350	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Feb-16	400	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Mar-16	600	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Apr-16	0	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	May-16	101	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Jun-16	0	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Aug-16	0	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Sep-16	4	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Oct-16	400	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Dec-16	3000	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Jan-17	200	Poor	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Feb-17	5	Poor	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Mar-17	730	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Apr-17	1	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Jul-17	0	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Aug-17	400	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Sep-17	0	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Oct-17	3000	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Dec-17	1500	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Jan-18	1800	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Feb-18	4500	Poor	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Mar-18	4000	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Apr-18	0	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	May-18	4	Good	Colwyn Bay to Rhos Point

Species Code	Species	Taxon Sort	Visit	Count	Species Cover	Location
CX	Common Scoter	5810	Oct-18	1	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Jan-19	1000	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Feb-19	5000	Good	Colwyn Bay to Rhos Point
CX	Common Scoter	5810	Mar-19	3000	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Dec-14	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Jan-15	21	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Feb-15	0	Poor	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Mar-15	6	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Apr-15	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	May-15	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Jun-15	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Jul-15	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Aug-15	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Sep-15	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Oct-15	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Dec-15	21	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Jan-16	17	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Feb-16	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Mar-16	2	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Apr-16	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	May-16	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Jun-16	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Aug-16	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Sep-16	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Oct-16	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Dec-16	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Jan-17	0	Poor	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Feb-17	0	Poor	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Mar-17	1	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Apr-17	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Jul-17	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Aug-17	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Sep-17	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Oct-17	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Dec-17	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Jan-18	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Feb-18	0	Poor	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Mar-18	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Apr-18	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	May-18	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Oct-18	0	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Jan-19	2	Good	Colwyn Bay to Rhos Point
RM	Red-breasted Merganser	6030	Feb-19	7	Good	Colwyn Bay to Rhos Point

Species Code	Species	Taxon Sort	Visit	Count	Species Cover	Location
RM	Red-breasted Merganser	6030	Mar-19	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Dec-14	6	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Jan-15	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Feb-15	1	Poor	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Mar-15	17	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Apr-15	2	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	May-15	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Jun-15	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Jul-15	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Aug-15	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Sep-15	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Oct-15	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Dec-15	58	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Jan-16	6	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Feb-16	3	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Mar-16	1	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Apr-16	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	May-16	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Jun-16	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Aug-16	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Sep-16	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Oct-16	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Dec-16	5	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Jan-17	1	Poor	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Feb-17	0	Poor	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Mar-17	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Apr-17	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Jul-17	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Aug-17	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Sep-17	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Oct-17	1	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Dec-17	3	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Jan-18	13	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Feb-18	3	Poor	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Mar-18	4	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Apr-18	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	May-18	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Oct-18	0	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Jan-19	6	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Feb-19	24	Good	Colwyn Bay to Rhos Point
RH	Red-throated Diver	16760	Mar-19	0	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Dec-14	10	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Jan-15	2	Good	Colwyn Bay to Rhos Point

Species Code	Species	Taxon Sort	Visit	Count	Species Cover	Location
CA	Cormorant	25040	Feb-15	4	Poor	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Mar-15	14	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Apr-15	4	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	May-15	26	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Jun-15	1	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Jul-15	2	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Aug-15	12	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Sep-15	4	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Oct-15	0	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Dec-15	22	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Jan-16	21	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Feb-16	20	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Mar-16	1	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Apr-16	3	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	May-16	16	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Jun-16	3	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Aug-16	3	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Sep-16	2	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Oct-16	4	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Dec-16	14	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Jan-17	53	Poor	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Feb-17	2	Poor	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Mar-17	8	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Apr-17	3	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Jul-17	3	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Aug-17	6	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Sep-17	5	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Oct-17	30	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Dec-17	18	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Jan-18	16	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Feb-18	3	Poor	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Mar-18	0	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Apr-18	2	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	May-18	14	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Oct-18	4	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Jan-19	26	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Feb-19	10	Good	Colwyn Bay to Rhos Point
CA	Cormorant	25040	Mar-19	19	Good	Colwyn Bay to Rhos Point

Source: BTO (2020)

D. Distribution Maps (JNCC Report Extracts)

Lawson *et al.* (2016) includes the distribution maps showing the location of red-throated diver, common scoter and little gull within the Liverpool Bay SPA. Extracts from this report are provided here.

3.2 Distribution and densities of birds in Liverpool Bay/Bae Lerpwl area of search

3.2.1 Red-throated diver

The higher density areas of red-throated diver are located along the coastline close inshore. The main aggregation of red-throated diver is captured within the existing Liverpool Bay/Bae Lerpwl SPA, although a satellite aggregation is evident to the north of this, adjacent to the Duddon Estuary SPA and extending around towards Morecambe Bay.

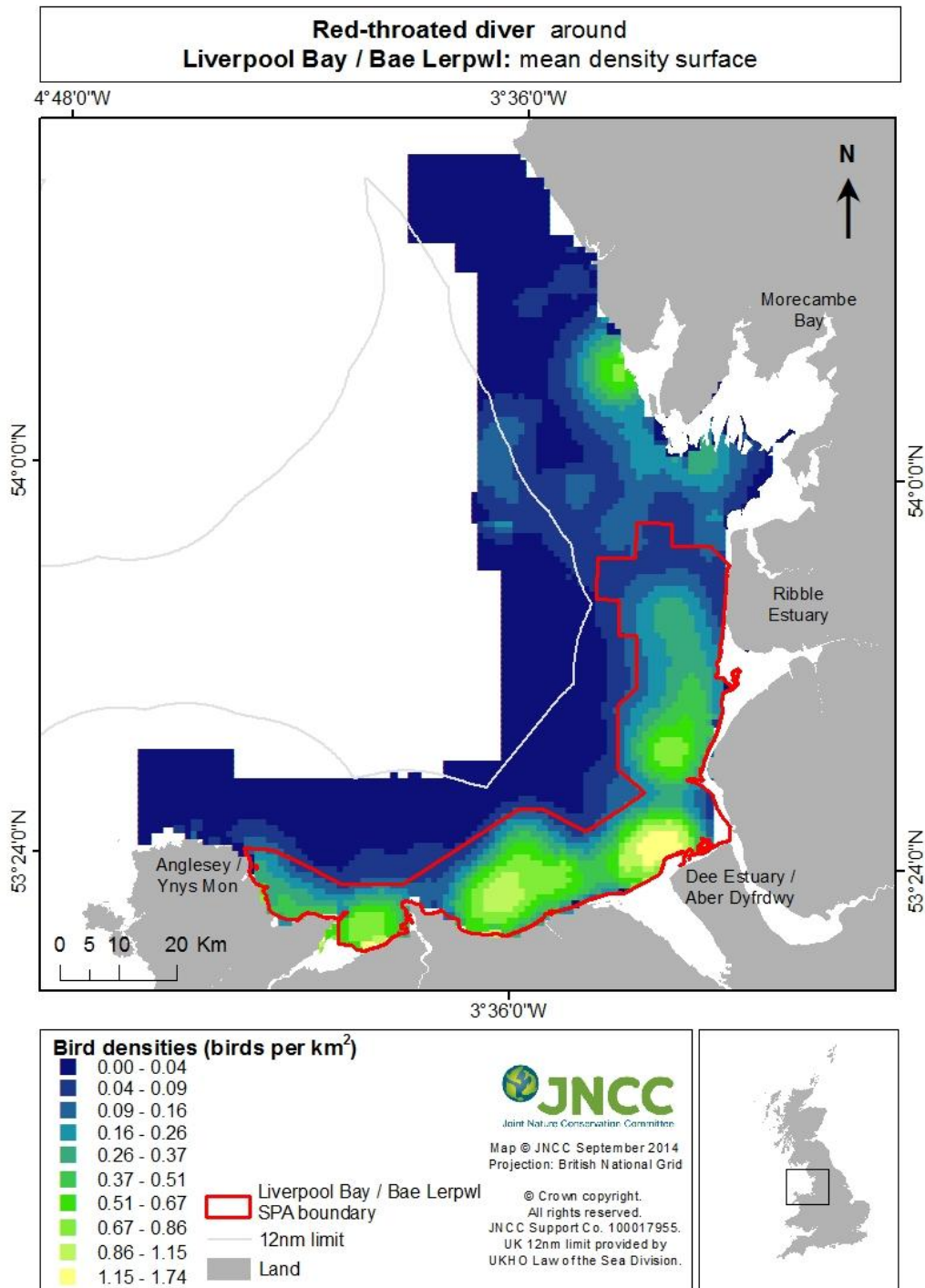


Figure 6. Estimated mean density surface of red-throated diver recorded from aerial surveys within Liverpool Bay/Bae Lerpwl area of search (2004/05, 2005/06, 2006/07, 2007/08, 2010/11).

3.2.2 Common scoter

Two main aggregations of common scoter are evident from the mean density surface and these are contained within the existing Liverpool Bay/Bae Lerpwl SPA.

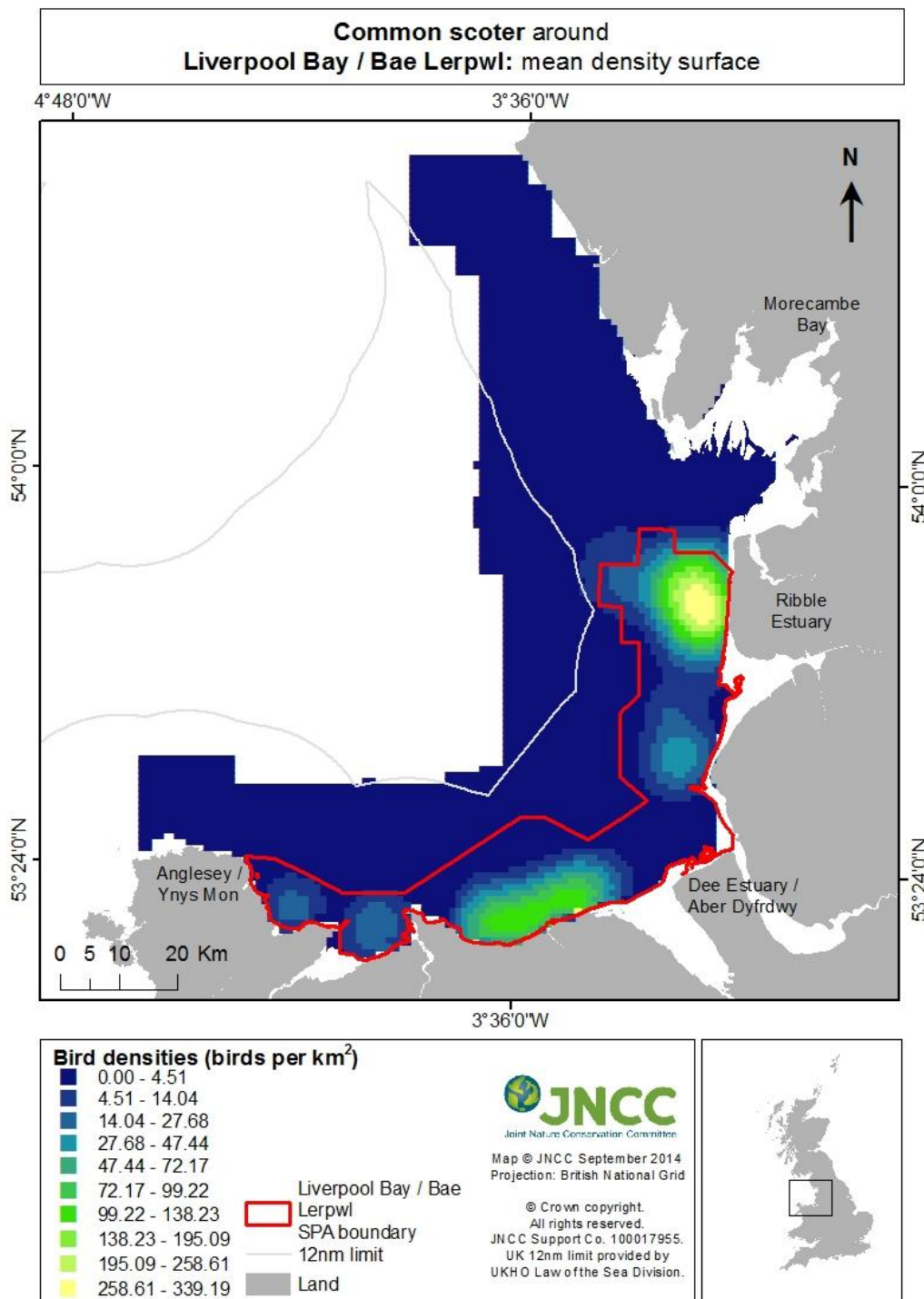


Figure 7. Estimated mean density surface of common scoter recorded from aerial surveys within Liverpool Bay/Bae Lerpwl area of search (2004/05, 2005/06, 2006/07, 2007/08, 2010/11).

3.2.3 Little gull

Observations of little gull within the Liverpool Bay/Bae Lerpwl area of search were concentrated off Blackpool close to the 12 nautical mile limit, the mean density surface reflects this pattern (Figure 8 and Figure 9), the higher density aggregation of little gull extends beyond the existing Liverpool/Bae Lerpwl SPA boundary to just beyond the 12 nautical mile line.

To assess the consistency of these aggregations or hotspots, the density threshold (0.0648 birds per km²) - determined by maximum curvature analysis - was applied to each survey-specific density surface. As a result each cell on the surface with a density equal to or greater than the density threshold was given a score of 1 (hotspot present) and cells with a density less than the threshold were given a score of 0 (hotspot absent). The survey-specific density surfaces were then overlaid and summed to create a hotspot assessment surface, such that each cell on this surface had a count of the number of times a hotspot was present in that cell.

The results of this hotspot analysis are presented in Figure 10 and shows that little gull were consistently present in a well defined location within the Liverpool Bay/Bae Lerpwl area of search. Twelve surveys were assessed in the hotspot analysis from the seasons (2004/05–2010/11), though the area covered varied between surveys.

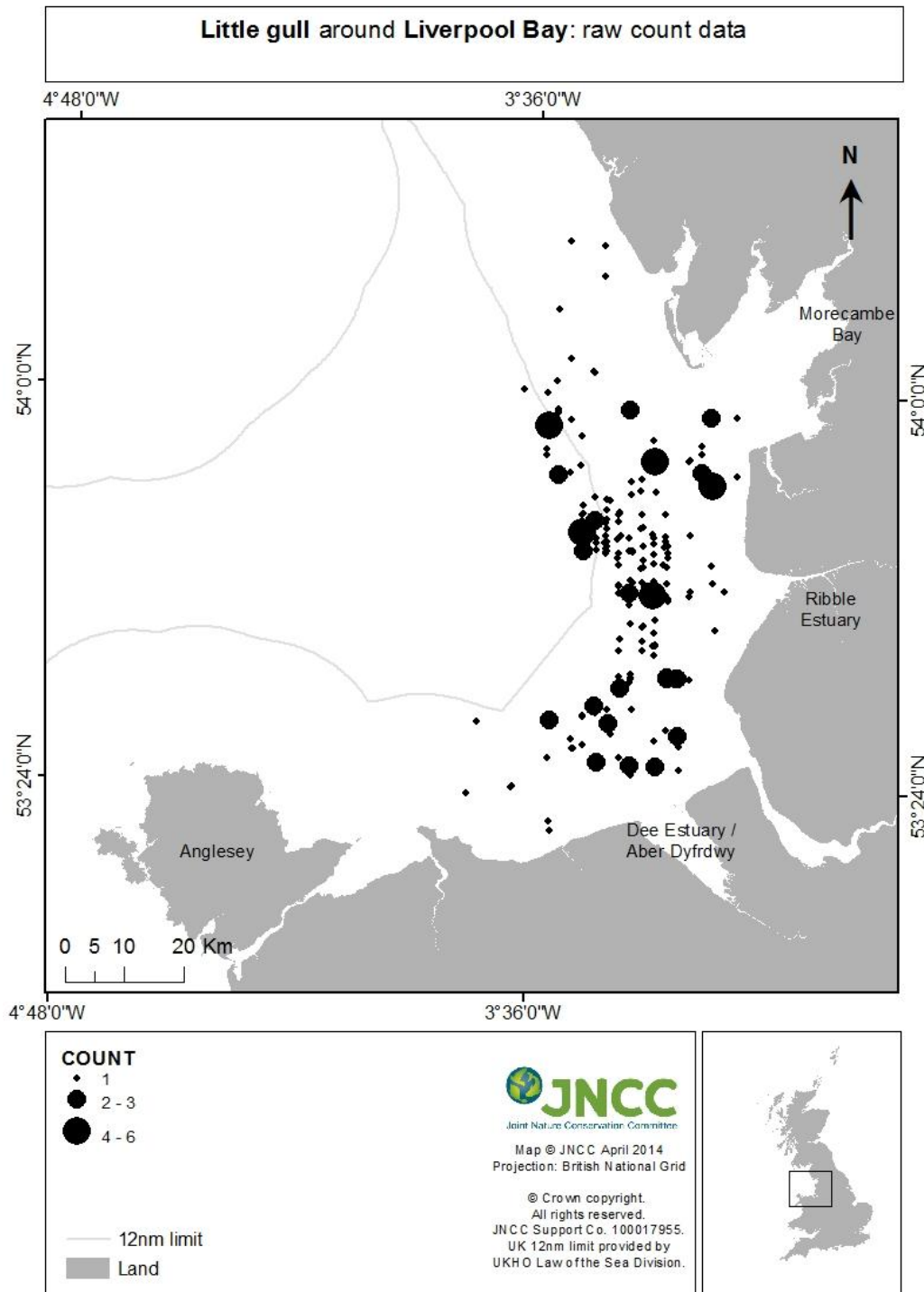


Figure 8. Raw count data of little gull recorded during WWT Consulting aerial surveys within Liverpool Bay/Bae Lerpwl area of search (2004/05, 2005/06, 2006/07, 2007/08, 2010/11).

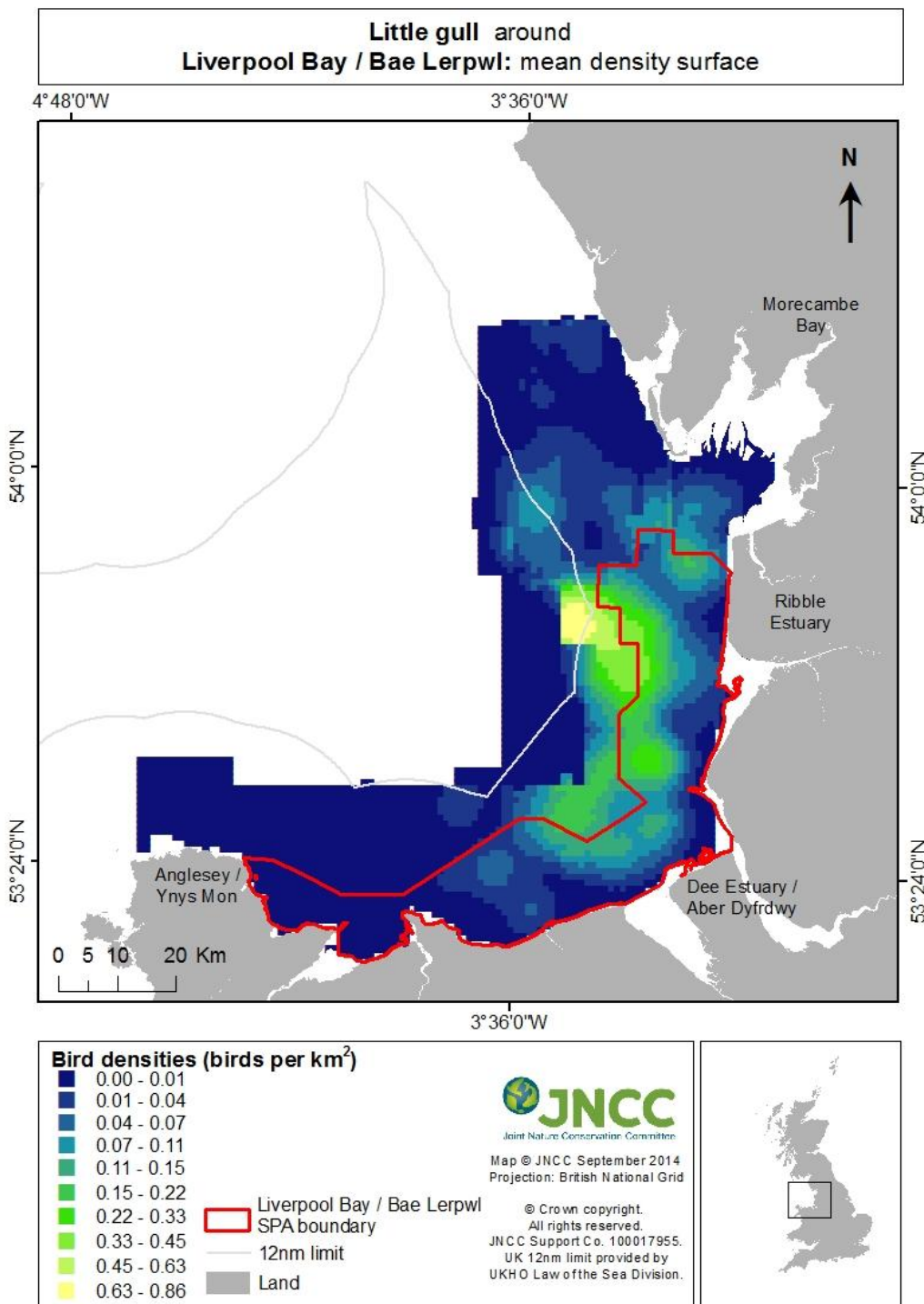


Figure 9. Estimated mean density surface of little gull recorded from aerial surveys within Liverpool Bay/Bae Lerpwl area of search (2004/05, 2005/06, 2006/07, 2007/08, 2010/11).

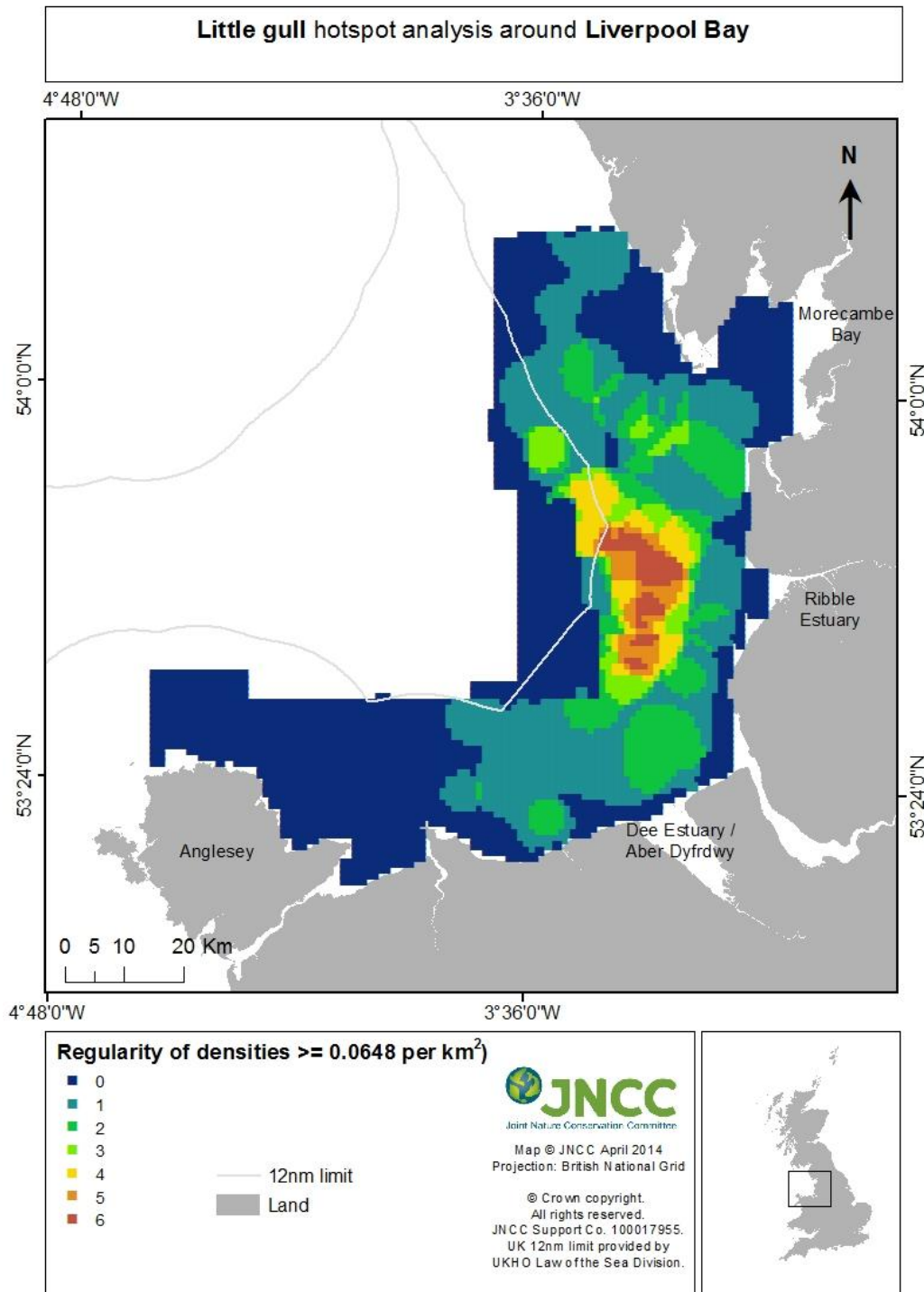


Figure 10. The number of surveys on which little gull densities met or exceeded the maximum curvature density threshold (0.0648 birds per km²) in the Liverpool Bay/Bae Lerpwl area of search.



Appendix 10.2 – Flood Consequence Assessment



Old Colwyn Coastal Defence and Active Travel

Flood Consequence Assessment (FCA)

July 2020

Mott MacDonald
Mott MacDonald House
8-10 Sydenham Road
Croydon CR0 2EE
United Kingdom

T +44 (0)20 8774 2000
mottmac.com

Conwy County Borough
Council
Environment, Roads &
Facilities
Swyddfeydd Mochdre
Ffordd Conway
Mochdre
BAE COLWYN
LL28 5AB

Old Colwyn Coastal Defence and Active Travel

Flood Consequence Assessment (FCA)

July 2020

Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
P01	July 2020	E. Smyth	V. Deakin	Z. Hutchison	First Issue

Document reference: 415437-MMD-00-XX-RP-N-1720

Information class: Standard

This document is issued for the party which commissioned it and for specific purposes connected with the above-captioned project only. It should not be relied upon by any other party or used for any other purpose.

We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

This document contains confidential information and proprietary intellectual property. It should not be shown to other parties without consent from us and from the party which commissioned it.

Contents

Abbreviations and Acronyms	1
1 Introduction	2
1.1 Overview	2
1.2 Current Flood Risk	2
1.3 Proposed Scheme	4
1.4 Construction Works Methodology	5
1.4.1 Timescales	5
1.4.2 Promenade and Active Travel Improvements	5
1.4.3 Construction Compounds	6
1.5 Requirements of the FCA	6
2 Flood Zone Category and Justification	7
3 TAN15 Acceptability Criteria	9
4 Potential Sources of Flooding and Probability	10
4.1 Coastal Flooding	10
4.2 Fluvial Flooding	13
4.3 Surface Water Flooding	13
4.4 Construction Flood Risk Management	13
4.5 Potential Flooding impacts of Proposed Scheme	14
5 Acceptable Consequences for Nature of Use	15
6 Occupiers Awareness of Flood Risk and Flood Warnings Procedures	17
7 Flood Resilient Design	18
8 No Increase in Flooding Elsewhere	19
9 Summary and Conclusions	20
10 Recommendations	21
A. Location Plan and Existing Arrangement	22
B. Proposed Scheme Plan and Cross-Sections	23

C. Wave Overtopping Report

24

Tables

Table 2.1: Flood Zone Classification	7
Table 4.1: Extreme Wave Height and Water Levels	11
Table 4.2: Overtopping Results	12
Table 4.3: Recommended Discharge Limits for Assets and Users	12
Table 4.4: Potential impacts of proposed Scheme	14
Table 5.1: Flood Frequency Thresholds from TAN15	15
Table 5.2: Tolerable Conditions from TAN15	15

Figures

Figure 1.1: Examples of Storm Damage at Old Colwyn	3
Figure 2.1: Colwyn Bay surface water flood risk	8

Abbreviations and Acronyms

CCBC	Conwy County Borough Council
FCA	Flood Consequence Assessment
FR&I	Flood Risk and Infrastructure
HM	Harbourmaster
Hs	Significant wave height
NGR	National Grid Reference
NWC	North West & Central – Network Rail
NWR	Natural Resources Wales
PPW	Planning Policy Wales
OD	Ordnance Datum
OS	Open Spaces
RCP	Representative Concentration Pathway
RP	Return period
TAN15	Technical Advice Note 15: Development and Flood Risk

1 Introduction

1.1 Overview

Mott MacDonald has been appointed by Conwy County Borough Council (CCBC) Environment, Roads and Facilities Team (hereafter referred to as “the Applicant”) to prepare a Flood Consequence Assessment (FCA) to accompany the Environmental Statement, for the Old Colwyn Coastal Defence and Active Travel Scheme (hereafter referred to as the ‘Scheme’). A location plan and the current coastal defences are included in Appendix A.

1.2 Current Flood Risk

As early as 1991, the Colwyn Borough Sea Defence Review¹ identified that “overtopping, which occurs regularly when onshore winds coincide with spring tides, results in large quantities of shingle and cobbles being thrown over the wall. The road is closed up to a dozen times a year for several days at a time while the shingle is cleaned back onto the beach”. These conditions have continued to the present day with increasing frequency and severity.

The observed impacts of present-day conditions from more recent storm events – February 2005, March 2007, March 2010, December 2013, December 2016, December 2017, February/March 2018, January 2019 etc², confirms the overtopping behaviour identified by HR Wallingford but also identifies the following as taking place:

- Damage/loss of railings;
- Damage to promenade/highway surfacing and removal of fill behind sea wall;
- Damage to boundary wall and erosion at toe of railway embankment;
- Lowering of beach levels in front of the wall;
- Undermining of sea wall; and
- Removal of facing blocks to the sea wall.

Examples of this damage are provided in Figure 1.1.

Furthermore, with sea levels predicted to rise in the future, due to anticipated climate change, by the end of the 21st century the tide is anticipated to reach approximately the crest of the current wall (which varies between +5.00m OD to +6.20m OD) on each spring tide i.e. every 2 weeks.

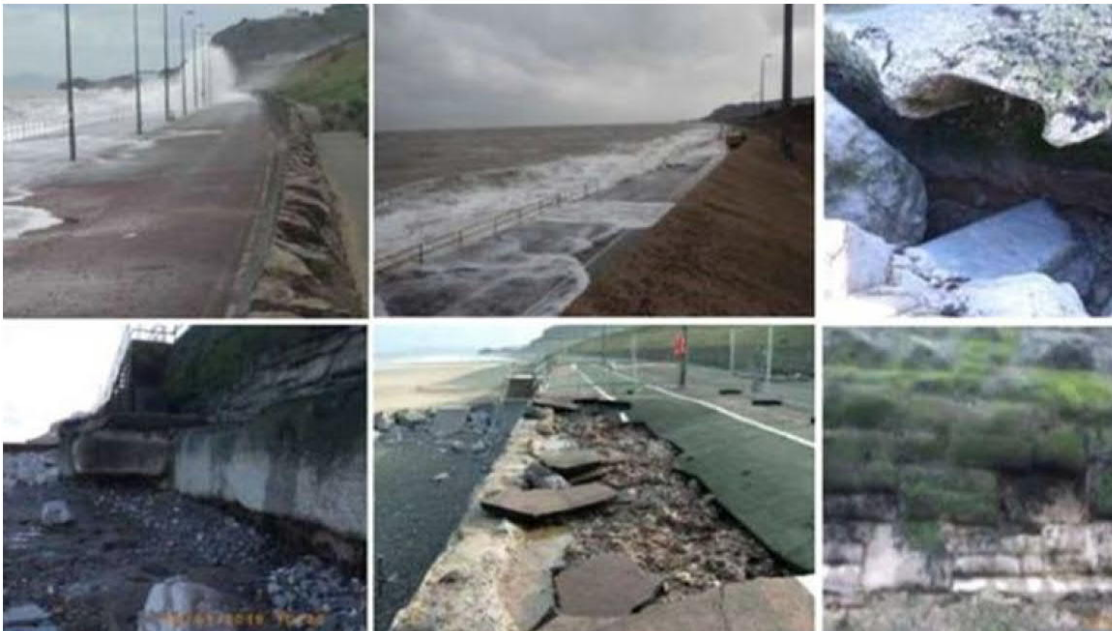
The current seawall provides protection to the following assets:

- The pedestrian promenade and designated cycle path, which is part of the National Cycle Network Route 5;
- The promenade highway, linking Old Colwyn to Rhos-on-Sea;
- The North West & Central (NWC) Railway Line;
- The A55 trunk highway; and
- Utilities services buried underneath the promenade or promenade highway surfacing.

¹ HR Wallingford, 1991. Colwyn Borough Sea Defence Review (Report EX 2367). UK: H R Wallingford.

² Mott MacDonald. (2020a). Old Colwyn Promenade Coastal Defence & Active Travel Improvement – Basis of Design Report - 415437-MMD-00-XX-RP-C-3100. Mott MacDonald

Figure 1.1: Examples of Storm Damage at Old Colwyn



Source: BBC, 2019³

CCBC currently have an operational procedure to manage the risk to promenade users from high tides and or damage⁴. The key elements of this procedure are summarised below:

- The trigger conditions for potential closure of the promenade is a tide level of 3.9m OD or greater, which typically is predicted to occur for periods of up to 7 days at a time, 1-2 times per month, concurrently with strong onshore winds, from directions north-west to north-east (onshore);
- Following review of the data the decision for closure is taken by Council staff from the Flood Risk and Infrastructure (FR&I), Open Spaces (OS) and Harbourmaster (HM) departments. County Councillors for the immediate location are informed directly and CCBC's marketing department inform the general public via social media;
- The road barrier at Cliff Gardens (by the arches at Splashpoint) is closed first, followed by a walk through the Promenade length to inform remaining cars, followed by closure of the road barrier at Rotary Way junction and Marine road junction;
- When the high tide has passed, an inspection of the coastal defence is carried out by FR&I to record condition and to ensure that the promenade is safe to re-open. Any debris thrown up onto the Promenade during the storm is cleared before re-opening; and
- County Councillors for the immediate location are informed directly and CCBC's marketing department inform the general public via social media that the promenade has been re-opened.

³ BBC. (2019). Weather and storm defences: Who pays when sea walls crumble? [online]. Available at: <https://www.bbc.co.uk/news/uk-wales-50069665>, photos by CCBC [Accessed 13 July 2020].

⁴ Mott MacDonald. (2020b). Old Colwyn Promenade Coastal Defence & Active Travel Environmental Statement – Volume 1: Main Text. - 415437-MMD-00-XX-RP-N-1719. Mott MacDonald.

During autumn and winter seasons when there are consecutive days of high tides and onshore winds, or when repairs are required following storm damage, the promenade can remain closed for a few days or longer at a time.

Should construction of this Scheme not be implemented in the near future, CCBC have indicated that it is highly likely that a decision will have to be made as to whether to continue to carry out repairs. Should the decision be that repairs will not sustain the defences any further, then a decision to permanently shut the promenade, with the associated consequences for general users and particularly the emergency services, would have to be made.

The current overtopping rates for the frontage have been assessed and are presented in Appendix C. The results indicated that for a current 1 in 10-year return period the maximum overtopping discharge (q) estimated is 690 l/m/s with a maximum overtopping volume (V_{max}) of 57,500 l/m. These values are significantly higher than the limits proposed by guidelines and impose risk to public health and safety, as well as risk for the protected assets beyond the sea wall.

1.3 Proposed Scheme

The Scheme is located in the Old Colwyn area of Colwyn Bay and comprises coastal defence works in the form of a new rock revetment and promenade raising. This is in combination with improvements to the promenade to facilitate active travel. The proposed Scheme and sections are included in Appendix B.

The proposed rock revetment is +7.5m OD at approximately 32m in cross sectional width, 1.2km in length with an approximately 5m wide crest and a slope of 1:3 down to beach level. The revetment is required to protect the active travel routes along the promenade along with the Promenade highway, underground services, NWC Railway Line and A55 Expressway. The revetment will tie-in to the existing rock revetment east of Porth Eirias to the west and Splashpoint to the east – the toes and crests would merge as cross-sections are very similar.

Modifications to five existing outfalls would be required along the length of the revetment including extensions and protective slabs where necessary. The revetment toe would need to be widened locally to 7.2m (from typically 3.6m) at two locations. Stainless steel grills would be fixed to the end of each of the three culverts which are to be extended.

A new access build out area would be constructed in the western half of Area 1, located between Porth Eirias and the first set of beach groynes, to the north-east of the picnic area.

New pedestrian accesses through the proposed revetment to comprise three sets of beach access steps perpendicular to the linear rock revetment, would be constructed at the location of each of the three longest groynes within the Scheme area to the west of Rotary Way

The existing groynes present would be retained, maintained and enhanced ecologically. Concrete access steps would be provided across the southernmost section of each groyne adjacent to the revetment.

The existing slipway at Splashpoint would be retained in its current location.

A fishing platform would be constructed in the Splashpoint Area to ensure anglers to not block active travel routes (as is currently the case). The platform would be accessed from a pedestrian only area and extend out over the revetment with supporting steelworks to be pocketed into the raised sea wall structure at this location. Access to fishing platform walkway would have a galvanised steel chain with signage prohibiting access during dangerous weather condition.

The raising of the promenade and the construction of the rock revetment are required to reduce overtopping levels for present day, whilst considering future sea levels as a result of climate change. The new promenade finished level is to be +7.0m OD at directly behind the seawall, with the promenade slabs typically falling approximately 1:40 towards the seawall to allow over the edge drainage for surface water run-off .

In addition to the above works the Scheme will provide:

- Improvements to pedestrian and cycle paths;
- Picnic and outdoor education area;
- Landscape improvements;
- Parking improvements;
- Highway improvements; and
- Concessions building foundation - The actual building for the site is currently unknown and will therefore be subject to its own FCA.

1.4 Construction Works Methodology

The Scheme is currently at detailed design stage and the following is based discussions with the Applicant, examining information from previous Phases of the Colwyn Bay Waterfront Project and some limited Early Contractor Engagement. The below is a preliminary outline methodology and is subject to amendment, consent and construction stage contractor methodology and risk assessments.

1.4.1 Timescales

CCBC are currently seeking funding for these critical works. There are a number of stakeholders and the amount of funding required is considerable, therefore it is not possible at this time to predict when the works may go ahead. However, the following programme assumptions have been made:

- Detailed design of the Project will be complete in Summer 2020;
- Finance is available to enable a Spring 2021 start;
- Planning is granted prior to tender action; and
- The Project is delivered as one scheme.

1.4.2 Promenade and Active Travel Improvements

To provide improved costal protection to the promenade, highway, railways embankment and welsh water assets the promenade crest height would be raised. The existing sea walls would be raised by constructing new reinforced concrete (RC) sea walls on top of the existing, therefore reusing the existing structures as much as possible and reducing associated structural disturbance.

The new RC structures along the promenade seaward edge would not be constructed nor the promenade raised until the new rock revetment is constructed to the existing promenade level. To provide restraint to the existing sea wall, the lower section of existing sea wall would be embedded by fill material and the rock armour would be constructed to rest against the sea wall (as discussed in Paragraph 4.4.54). In the western section, the existing recurved sea wall upstand would remain in place and a mass gravity reinforced concrete stepped wall would be constructed on top. Along the majority of the remaining seaward edge the existing sea wall coping would be locally removed, and a new reinforced concrete balanced cantilevered wall would be built on top.

Possible localised existing voids in the highway and promenade would be remediated (by excavating voids and backfilling with compacted granular fill). Along the lower western highway section and splash point, new drainage pipes, kerbing, services ducts, street lighting / sign foundations and back of promenade retaining wall foundations which are lower than the new finished promenade level would be installed.

Elsewhere where the promenade / Promenade highway would be raised, and the existing surfacing would be perforated for drainage by core drilling on a local grid (so the existing highway can typically remain in-situ). Suitable compacted granular fill in accordance with the specification of highway works (ideally from recycled suitable materials) would be installed in layers. During this process new drainage pipes, services ducts, kerbing, street lighting and sign foundations would be constructed. After the promenade and highway is raised the new RC promenade slabs, highway sub-base and asphalt pavement and footway paving would be installed.

Once the heavy civil engineering works are complete, the street furniture, signs, artwork features, lighting, landscaping, road markings etc would be installed.

1.4.3 Construction Compounds

The location of the construction compounds for the Scheme have not yet been finalised. It is likely that there would be more than one and that there may be several different locations along the promenade within the red line boundary as the Scheme progresses (as dictated by the phasing of construction).

1.5 Requirements of the FCA

This FCA establishes *'whether appropriate mitigation measures can be incorporated within the design of the development to ensure that development minimises risk to life, damage to property and disruption to people living and working on the site or elsewhere in the floodplain'*⁵.

⁵ Welsh Assembly Government. (2004). Planning Policy Wales – Technical Advice Note 15: Development and Flood Risk. [online]. Welsh Assembly Government Available at: <https://gov.wales/sites/default/files/publications/2018-09/tan15-development-flood-risk.pdf> [Accessed 13 July 2020].

2 Flood Zone Category and Justification

Planning Policy Wales (PPW) edition 9 was published in 2016 and outlines the land use planning policies and the planning system for the Wales. The PPW is supported by the Technical Advice Notes (TANs), including TAN15: Development and Flood Risk. The TAN15 is guidance for Welsh local planning authorities to reduce flood risk and encourage developments away from high risk areas. The TAN 15 provides a framework within which risks arising from both river and coastal flooding, and from additional run-off from development in any location, can be assessed. The TAN15 has been followed within this FCA to justify the proposed Scheme.

Within the TAN15, Wales is divided into three flood zones, with flood zone A representing little to no risk to flood zone C being the areas of higher flood risk. Flood zone C is then further subdivided into flood zones C1 and C2, indicating if the area has defences or not. Table 2.1, taken from the TAN15, outlines these flood zones.

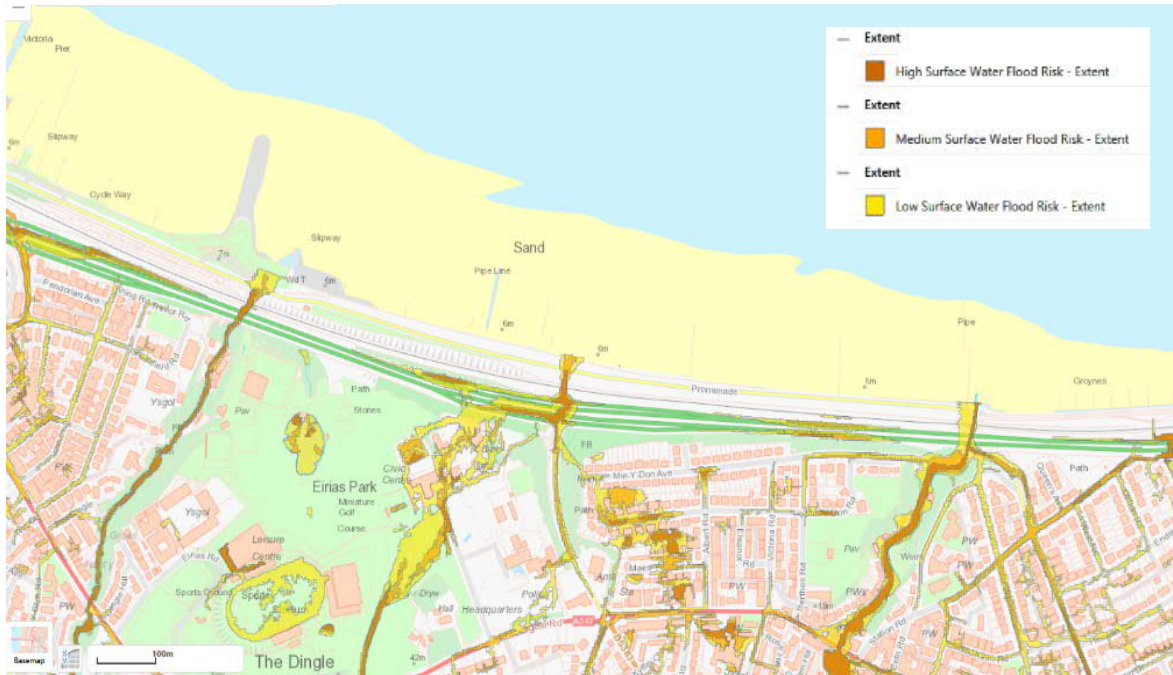
Table 2.1: Flood Zone Classification

Description of zone	Zone	Use Within the Precautionary Framework
Considered to be at little or no risk of fluvial or tidal/coastal flooding.	A	Used to indicate that justification test is not applicable and no need to consider flood risk further
Areas known to have been flooded in the past evidenced by sedimentary deposits.	B	Used as part of a precautionary approach to indicate where site levels should be checked against the extreme (0.1%) flood level. If site levels are greater than the flood levels used to define adjacent extreme flood outline there is no need to consider flood risk further.
Based on Environment Agency extreme flood outline, equal to or greater than 0.1% (river, tidal or coastal)	C	Used to indicate that flooding issues should be considered as an integral part of decision making by the application of the justification test including assessment of consequences.
Areas of the floodplain which are developed and served by significant infrastructure, including flood defences.	C1	Used to indicate that development can take place subject to application of justification test, including acceptability of consequences.
Areas of the floodplain without significant flood defence infrastructure.	C2	Used to indicate that only less vulnerable development should be considered subject to application of justification test, including acceptability of consequences. Emergency services and highly vulnerable development should not be considered.

Source: Welsh Assembly Government, 2004.

Indicated in the Welsh Government Development Advice Map (Figure 2.1), the site is located within Flood Zone C2. This classification indicates the areas is at flood risk of a 1 in 1000-year return period (RP) within any given year.

Figure 2.1: Colwyn Bay Surface Water Flood Risk



Source: Welsh Government, 2017. (Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved. Some features of this information are based on digital spatial data licensed from the UK Centre for Ecology & Hydrology © UKCEH, the Environment Agency © EA and Getmapping Plc and Bluesky International Limited [2015]. Defra, Met Office and DARD Rivers Agency © Crown copyright. © Cranfield University. © James Hutton Institute. Contains OS data © Crown copyright and database right. Land & Property Services © Crown copyright and database right.)

The Welsh Government's Technical Advice Note 15 - Development and Flood Risk (TAN15) Figure 2 outlines the different land uses to flooding. However, coastal defence Schemes are not classified within this land use classification, and therefore fall under 'other' for this FCA assessment. In Section 9 'Summary of Policy Requirements' of the TAN15, development types that are classified as 'other' can be considered within Flood Zone C2. However, the proposed Scheme by virtue of its purpose must be located within the coastal frontage, and as it is a form of flood defence infrastructure, it is not required to be subjected to the justification test of the TAN15.

3 TAN15 Acceptability Criteria

Section 9 'Summary of Policy Requirements' of the TAN15, states that developments classified as 'other' within Zone C2 must satisfy the below Acceptability Criteria:

- Acceptable consequence for nature of use;
- Occupiers aware of flood risk;
- Effective flood warning provided;
- Flood resilient design; and
- No increase in flooding elsewhere.

The criteria listed above are reviewed in Section 5 to Section 8. However, the potential sources of flooding are considered in Section 4 to assist with this assessment.

4 Potential Sources of Flooding and Probability

4.1 Coastal Flooding

As the proposed Scheme is a coastal flood defence infrastructure project the primary source of flood risk within the project area is therefore from coastal flooding.

The extreme wave and water levels for the Scheme area were extracted from Modelling completed by Royal Haskoning in 2010⁶ at a location offshore from Colwyn Bay. These values were propagated from the offshore location to the project area (toe of the proposed rock revetment) by applying the Goda shoaling formula. This calculation was done for four beach profiles within the project area⁷. Present day water levels and climate change water levels (based on UK Climate Projections RCP 8.5 (UKCP 18)⁸ in 50 years were assessed to determine the flood risk to the local area from the proposed coastal defence Scheme. A summary of the water levels and extreme wave height is provided in Table 4.1.

It should be noted that the proposed Scheme is adaptable, where the sea defences can be raised in the future in line with sea level rise. This was agreed with the CCBC in order for the Scheme to be cost-effective. Therefore, 50-years of climate change induced sea level rise and a 1 in 100-year return period were the highest events reviewed in this assessment.

⁶ Colwyn Bay Detailed Modelling Study for Coast Defence Scheme, Royal Haskoning, June 2010

⁷ Mott MacDonald. (2020c). Old Colwyn Promenade Defence & Active Travel Improvements – Wave Overtopping Assessment - 415437-MMD-C-R-00-XX-3000 | P02. Mott MacDonald.

⁸ Met Office Hadley Centre. (2018). UK Climate Projections (UKCP 18). [online]. Available at: <https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index> [Accessed 14 July 2020].

Table 4.1: Extreme Wave Height and Water Levels

RP [yrs]	Present Day					Climate Change Levels - In 50 years				
	Water levels [m OD]	Profile 1 – Hs*	Profile 2 – Hs*	Profile 3 – Hs*	Profile 4 – Hs*	Water levels [m OD]	Profile 1 – Hs*	Profile 2 – Hs*	Profile 3 – Hs*	Profile 4 – Hs*
1	2.84	1.76	1.68	2.43	2.22	3.43	2.09	2.02	2.44	2.46
	3.29	1.98	1.91	2.22	2.24	3.88	2.18	2.25	2.20	2.24
	3.75	2.00	2.07	2.01	2.05	4.34	1.92	1.96	1.86	1.89
	4.21	1.54	1.56	1.48	1.50	4.8	1.50	1.52	1.46	1.47
	4.67	0.56	0.57	0.55	0.55	5.26	0.55	0.56	0.55	0.55
10	2.84	1.88	1.80	2.55	2.34	3.43	2.20	2.14	2.88	2.67
	3.29	2.12	2.06	2.80	2.59	3.88	2.44	2.4	3.14	2.93
	3.75	2.36	2.31	3.05	2.85	4.34	2.68	2.66	3.27	3.18
	4.21	2.59	2.56	3.09	3.09	4.8	2.91	2.90	3.09	3.11
	4.67	2.82	2.80	2.93	2.95	5.26	2.88	2.98	2.92	2.95
50	5.13	2.00	2.03	1.94	1.96	5.72	1.97	1.99	1.91	1.93
	3.29	2.17	2.12	2.86	2.65	3.88	2.49	2.46	3.19	2.98
	3.75	2.42	2.38	3.11	2.91	4.34	2.74	2.72	3.45	3.24
	4.21	2.66	2.63	3.36	3.15	4.8	2.98	2.97	3.63	3.49
	4.67	2.88	2.87	3.45	3.39	5.26	3.21	3.21	3.45	3.47
100	5.13	2.99	3.08	3.03	3.07	5.72	2.99	3.09	2.98	3.02
	5.58	1.86	1.88	1.81	1.83	6.17	1.83	1.85	1.79	1.80
	3.29	2.20	2.14	2.88	2.67	3.88	2.52	2.48	3.21	3.01
	3.75	2.44	2.40	3.13	2.93	4.34	2.76	2.74	3.46	3.26
	4.21	2.68	2.65	3.38	3.18	4.8	3.00	2.99	3.71	3.52
100	4.67	2.91	2.89	3.62	3.42	5.26	3.23	3.23	3.63	3.65
	5.13	3.12	3.12	3.34	3.36	5.72	3.27	3.38	3.31	3.36
	5.58	2.88	2.98	2.90	2.94	6.17	2.89	2.98	2.87	2.90

Source: Mott MacDonald, 2020

*Hs – significant wave height

As shown on the cross-section drawings in Appendix B, the proposed Scheme will have the revetment set at +7.50m OD and the promenade at +7.00 OD. Comparing the extreme wave height and water levels in Table 4.1 above, it is evident that the proposed coastal defences will not result in flooding behind the promenade due to high water levels or extreme wave height under present day condition up to a 1 in 50 year RP and up to a 1 in 1 year RP in 50 years with climate change, but it is likely to flood under a 1 in 100 RP under present day conditions and for a 1 in 10 year RP or higher in 50 years with climate change.

However, the risk of flooding along the frontage arises from wave overtopping of the coastal defences. Both mean overtopping discharge (q), which is the average overtopping from all waves, and individual maximum overtopping volume (V_{max}), which is the maximum discharge from a single wave, were assessed in the Mott MacDonald Overtopping Assessment⁷. These values are present in Table 4.2 below.

Table 4.2: Overtopping Results

Profile	Return period [yrs]	Present Day		In 50 years	
		q [l/m/s]	Vmax [l/m]	q [l/m/s]	Vmax [l/m]
1	1	0	89	0	252
	10	13	575	35	7,143
	50	39	958	81	12,520
	100	54	1,010	138	19,809
2	1	0	120	0	563
	10	12	557	41	8,434
	50	48	1,122	91	13,574
	100	68	1,200	154	22,345
3	1	0	215	0	265
	10	18	692	37	7,477
	50	60	1,622	98	17,052
	100	83	2,077	144	20,478
4	1	0	153	0	294
	10	19	714	39	7,810
	50	54	1,496	100	17,376
	100	86	1,795	150	21,136

Source: Mott MacDonald. (2020c). Old Colwyn Promenade Defence & Active Travel Improvements – Wave Overtopping Assessment - 415437-MMD-C-R-00-XX-3000 | P02. Mott MacDonald

Following the criteria set out in the EurOtop II Manual⁹ and in the EurOtop Manual¹⁰, the overtopping limits for structural designs and to people and vehicles were reviewed. **Error! Reference source not found.** presents these overtopping discharge limits.

Table 4.3: Recommended Discharge Limits for Assets and Users

Type	Limit	Return Period [yrs]
Surface	q [l/m/s]	
Paved	200	100
Grass	50	100
User	Vmax [l/m]	
Pedestrian	600	1 - 10
Vehicle	2,000	1 - 10

Source: EurOtop II Manual and EurOtop Manual

The proposed Scheme consists of a revetment set at +7.50m OD and the promenade at +7.00 OD. From the overtopping assessment it can be seen that the paved area of the promenade will not be damaged during the lifetime of the project. However, mitigation measures, such as road / promenade closures during severe storms will be required, along with barriers to prevent vehicle and pedestrian access along the promenade.

⁹ Van der Meer, J., Allsop, N., Bruce, T., De Rouck, J., Kortenhaus, A., Pullen, T., . . . Zanuttigh, B. (2018). EurOtop. Manual on wave overtopping of sea defences and related structures. An overtopping manual largely based on European research, but for worldwide application. [online]. Available at: www.overtopping-manual.com [Accessed 13 July 2020].

¹⁰ Pullen, T., Allsop, N. W., Bruce, T., Kortenhaus, A., Schüttrumpf, H., & Meer, J. W. (2007). EurOtop. Wave Overtopping of Sea Defences and Related Structures: Assessment Manual. Die Küste.

4.2 Fluvial Flooding

There are three fluvial watercourses which discharge to the beach to the east of Porth Eirias, two of which are located within the red line boundary:

- The Nant-y-Groes (classified as a Main River by NRW flood mapping) is present to the immediate west of the Scheme area, discharging to the beach via a culvert that passes beneath Porth Eirias at approximate NGR 285760, 378946. The Nant-y-Groes is classified as a Main River by NRW flood mapping ;
- A small watercourse, Llwyd, (classified as a Main River by NRW flood mapping although in reality is a small overflow from the lake at Eirias Park) is culverted and is understood to discharge to the beach at approximate NGR 285877, 378888 within the Scheme area to the east of Porth Eirias. The culvert flows beneath a sports centre and recreational ground before discharging to the beach; and
- The Nant-y-Fynnon (Ordinary Watercourse) passes through Old Colwyn, flowing in an artificial channel down Beach Road and beneath the A55 Expressway before being culverted beneath the NWC Railway Line and outfalling directly onto the beach at Splashpoint at approximate NGR 287008, 378709.

This Scheme focuses on the impact of overtopping on the frontage. The diversion of the existing outfalls along the beach within the Scheme will allow the rivers to flow as they do at present and therefore not result in an increase in fluvial flooding.

4.3 Surface Water Flooding

The Environment Agency's 'Risk of Flooding from Surface Water' online maps shows that there is some surface water flood risk in the area of interest (Figure 2.1). However, the majority of these surface water sources are culverted under the promenade before discharging to the beach. In general, surface water runoff from the promenade and highway area flows into outfalls and directly to the foreshore and into the sea. Additionally, for the Scheme, the promenade will be at a higher elevation at the retainer wall and will have a decreasing profile of 1:40 towards the top of the rock revetment, so that any surface water on the promenade will drain out towards the sea. Furthermore, kerbside drains, along the highway, will direct surface water flooding through outfalls under the promenade out to sea as well.

4.4 Construction Flood Risk Management

During site clearance, existing rock armour is to be removed and re-used where appropriate in accordance with specification.

The Contractor would produce a Construction Flood Risk Management Plan to set out the methodology to be followed during construction to ensure coastal protection of the site is maintained throughout the construction phase.

This plan would also set out the emergency access and egress procedures and specific site precautions necessary to protect both human life and the environment in the case of storm overtopping events occurring during the construction period.

The placement of stockpiled rock armour immediately seaward of where it is to be used within the revetment would help to dissipate wave energy and provide some limited additional protection during any storm events.

4.5 Potential Flooding impacts of Proposed Scheme

The impacts on flood risk during the construction of the Scheme are considered to be mostly negligible⁴. It is also assumed that the Contractor would develop and implement a robust flood management plan during the works. The construction site, equipment and timing of construction activity would need to consider the risk of flooding from tidal and wave conditions as best practice.

Table 4.4: Potential impacts of proposed Scheme

Effects	Construction	Operation
Potential Insignificant Effects	Construction site and equipment could be at risk of getting inundated from overtopping. It is assumed the Contractor would have a flood risk management plan in place.	The Scheme would provide additional tidal flood protection for Colwyn Bay, however, there is still a residual risk and the Flood Management Plan would need to be reviewed and updated.
Potential Significant Effects	N/A	The installation of the new coastal defences strongly complies with policy objectives. Overall, the impact of the Scheme is considered to be significantly beneficial as it would provide additional tidal flood protection for Colwyn Bay

Source: Mott MacDonald Ltd, 2020

5 Acceptable Consequences for Nature of Use

Section A1.14 of the TAN15 outlines that there is ‘a frequency threshold of flooding below which flooding of development should not be allowed.’⁵ **Error! Reference source not found.**, from the TAN15, outlines an indicative guidance on what the frequency threshold might be for different type of developments, in terms of annual probability of occurrence.

Table 5.1: Flood Frequency Thresholds from TAN15

Type of Development	Threshold Frequency (Yrs)	
	Fluvial	Tidal
Residential	1%	0.5%
Commercial/ retail	1%	0.5%
Industrial	1%	0.5%
Emergency services	0.1%	0.5%
General infrastructure	1%	0.5%

Source: Welsh Assembly Government, 2004

As shown in **Error! Reference source not found.**, no flooding should occur during a 0.5% (1 in 200-year RP) for general infrastructure over the lifetime of the proposed Scheme. As presented in Table 4.1 in Section 4, the proposed Scheme will not flood due to high water levels or extreme wave height.

From A1.15 of the TAN15, beyond the threshold frequency outlined above, the proposed development would be expected to flood under extreme conditions. **Error! Reference source not found.** presents the indicative guidance from the TAN15 on what is considered to be tolerable flood conditions for different types of developments.

Table 5.2: Tolerable Conditions from TAN15

Type of Development	Maximum Depth of Flooding (mm)	Maximum Rate of Rise of Floodwaters (m/hr)	Maximum Speed of inundation (of flood risk area (hrs))	Maximum Velocity of Floodwaters (m/s)
Residential (habitable rooms)	Property Access			Property Access
	600	0.1	4	0.15
Commercial/ retail	600			0.3
	600	0.3	2	0.15
Industrial	1000			0.3
	1000	0.3	2	0.45
Emergency services	450			0.15
	600	0.1	4	0.3
General infrastructure	600			0.3
	600	0.3	2	0.3

Source: Welsh Assembly Government, 2004

As outlined in Table 4.2 and table 4.3 indicates the proposed Scheme will experience significant overtopping but the flood depths will not exceed the discharge limit for a paved surface, such as the paved promenade. Therefore, the paved promenade will not be damaged during extreme events. The proposed Scheme is adaptable, and the sea defences can be raised in the future in line with sea level rise. This was agreed with the CCBC in order for the Scheme to be cost-effective. At present the promenade is closed during events, approximately a dozen times a year that lead to significant overtopping. The proposed Scheme would reduce the number of times the promenade would need to be closed, whilst remaining economically viable and minimising the carbon footprint of the Scheme which would be better used for future Schemes when raising the coastal defences in line with sea level rise.

Mitigation measures for the risks to pedestrians and vehicles are discussed and outlined in Section 7.

6 Occupiers Awareness of Flood Risk and Flood Warnings Procedures

As this is a coastal defence Scheme, there will be no direct resident or business occupants to inform in the event of a flood warning being issued. However, in the event of a flood warning being issued the Council will install signs at either end of the promenade road and where road barriers are located to inform users that the promenade is closed and that a flood warning has been issued.

Presently CCBC close the promenade to the public during times of flooding caused by overtopping. The key elements of this procedure are:

- The trigger tide levels of 3.9m OD or greater are predicted;
- The trigger conditions and relevant data are reviewed. This is followed by the decision of the closure of the promenade, which is taken by Council staff from the FR&I, OS and HM departments. County Councillors for the immediate location are informed directly and CCBC's marketing department inform the general public via social media;
- The road barrier at Cliff Gardens is closed first, followed by a walk through the Promenade length to inform remaining cars, followed by closure of the road barrier at Rotary Way junction. Temporary signs are installed at all road barrier locations to inform users the promenade is closed;
- When the high tide has passed, an inspection of the coastal defence is carried out by FR&I to record condition and to ensure that the promenade is safe to re-open. Any debris on the promenade from the storm cleared before re-opening; and
- County Councillors for the immediate location are informed directly and CCBC's marketing department inform the general public via social media that the promenade has been re-opened.

As the closure of the promenade occurs approximately a dozen times a year for several days, the procedure outlined above should therefore continue when a flood warning is issued in the case of extreme storm events beyond a 1 in 10-year return period.

7 Flood Resilient Design

The primary flood resilient design aspect of this Scheme is the raising of both the revetment and promenade. The rock revetment will be raised to +7.50m OD and the promenade to +7.00m OD. Raising these structures will reduce the current frequency of coastal flooding and overtopping volumes.

The promenade will also be at a higher elevation at the retainer wall and will have a decreasing profile of 1:40 towards the top of the rock revetment, so that any surface water on the promenade will drain out towards the sea.

Additionally, between the promenade highway and the retainer wall of the promenade, kerbs drains will be installed. These kerb drains will direct any surface water away from the highway through an outfall that drains under the promenade and into the rock revetment at approximately +7.00m OD. As water levels do not reach this elevation these outfalls will not experience tidal locking and thus will remain free draining during an overtopping event.

The Scheme will also tie into the current sea defences at Porth Eirias to the west, which are already at +7.00m OD and into the raised footpath defences to the east at Splashpoint, where a flood gate will be installed across the current slipway.

Furthermore, the new promenade and rock revetment are proposed to be adaptable for future sea level rise, beyond the current 50-year allowance, through the modification of the cross section by adding additional layers of rock or reconstructing the design profile. Raising the sea defences later on is judged as a more cost-efficient approach rather than raising the promenade to 120-year design criteria at present day.

8 No Increase in Flooding Elsewhere

The proposed coastal defences are at risk of significant overtopping under a 1 in 10-year event and beyond, under present conditions. However, the risk of overtopping is only restricted to the promenade area and promenade highway, and the proposed defences will improve the level of protection from present day levels.

Existing drainage outfalls through the seawall will be maintained by extending outfalls through the proposed rock revetment. The promenade will be profiled to encourage drainage out to sea, and kerbside drains will direct surface water flooding through outfalls under the promenade out to sea as well.

The Scheme is also tying into sea defences at both Porth Eirias and at Splashpoint. This will therefore significantly reduce flood waters entering areas adjacent to the Scheme therefore, lowering the risk of coastal flooding for both these Scheme and surrounding areas.

Consequently, the proposed design will have an improvement on flood risk to the infrastructure at present rather than a negative impact.

Additionally, the impacts on flood risk during the construction of the Scheme are considered to be mostly negligible. The construction site, equipment and timing of construction activity would need to consider the risk of flooding from tidal and wave conditions as best practice.

9 Summary and Conclusions

The proposed Scheme comprises of coastal defence works in the form of a new rock revetment and promenade raising. The development forms part of the for the Old Colwyn Coastal Defence and Active Travel Scheme. The coastal defences must be located along the coastal frontage by virtue of their purpose.

The proposed Scheme will have the revetment set at +7.50m OD and the promenade at +7.00 OD. The Scheme will experience significant overtopping, though impacts are restricted to the promenade area and promenade highway, and will exceed the discharge limit for users under a number of return periods for both present day and in 50 years. Pedestrians on the promenade will be at risk under a 1 in 10-year event under present day conditions, and both pedestrians and vehicles (on the promenade highway) will be at risk under a 1 in 10-year event in 50 years. However, overtopping will not exceed the discharge limit for a paved surface, such as the paved promenade. Therefore, the paved promenade and promenade highway will not be damaged during extreme events, behind the crest of the revetment / seawall of this Scheme.

The flood risk to pedestrians and vehicles will be mitigated through flood warning systems, signage, barriers to restrict access to the promenade, maintaining existing drainage outfalls through the seawall, and by extending outfalls through the proposed rock revetment. The promenade will be profiled to encourage drainage out to sea, and kerbside drains will direct surface water flooding through outfalls under the promenade out to sea as well. The Scheme is also tying into sea defences at both Porth Eirias and at Splashpoint, this will therefore significantly reduce flood waters entering areas adjacent to the Scheme. Therefore, lowering the risk of coastal flooding for both these Scheme and surrounding areas.

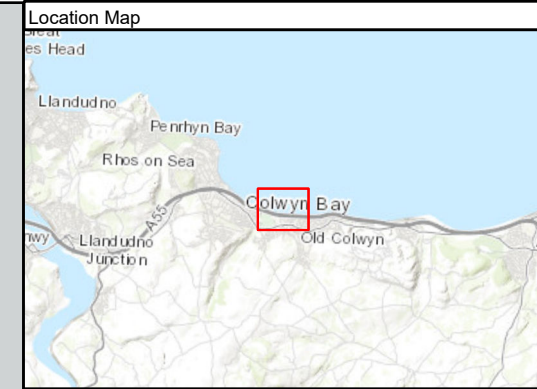
10 Recommendations

The proposed Scheme should maintain the existing drainage outfalls through the seawall and extend the outfalls through the proposed rock revetment. The promenade will also need to be graded to encourage surface water drainage out to sea and kerb drains to be installed to direct surface water from the promenade highway under the promenade out to sea.

A Flood Management Plan, defining the conditions requiring promenade/road closures during the operational phase, should be prepared, and signage install along the promenade to inform users of the risk of flooding in the area.

A copy of this report should be submitted to the Planning Authority in support of the planning application.

A. Location Plan and Existing Arrangement



Key to Symbols

Red line boundary

Notes

- 1. For information only, not for construction.
- 2. Contains Ordnance Survey data © Crown copyright and database rights 2019 Ordnance Survey. All rights reserved.
- 3. Contains OS data © Crown Copyright and database right 2020 Contains data from OS Zoomstack, Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

P1	23/07/20	MH	For information	NS	CW
Rev	Date	Drawn	Description	Ch'k'd	App'd

M M
MOTT MACDONALD

Mott MacDonald House
 5 Woodland Road West
 Colwyn Bay
 LL29 7DH
 T +44 (0)2920 467800
 W www.mottmac.com

Client

CONWY
 CYNOR IWRDISTREF SIROL
 COUNTY BOROUGH COUNCIL

Conwy County Borough Council

Title
 Old Colwyn Coastal Defence and Active Travel Scheme
 Anticipated principal working area buffer (approximate only)
 Red Line Boundary

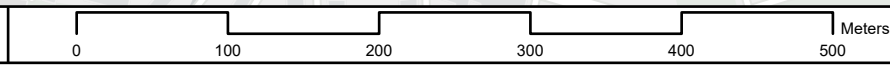
Designed	N Spofforth	NS	Eng. Check	N Spofforth	NS
Drawn	M Hayward	MH	Coordination	N Spofforth	NS
GIS Check	G O'Donovan	GO	Approved	C Williams	CW

Scale at A3	Status	Rev	Security
1:5,000	INF	P1	STD

Drawing Number
415437-MMD-00-XX-DR-N-1707



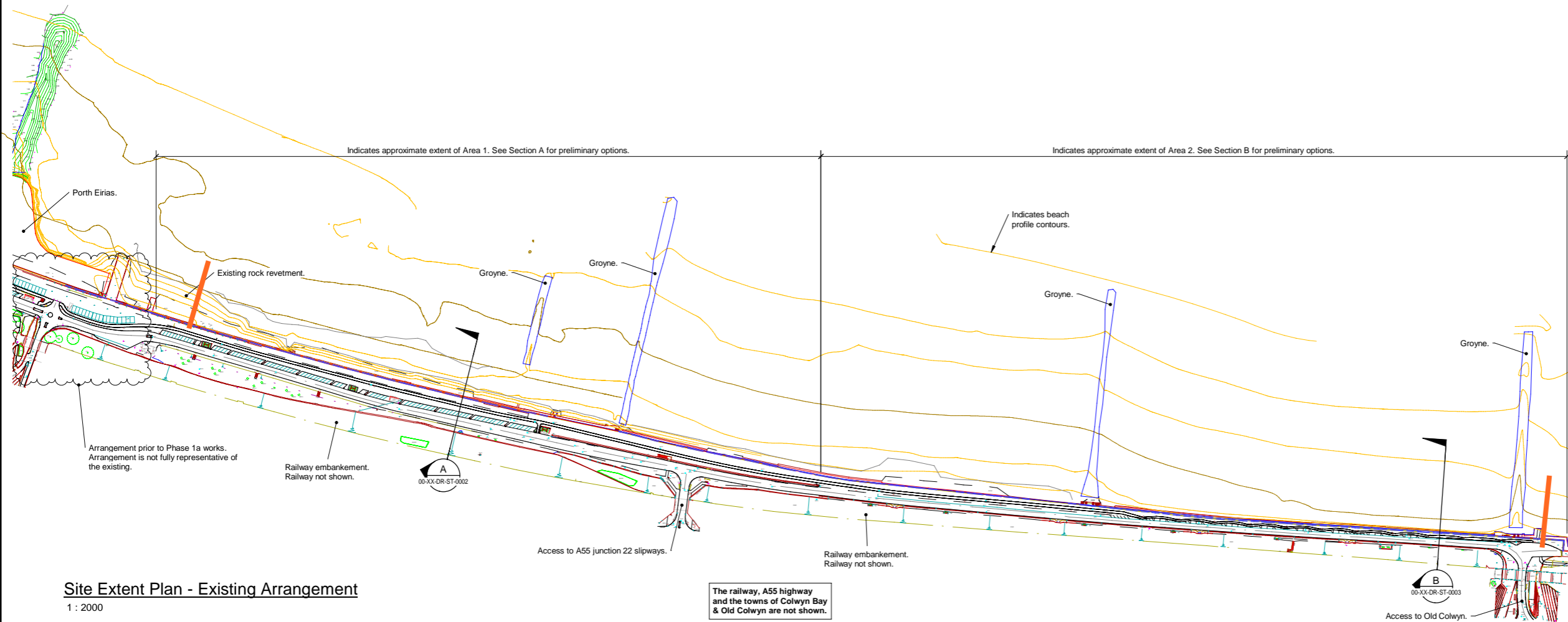
© Mott MacDonald Ltd.
 This document is issued for the party which commissioned it and for specific purposes connected with the captioned project only. It should not be relied upon by any other party or used for any other purpose.
 We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.





Location Plan

1 : 20000



Site Extent Plan - Existing Arrangement

1 : 2000

The railway, A55 highway and the towns of Colwyn Bay & Old Colwyn are not shown.

- Notes
1. Unless otherwise noted (UNO), all dimensions are in millimetres, all levels are in meters above ordnance datum (AOD). Do not scale from drawing, if in doubt ask.
 2. The offshore topographical survey was supplied by Survey Operations Ltd in April 2010. The onshore topographical survey was supplied by Conwy County Borough Council in xxxxxx.
 3. Structural drawings do not show full extent and location of services. See statutory undertakers plans for services information.
 4. Proposals are preliminary and subject to change pending detail design and consultation.
 5. Further options are possible subject to review of coastal modelling and consultation.

Key to symbols

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	04.02.2020	JH	PRELIMINARY ISSUE	GWM	DRG

Status Stamp

NOT FOR CONSTRUCTION

MOTT MACDONALD

Mott MacDonald House
5 Woodland Road West
Colwyn Bay
LL29 7DH
United Kingdom
T +44 (0)1492 534601
W mottmac.com

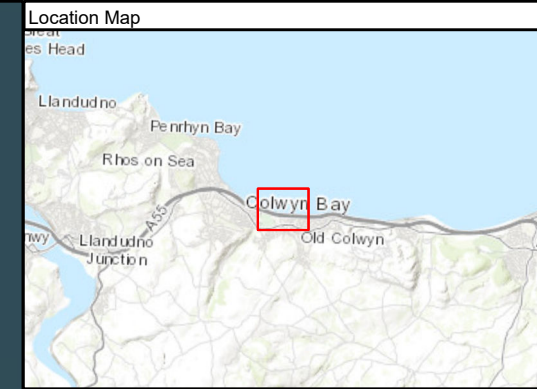
Client

CONWY
CYNGOR BWRDEISTREF SIROL
COUNTY BOROUGH COUNCIL




Title

Old Colwyn Promenade Coastal
Defence & Active Travel Improvements
LOCATION PLAN & SITE EXTENTS
LOCATION PLAN & SITE EXTENTS
LOCATION PLAN & SITE EXTENTS

Designed	J. Hughes	Eng.check.	Not applicable
Drawn	J. Hughes	Coordination	G. Mitchell
Dwg.check.	G. Mitchell	Approved	Approver
MMD Project Number	415437	Scale at A1	As indicated
Suitability Description	Suitable for Review & Comment		Security STD
Drawing Number	415437-MMD-00-XX-DR-ST-0001	Rev	P1



Key to Symbols

-  Red line boundary
-  Area of permanent construction
-  Ecological enhancements only

Notes


1. For information only, not for construction.
2. Contains Ordnance Survey data © Crown copyright and database rights 2019 Ordnance Survey. All rights reserved.
3. Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

P1	23/07/20	SA	For information	NS	CW
Rev	Date	Drawn	Description	Ch'k'd	App'd

M M
MOTT MACDONALD

Mott MacDonald House
5 Woodland Road West
Colwyn Bay
LL29 7DH
T +44 (0)2920 467800
W www.mottmac.com

Client



CONWY
CYNIGOR Y BRIDISTREF SIROL
COUNTY BOROUGH COUNCIL

Conwy County Borough Council

Title Old Colwyn Coastal Defence and Active Travel Scheme
Area of Permanent Construction

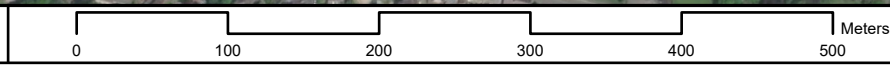
Designed	N Spofforth	NS	Eng. Check	N Spofforth	NS
Drawn	S Anstice	SA	Coordination	N Spofforth	NS
GIS Check	G O'Donovan	GO	Approved	C Williams	CW

Scale at A3	Status	Rev	Security
1:5,000	INF	P1	STD

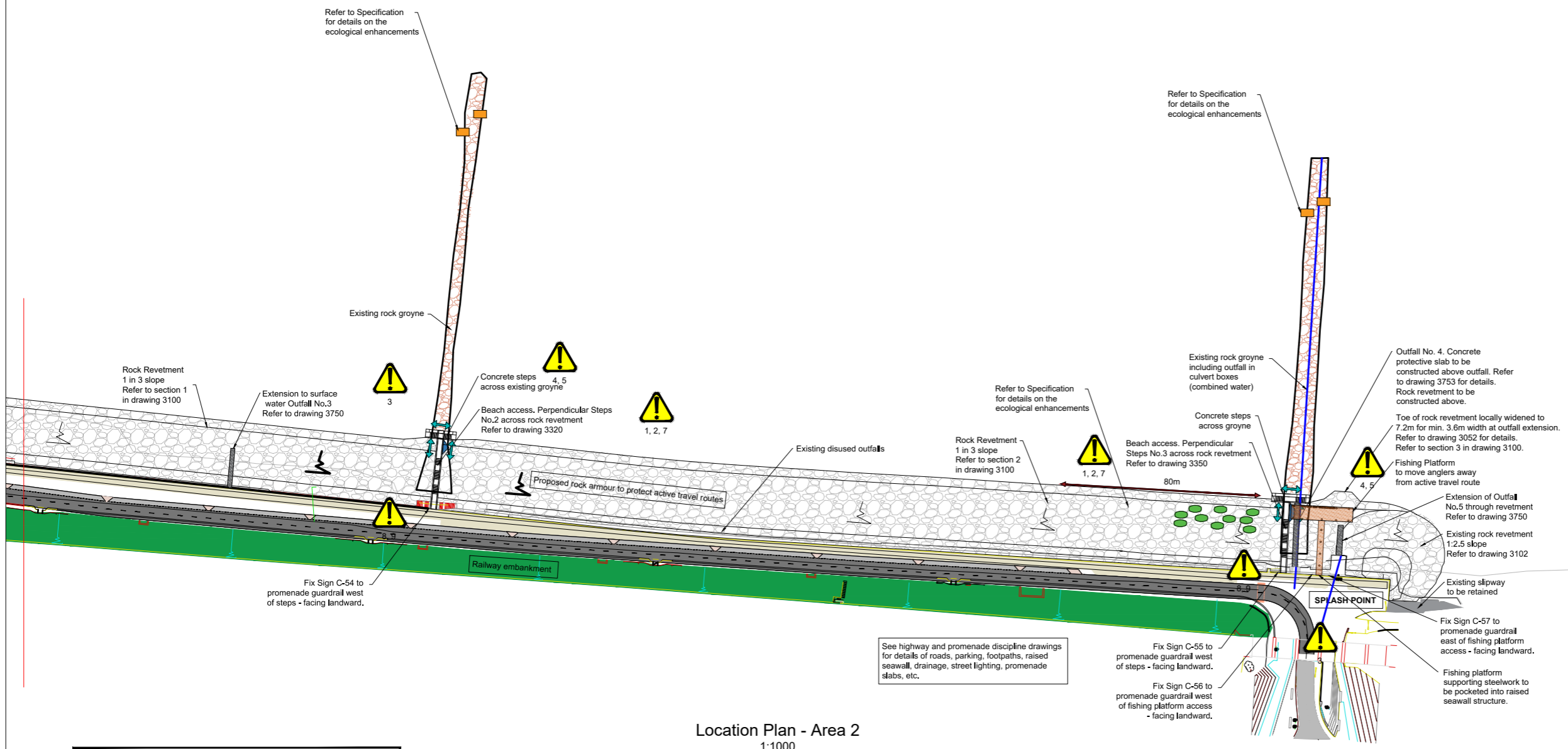
Drawing Number
415437-MMD-00-XX-DR-N-1708



© Mott MacDonald Ltd.
This document is issued for the party which commissioned it and for specific purposes connected with the captioned project only. It should not be relied upon by any other party or used for any other purpose.
We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.



B. Proposed Scheme Plan and Cross-Sections



Location Plan - Area 2
1:1000

Safety, Health & Environmental Information

It is assumed that all works will be carried out by a competent contractor working, where appropriate, to an approved method statement.

⚠ In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following risks and information:

CONSTRUCTION

- 1 Depth and full extent of existing seawall foundations are unknown. Existing seawall becomes destabilised (DHER Ref. 19 & 23).
- 2 Unforeseen ground conditions/obstructions prevent sheet piles being driven (DHER Ref. 20).
- 3 The status (i.e. disused or live) and precise positions of some outfalls are unknown (DHER Ref. 21).
- 4 Falling from height. Falling objects from promenade (DHER Ref. 22).
- 5 Working in tidal zone (DHER Ref. 27).
- 6 Presence of Unexploded ordnances (UXOs). Site area categorised as low risk. (DHER Ref. 30).

OPERATION AND MAINTENANCE

- 7 Beach levels to be reinstated to existing levels or higher after completion of works. Beach levels shall be monitored at regular intervals including before and after storms and at least once a year in spring (DHER Ref. 4).
- 8 Marine growth to be removed periodically from pedestrian access surfaces (DHER Ref. 5).

- Notes**
1. This drawing is to be read in conjunction with all discipline drawings, specifications and standards.
 2. Unless otherwise noted (UNO), all dimensions are in millimetres, all levels are in meters above ordnance datum (AOD), and all setting-out points in millimeters to the British National Grid (OSGB36). Do not scale from drawing, if in doubt ask.
 3. All relevant setting-out points, dimensions & levels are to be checked by Contractor on-site prior to commencement of the works.
 4. The onshore topographical survey was supplied by Survey Operations Ltd in April 2008. The offshore topographical (beach) survey was supplied by Environmental & Engineering Services in 2019. The CCTV survey was supplied by Invek Surveys Ltd in May 2020.
 5. Drawings show approximate position of known services. See Site Information for further information. Further unknown services maybe present. Contractor to undertake survey to determine full extent of services present within working area. Results to be forwarded to the Structural Design Engineer 2 week prior to commencement of works, or ordering of materials, whichever occurs first.
 6. See 415437-MMD-00-XX-DR-C-2000 series drawings for the proposed promenade works. See 415437-MMD-00-XX-DR-D-0000 to 1399 series drawings for the proposed highway & drainage works.
 7. Refer to Appendix 12/1 of the Works Specification for all the sign details.

Key to symbols

	Existing railway embankment		Rock structures
	Proposed extent of highway		Fishing platform
	Group of 5 Vertipools fixed to wall		Outfall extension/ protection
	Textured outer walls		Tidal pools
	Enhancement of rocks		Ecological Armouring unit

- Reference drawings**
- 415437-MMD-00-XX-DR-C-3052 - Plan at Splash Point End
 - 415437-MMD-00-XX-DR-C-3100 - Revetment Cross Sections - Sheet 1 of 3
 - 415437-MMD-00-XX-DR-C-3102 - Revetment Cross Sections - Sheet 3 of 3
 - 415437-MMD-00-XX-DR-C-3320 - Perpendicular Steps No. 2 Plan
 - 415437-MMD-00-XX-DR-C-3350 - Perpendicular Steps No. 3 Plan
 - 415437-MMD-00-XX-DR-C-3450 - Fishing Platform Plan
 - 415437-MMD-00-XX-DR-C-3750 - Outfall and Culvert Cross Sections
 - 415437-MMD-00-XX-DR-C-3753 - Outfall No.4 Protection Details
 - 415437-MMD-00-XX-DR-C-2000 series - Promenade Works
 - 415437-MMD-00-XX-DR-D-0000 to 1399 series drawings - Highway and Drainage Works
 - 19.537 - 100 Old Colwyn GA Landscape Drawing

Rev	Date	Drawn	Description	Ch'k'd	App'd
P05	17/07/20	AA	Construction Issue for Client Approval	AD	ZH
P04	26/06/20	AA	Construction Issue for Client Approval	AD	ZH
P03	28/04/20	ZD	Tender Issue for Client Comments	AD	ZH
P02	13/04/20	ZD	Second Issue for Internal Comments	AD	ZH
P01	12/03/20	ZD	First Issue for Comments	AD	ZH

MOTT MACDONALD

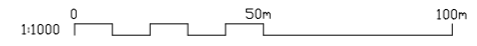
Mott MacDonald House
5 Woodland Road West
Colwyn Bay
LL29 7DH
United Kingdom
T +44 (0)1492 534601
F +44 (0)1492 533063
W www.mottmac.com

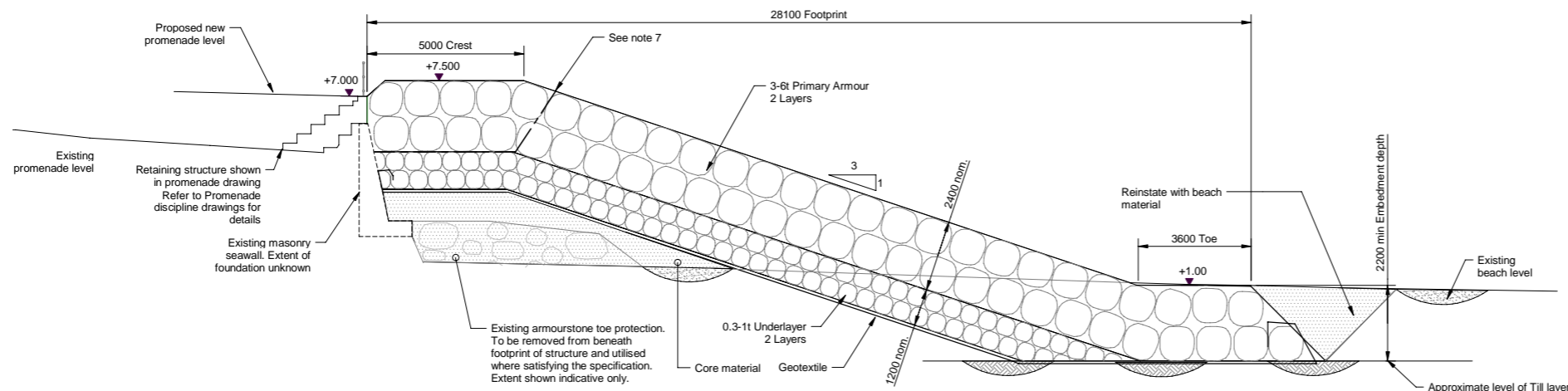


Title
Old Colwyn Promenade Coastal Defence & Active Travel Improvements General Arrangement Plan - Area 2

Sheet 02 of 02

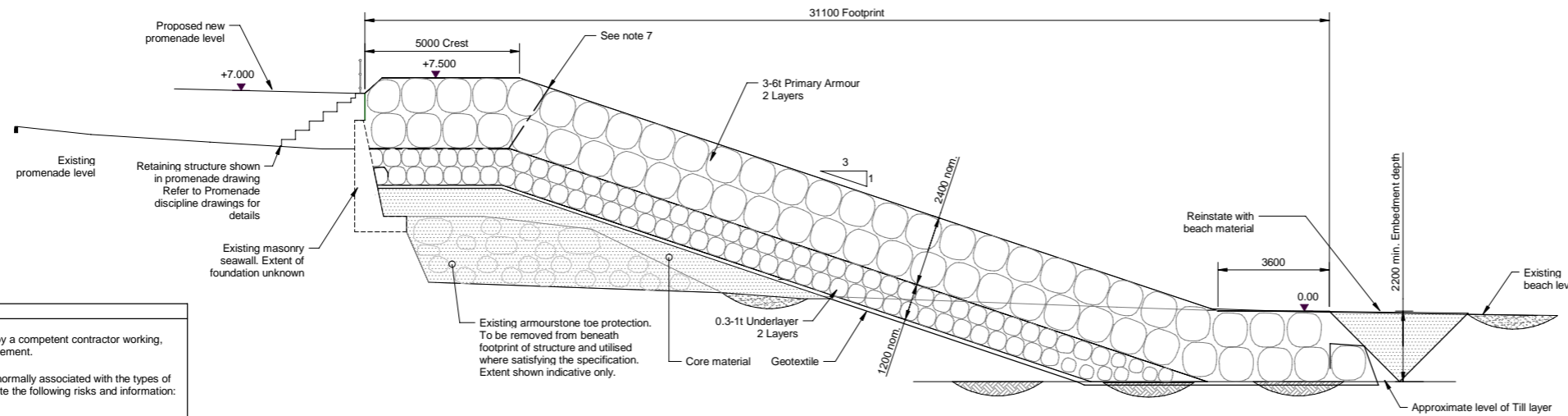
Designed	P. Kacperek	PK	Eng check	A. Douglas	AD
Drawn	A. Al-Abdullah	AA	Coordination	F. Loy	FL
Dwg check	D. Sciuto	DS	Approved	Z. Hutchison	ZH
MMD Project Number	Scale at A1			Security	
415437	1:1000			STD	
Suitability Description					Suit. Code
Issue for Construction Approval					S4
Drawing Number					Revision
415437-MMD-00-XX-DR-C-3002					P05





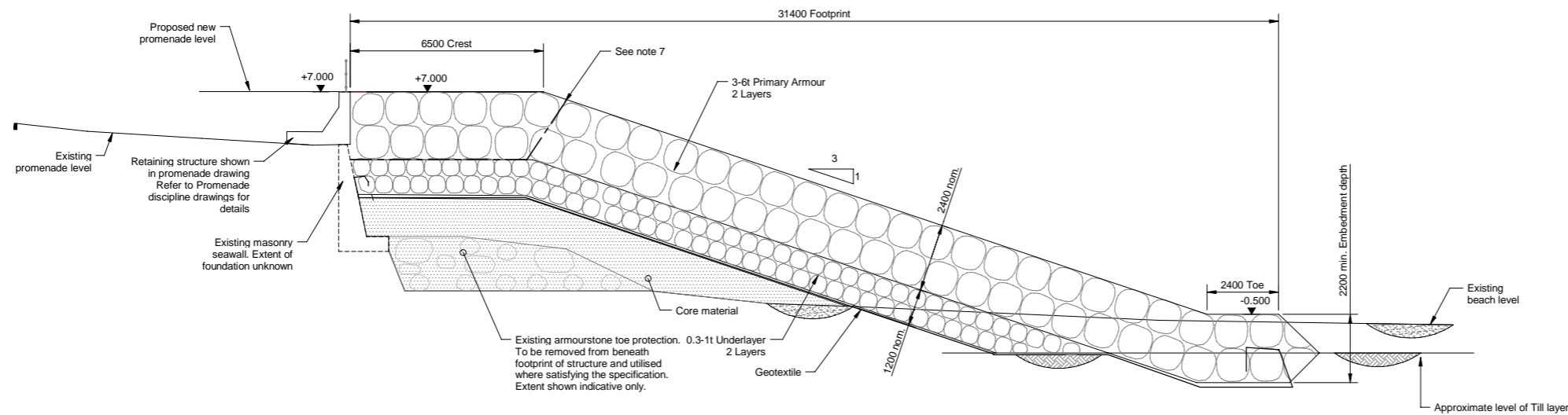
**Section 1 - Rock Revetment Cross-section
(between Porth Eirias and Perpendicular steps 2)**

1 : 100



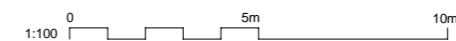
**Section 2 - Rock Revetment Cross-section
(between Perpendicular steps 2 and 3)**

1 : 100



**Section 3 - Rock Revetment Cross-section
(between Perpendicular Steps 3 and Splash Point)**

1 : 100



Safety, Health & Environmental Information

It is assumed that all works will be carried out by a competent contractor working, where appropriate, to an approved method statement.

! In addition to the hazards/ risks normally associated with the types of work detailed on this drawing, note the following risks and information:

Construction:

- 1 Depth and full extent of existing seawall foundations are unknown. Existing seawall becomes destabilised (DHER Ref. 19 & 23).
- 2 Falling from height. Falling objects from promenade (DHER Ref. 22).
- 3 Working in tidal zone (DHER Ref. 27).

Operation & Maintenance:

- 4 Beach levels to be maintained to within 0.5m of current levels. Beach levels shall be monitored at regular intervals including before and after storms and at least once a year in spring (DHER Ref. 4).

- Notes**
1. All dimensions in millimetres unless otherwise stated.
 2. All levels shown are in metres relative to Ordnance Datum (mOD).
 3. Horizontal control points are relative to the National Grid OSGB36.
 4. Beach survey information based on PENRHYN BAY - COLWYN BAY POST STORM SURVEY undertaken in 2019 by Environmental & Engineering Services.
 5. Contractor to undertake trial holes to determine full extent and depth of existing seawall foundations present at least two weeks prior to the commencement of affected works, or ordering of materials, whichever occurs first.
 6. Contractor to survey the existing wall at tie in locations to confirm the extent and geometry of the existing seawall at least two weeks prior to the commencement of affected works, or ordering of materials, whichever occurs first.
 7. Rock revetment to be partially constructed from the toe up to the line indicated prior to the promenade raising works. Construction of remaining part of revetment to follow after completion of promenade raising works.

Key to symbols

Reference drawings

415437-MMD-00-XX-DR-C-3051	Plan at Porth Eirias End - Area 1
415437-MMD-00-XX-DR-C-3052	Plan at Splash Point End - Area 2
415437-MMD-00-XX-DR-C-3101	Revetment cross section - Sheet 2 of 3
415437-MMD-00-XX-DR-C-3102	Revetment cross section - Sheet 3 of 3
415437-MMD-00-XX-DR-C-3200	Access Build-Out Plan
415437-MMD-00-XX-DR-C-3750	Outfall & Culvert Sections
415437-MMD-00-XX-DR-S-2000s	Promenade Discipline Drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P4	17.07.20	AA	Construction Issue for client approval	AD	ZH
P3	26.06.20	AA	Construction Issue for client approval	AD	ZH
P2	29.04.20	AA	Tender Issue for Client comment	AD	ZH
P1	28.02.20	SD	Issue for Client comment	NC	AD

Status Stamp

MOTT MACDONALD

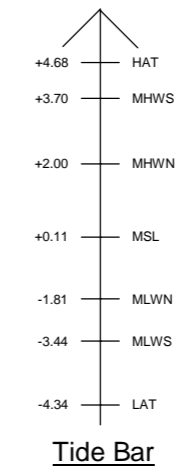
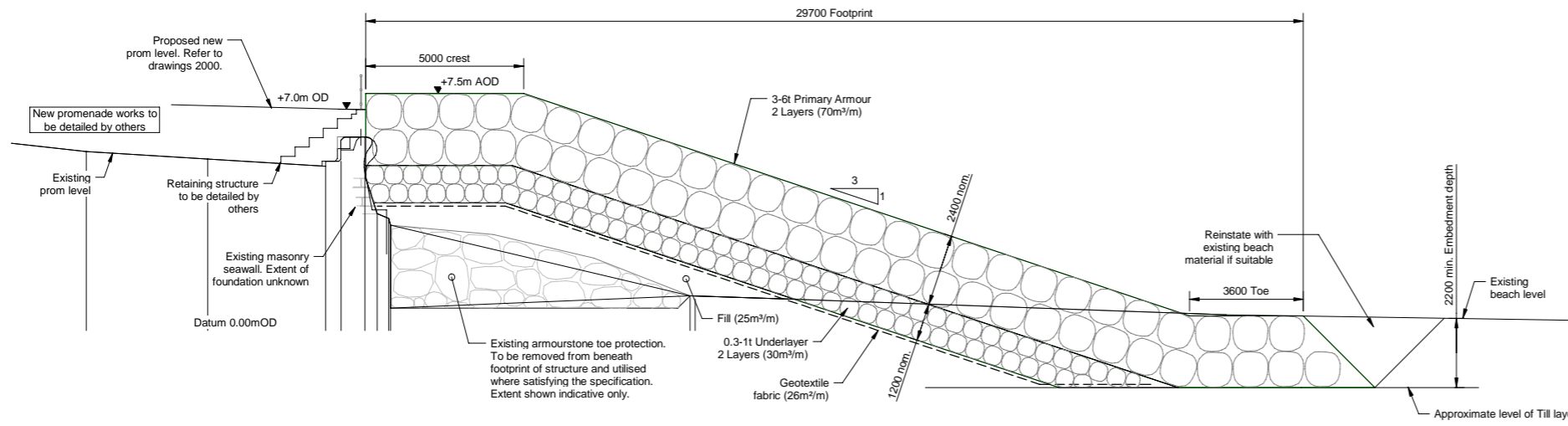
Mott MacDonald House
5 Woodland Road West
Colwyn Bay
LL29 7DH
United Kingdom
T +44 (0)1492 534601
W mottmac.com

Client

CONWY
CYNGOR BWRDEISTREF SIROL
COUNTY BOROUGH COUNCIL

Title
**Old Colwyn Promenade Coastal
Defence & Active Travel Improvements
Revetment Cross Sections
Sheet 1 of 3**

Designed	P Kacperk	PK	Eng. Check	A Douglas	AD
Drawn	A Al-Abdullah	AA	Coordination	F Loy	FL
Dwg. Check	D Sciuto	DS	Approved	Z Hutchison	ZH
MMD Project Number	415437	Scale at A1	1:100	Security	STD
Suitability Description	Issue for Construction Approval	Suit. Code	S4	Rev	P4
Drawing Number	415437-MMD-00-XX-DR-C-3100				



Section 3 - Section through Rock Revetment at Porth Eirias End

From drawing MMD-277894-C-DR-000-XX-1012 produced by Mott MacDonald on 05/02/2012.

Safety, Health & Environmental Information

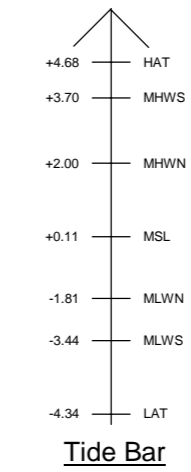
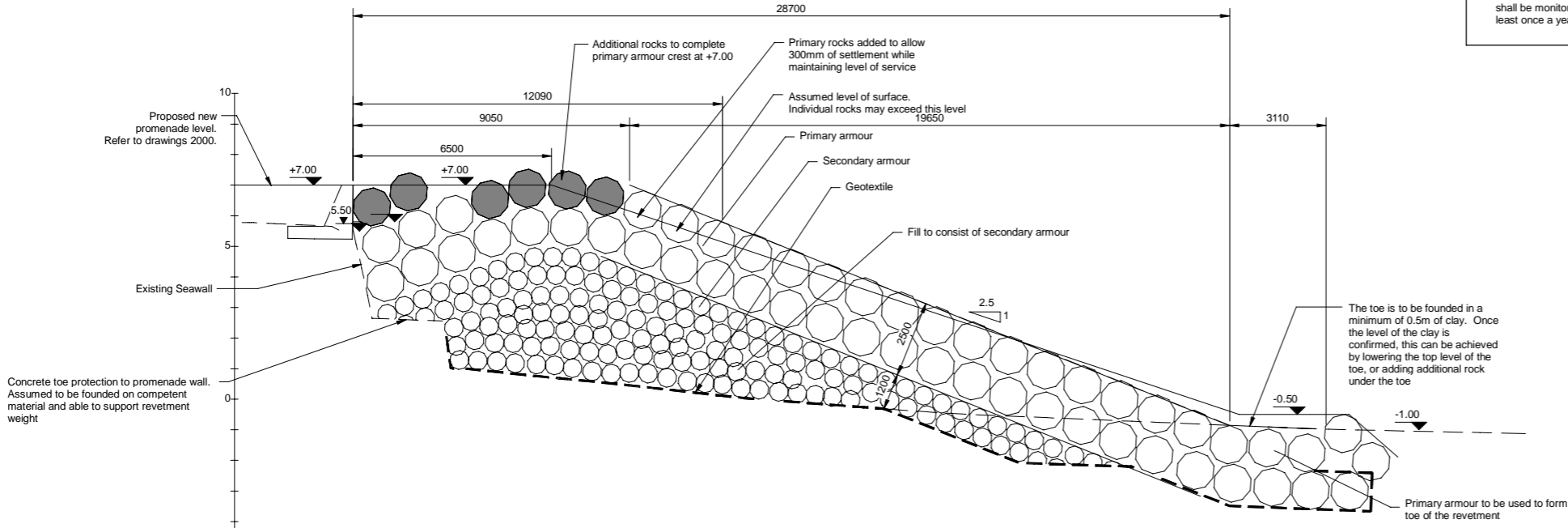
It is assumed that all works will be carried out by a competent contractor working, where appropriate, to an approved method statement.

Construction:

- 1 Depth and full extent of existing seawall foundations are unknown. Existing seawall becomes destabilised (DHER Ref. 19 & 23).
- 2 Falling from height. Falling objects from promenade (DHER Ref. 22).
- 3 Working in tidal zone (DHER Ref. 27).

Operation & Maintenance:

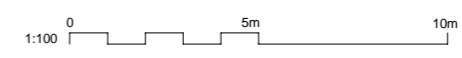
- 4 Beach levels to be maintained to within 0.5m of current levels. Beach levels shall be monitored at regular intervals including before and after storms and at least once a year in spring (DHER Ref. 4).



Section 4 - Section through Rock Revetment at Splash Point

From drawing OCSP-ACM-XX-XX-DR-CE-010002 C02 - Splash Point produced by AECOM on 07/02/2020

CHAINAGE	00.00	01.00	02.00	03.00	04.00	05.00	06.00	07.00	08.00	09.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00	28.00	29.00	30.00	31.00	32.00	33.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00			
EXISTING LEVELS	5.78	5.74	5.70	5.62	3.90	2.82	2.58	1.01	0.93	0.82	0.72	0.63	0.53	0.42	0.31	0.20	0.09	0.01	-0.09	-0.16	-0.23	-0.31	-0.38	-0.45	-0.51	-0.55	-0.59	-0.63	-0.67	-0.71	-0.76	-0.80	-0.84	-0.88	-0.92	-0.96	-0.99	-1.02	-1.04	-1.06	-1.08	-1.10	-1.10	-1.10	-1.10	-1.10
PROPOSED LEVELS					5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.27	4.87	4.47	4.07	3.67	3.27	2.87	2.47	2.07	1.67	1.27	0.87	0.47	0.07	-0.33	-0.73	-1.13	-1.53	-1.93	-2.33	-2.73	-3.13	-3.53	-3.93	-4.33	-4.73	-5.13	-5.53	-5.93



Notes

1. All dimensions in millimetres unless otherwise stated.
2. All levels shown are in metres relative to Ordnance Datum (mOD).
3. Horizontal control points are relative to the National Grid OSGB36.
4. Beach survey information based on PENRHYN BAY - COLWYN BAY POST STORM SURVEY undertaken in 2019 by Environmental & Engineering Services.

Key to symbols

Reference drawings

415437-MMD-00-XX-DR-C-3051 - Plan at Porth Eirias End - Area 1
 415437-MMD-00-XX-DR-C-3052 - Plan at Splash Point End - Area 2
 415437-MMD-00-XX-DR-C-3100 - Revetment cross section - Sheet 1 of 3
 415437-MMD-00-XX-DR-C-3101 - Revetment cross section - Sheet 2 of 3
 415437-MMD-00-XX-DR-C-3200 - Access Build-Out Plan
 415437-MMD-00-XX-DR-C-3750 - Outfall & Culvert Sections
 415437-MMD-00-XX-DR-S-2000s - Promenade Discipline Drawings

Rev	Date	Drawn	Description	Ch'kd	App'd
P3	17.07.20	AA	Construction Issue for client approval	AD	ZH
P2	26.06.20	AA	Construction Issue for client approval	AD	ZH
P1	29.04.20	SD	Tender Issue for Client comment	NC	AD

Status Stamp

MOTT MACDONALD

Mott MacDonald House
 5 Woodland Road West
 Colwyn Bay
 LL29 7DH
 United Kingdom
 T +44 (0)1492 534601
 W mottmac.com

Client

CONWY
 CYNGOR BURDEISTREF SIROL
 COUNTY BOROUGH COUNCIL

Title

Old Colwyn Promenade Coastal Defence & Active Travel Improvements
 Revetment Cross Sections
 Sheet 3 of 3

Designed	P Kacperek	PK	Eng. Check	A Douglas	AD
Drawn	A Al-Abdullah	AA	Coordination	F Loy	FL
Dwg. Check	D Sciuto	DS	Approved	Z Hutchison	ZH
MMD Project Number	415437	Scale at A1	1:100	Security	STD
Suitability Description	Issue for Construction Approval	Suit. Code	S4	Rev	P3
Drawing Number	415437-MMD-00-XX-DR-C-3102				

C. Wave Overtopping Assessment

Appendix 10.3 – Wave Overtopping Assessment

Old Colwyn Promenade Defence & Active Travel Improvements

Wave Overtopping Assessment

15 June 2020

Mott MacDonald
Mott MacDonald House
8-10 Sydenham Road
Croydon CR0 2EE
United Kingdom

T +44 (0)20 8774 2000
mottmac.com

Conwy County Borough
Council
PO Box 1
Conwy
LL30 9GN

Old Colwyn Promenade Defence & Active Travel Improvements

Wave Overtopping Assessment

15 June 2020

Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
P01	06/02/2020	F Loy	N Clarke A Douglas	R Griffiths	First Issue - Draft
P02	15/06/2020	F Loy N Sigalas	N Clarke	Z Hutchison	Second Issue - Final

Document reference: 415437-MMD-C-R-00-XX-3000 | P02

Information class: Standard

This document is issued for the party which commissioned it and for specific purposes connected with the above-captioned project only. It should not be relied upon by any other party or used for any other purpose.

We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

This document contains confidential information and proprietary intellectual property. It should not be shown to other parties without consent from us and from the party which commissioned it.

Contents

1	Introduction	1
1.1	Project Background	1
1.2	Site Location	1
1.3	Purpose of this Report	2
2	Site Information	3
2.1	Design Life	3
2.2	Promenade and Beach Levels	3
2.3	Tide Levels	3
2.4	Sea Level Rise	4
2.5	Beach Profile	4
2.6	Beach Drawdown	8
2.7	Existing Storm Events	8
3	Wave Overtopping Assessment	10
3.1	Joint Probability Analysis between Waves and Water Levels	10
3.2	Scenarios	13
3.3	Wave Overtopping Formulae	13
3.4	Wave Overtopping Criteria	15
3.5	Wave Overtopping Results	18
4	Interpretation of Results and Recommendations	23
4.1	Interpretation of Results	23
4.2	Potential Mitigations and Adaptations	25
4.3	Summary	25
4.4	Outline Recommended Crest Level and Promenade Level	26
5	References	27
	Appendices	28
A.	Overtopping Calculations	29
	Tables	
	Table 2.1: Tide Levels at Colwyn Bay	3
	Table 2.2: Existing Seawall Levels	5
	Table 3.1: Joint probability of design waves and water levels	10

Table 3.2: Joint probability of design waves and water levels (present day)	11
Table 3.3: Joint probability of design waves and water levels (in 50 years)	12
Table 3.4: Overtopping limits for structural design of breakwaters, seawalls, dikes	15
Table 3.5: Overtopping limits for people and vehicles (EurOtop II)	15
Table 3.6: Tolerable discharge comparison between EurOtop Manual I & II	16
Table 3.7: Overtopping limits for damage to the defence crest (EurOtop Manual I – 2007)	16
Table 3.8: Overtopping limits for people and vehicles (EurOtop Manual I – 2007)	17
Table 3.9: Recommended discharge limits for assets	17
Table 3.10: Recommended discharge limits for users	17
Table 3.11: Overtopping results – Case 1	18
Table 3.12: Overtopping results – Case 2	19
Table 3.13: Overtopping results – Case 3	20
Table 3.14: Overtopping results – Case 4	21
Table 3.15: Overtopping results – Case 5	22

Figures

Figure 1.1: Site Location	1
Figure 2.1: UKCP18 Projections at Colwyn Bay – RCP8.5	4
Figure 2.2: Location of Beach Profiles	5
Figure 3.1: Equations for overtopping discharge of smooth revetment	14
Figure 3.2: Equation for overtopping discharge of steep revetment	14
Figure 3.3: Equation for overtopping discharge of vertical wall	14
Figure 4.1: Illustration of proposed promenade raising and rock revetment crest	26

Photos

Photo 2.1: Profile 1	6
Photo 2.2: Profile 2	6
Photo 2.3: Profile 3	7
Photo 2.4: Profile 4	7
Photo 2.5: Damages to the promenade and the seawall	9

1 Introduction

1.1 Project Background

Conwy County Borough Council (hereinafter referred to as the Client) require a detailed design to be carried out for a new coastal defence and active travel improvements on an approximately 1,250m long section of frontage at Old Colwyn.

Coastal defence works include:

- a large rock revetment
- protection works to existing outfalls that will be covered by the revetment
- a new pedestrian beach accesses to replace the existing ones,
- the raising and widening of the promenade.

Mott MacDonald have previously worked on nearby projects including Colwyn Bay Promenade Phase 1a & b, Colwyn Bay Promenade Phase 2 and regularly undertakes inspections along this frontage.

The existing promenade is inundated during storms, causing flooding. This will be exacerbated with future climate change. The promenade requires raising to safeguard the area from overtopping including allowances for future climate change.

Additionally, the provision of new coastal defences should enable additional regeneration and amenity benefits. This will include widening the promenade along the narrow sections to improve access for cyclists, pedestrians and vehicles.

1.2 Site Location

The site is in Colwyn Bay, North Wales. The project area is located between Porth Eirias carpark (by Colwyn Bay Watersports Centre) and Splash Point Old Colwyn.

Figure 1.1: Site Location



Source: Google Maps

This part of the frontage is fairly narrow and is mainly used by the public for cycling, walking, and fishing. There is currently no amenity on the beach or shops and restaurants on the landward side of the promenade. A railway runs along the back of the promenade on top a large embankment.

1.3 Purpose of this Report

This report aims to:

- Define existing waves, water levels and wave overtopping rates along the promenade
- Assess options and scenarios to reduce the amount of overtopping
- Make a recommendation of crest levels for revetment and promenade levels for the outline stage of the scheme based on international guidelines

2 Site Information

2.1 Design Life

The following design lives are based on the Employer's Requirements and Basis of Design (Mott MacDonald, 2020).

The design life of the coastal structures (revetment, fishing platform and steel sub-structures) is 50 years.

The design life for the other structural elements (walls, piles, new highway and promenade) is 120 years.

The design life for other ancillary design items such as guardrails, handrails and outfall grills are likely to have limited design lives in accordance with manufacturers designs.

2.2 Promenade and Beach Levels

Existing levels are derived from topographical drawings supplied by the Client (undertaken by Survey Operations dated April 2008).

Beach survey information is based on Penrhyn Bay – Colwyn Bay post storm survey undertaken in 2019 by Environmental & Engineering Services.

All levels used are in metres above ordnance datum (AOD). Horizontal control points are relative to the National Grid (OSGB36).

2.3 Tide Levels

Table 2.1 presents the tide levels which represent typical water level conditions along the frontage.

Table 2.1: Tide Levels at Colwyn Bay

Tide		Chart Datum (mCD)	Ordnance Datum (mOD)
Highest Astronomical Tide	HAT	+8.78	+4.68
Mean High Water Spring	MHWS	+7.80	+3.70
Mean High Water Neap	MHWN	+6.10	+2.00
Mean Sea Level	MSL	+4.21	+0.11
Ordnance Datum		+4.10	0.00
Mean Low Water Neap	MLWN	+2.29	-1.81
Mean Low Water Spring	MLWS	+0.66	-3.44
Lowest Astronomical Tide	LAT	-0.24	-4.34

Source: (Royal Haskoning, 2010)

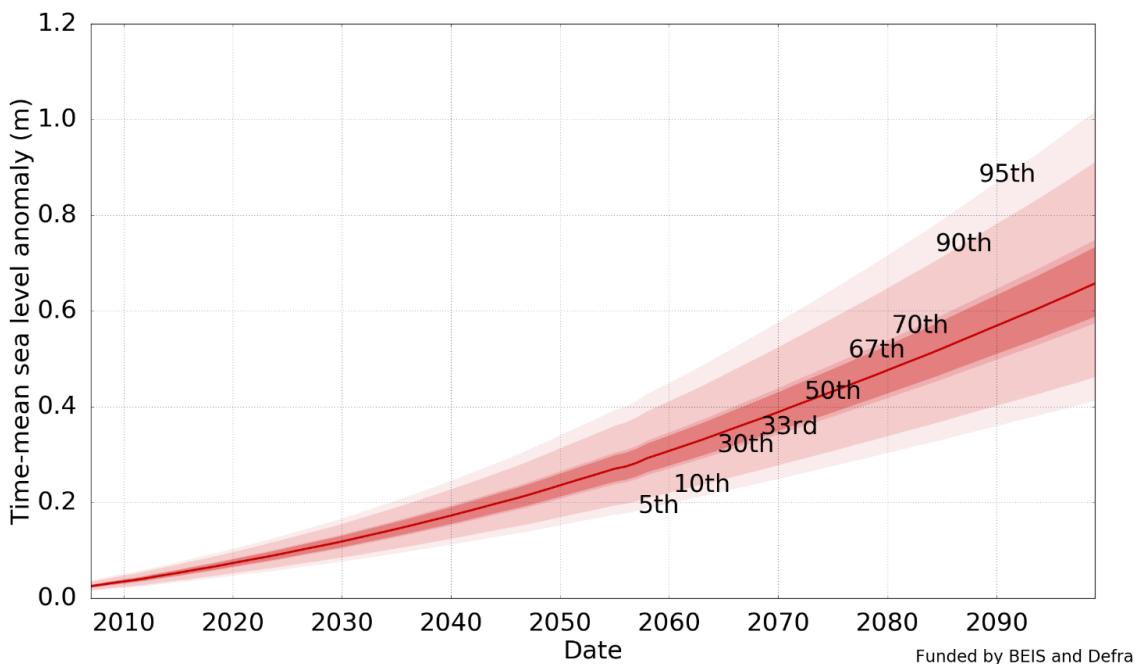
Note: MLWN and MLWS for Colwyn Bay calculation by interpolation between Llandudno and Hilbre Island.

2.4 Sea Level Rise

Tide data provided in Section 2.3 was published in the 2010 report but the actual baseline date for the levels was not provided. To allow adjustment of these levels to current mean sea levels, it has been conservatively been assumed that the data originates from 2007.

The assessment of the sea level rise covering the design life of the coastal structures is based on UK Climate Projections (UKCP 18) from (Met Office Hadley Centre, 2018). The value used in the overtopping calculation has been extracted from the data comprising the curve shown in Figure 2.1. The 95th percentile of the RCP8.5 scenario has been considered as a conservative approach at this stage. For the 50-year design life used to determine the proposed seawall design, a sea level rise allowance of 0.59m has been added to the sea levels.

Figure 2.1: UKCP18 Projections at Colwyn Bay – RCP8.5



Source: (Met Office Hadley Centre, 2018).

Funded by BEIS and Defra

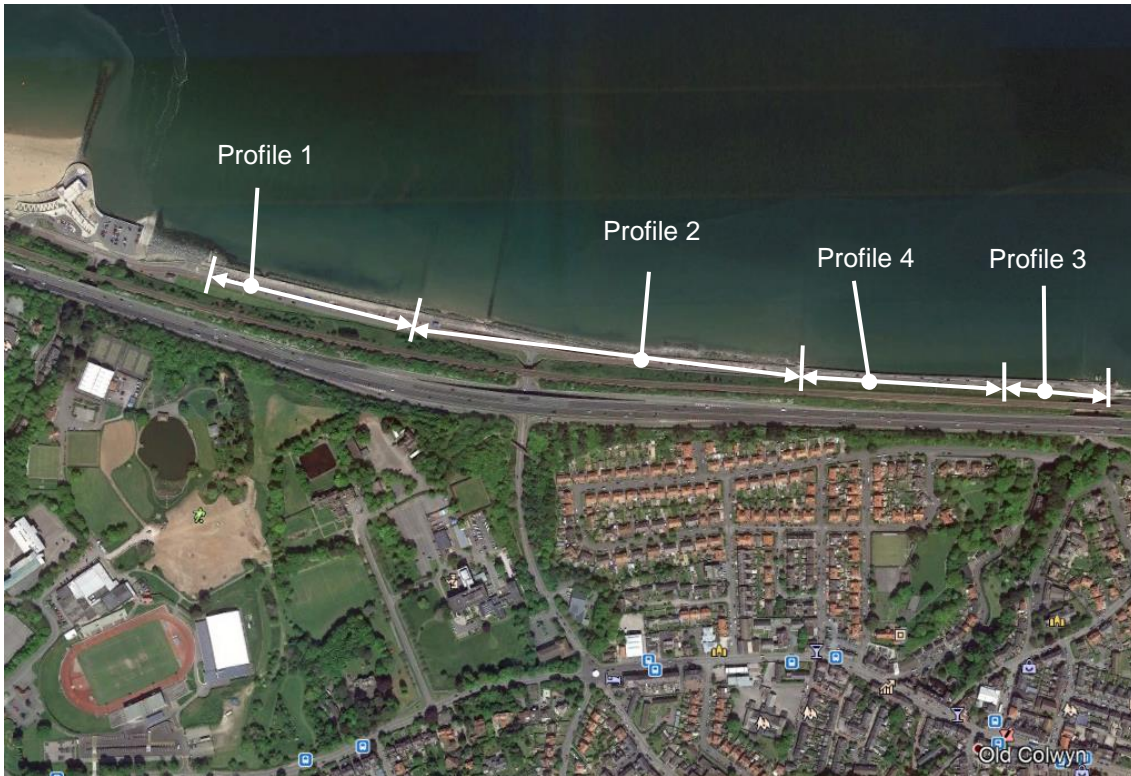
2.5 Beach Profile

The Old Colwyn Promenade frontage consists of a gently sloping sandy beach, with the geometry of the rock revetments varying along the project area. The eastern area does not include a rock revetment in front of the seawall.

The beach includes a number of stepped accesses from the promenade and a series of outfalls (owned by Welsh Water) and groynes.

The beach slope has been estimated from the beach survey at the location of four profiles. The location of these profiles can be seen in Figure 2.2.

Figure 2.2: Location of Beach Profiles



Source: Google Earth Pro (modified)

The geometry of the existing seawalls at the location of the four profiles is described in Table 2.2 as follows:

Table 2.2: Existing Seawall Levels

	Top of Seawall (m OD)	Toe of Seawall (m OD)	Wall Height (m)	Beach Slope
Profile 1	6.13	3.00	3.13	1 in 100
Profile 2	5.50	3.30	2.20	1 in 40
Profile 3	5.47	0.00	5.47	1 in 50
Profile 4	5.75	0.84	4.91	1 in 45

Photos of the structures and the beach at those profiles are shown in Photo 2.1 to Photo 2.4 below.

Photo 2.1: Profile 1



Source: MML Site Visit on 17th January 2020

Photo 2.2: Profile 2



Source: MML Site Visit on 17th January 2020

Photo 2.3: Profile 3



Source: MML Site Visit on 17th January 2020

Photo 2.4: Profile 4



Source: MML Site Visit on 17th January 2020

2.6 Beach Drawdown

Historic beach surveys dating back to 2005 along the Old Colwyn Promenade provided by the Client were reviewed to assess changes in beach levels over the years. The levels were checked at eight locations by the future beach step accesses.

The comparison between beach levels indicate that the beach is generally stable and that levels do not vary significantly with the control structures in place. The maximum variation in beach level is 0.7m while the variation at the other 7 locations varies between 0.1m and 0.5m. In light of those results a beach drawdown value of 0.5m from the current survey data has been adopted for the design of the beach steps with possibility for the steps to be extended in the future should localised erosion occur in the future (Mott MacDonald, 2020).

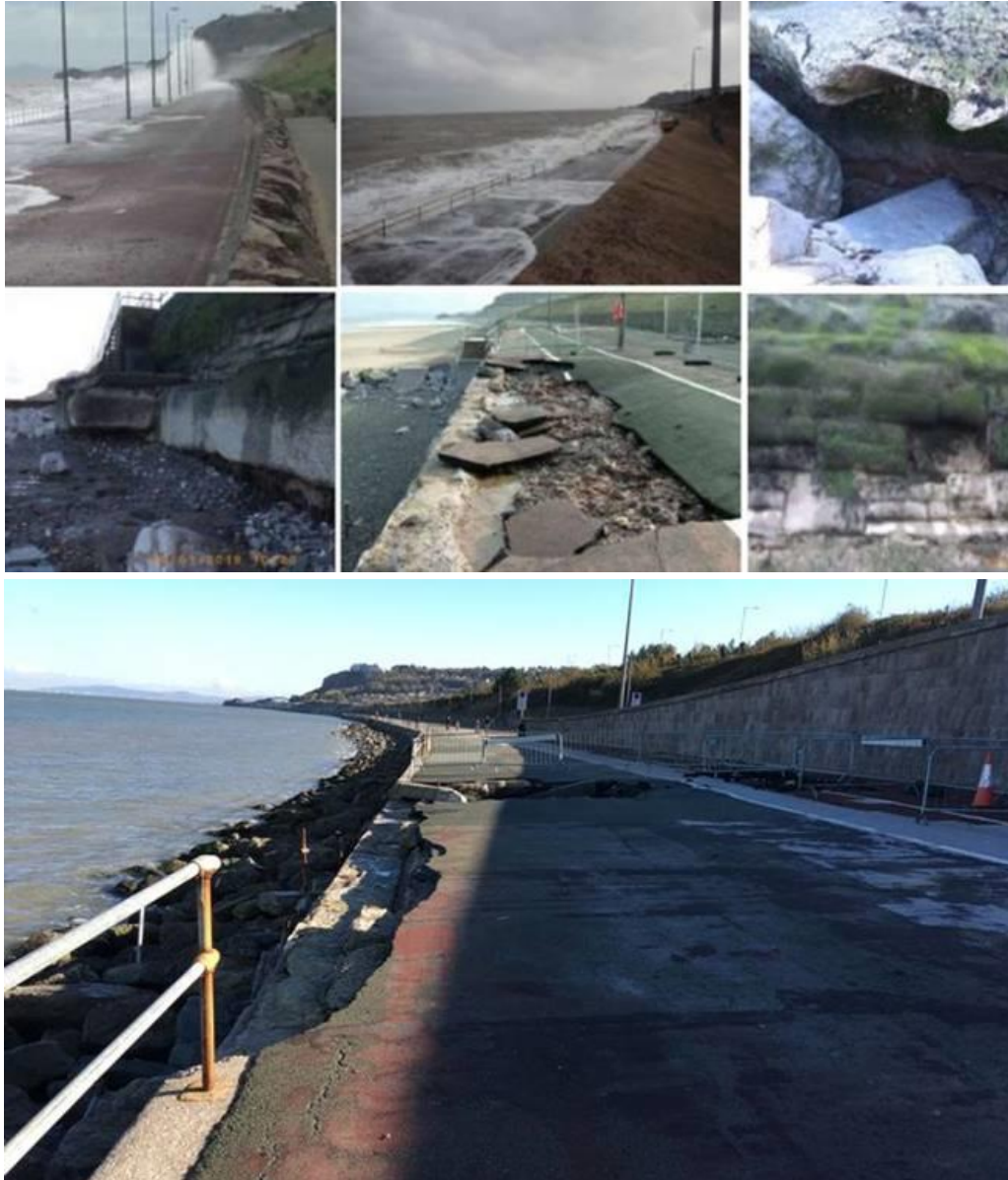
Local beach recharge or recycling may also be implemented if required over time.

2.7 Existing Storm Events

There is no formal record of road closures of the promenade highway from Rotary Way to Beach Road. However, it has been noticed that the number of closures has increased in recent years. The promenade is now routinely closed whenever spring tides coincide with forecast north or northwest winds.

In the past, overtopping has caused the surfacing of the promenade to get broken up, the handrails failed, sections of the seawalls have suffered from risk of undermining / voids to rear of the promenade, and the rear wall along the toe of the railway embankment has been damaged. These are repaired by the Client on a reactionary basis.

Photo 2.5: Damages to the promenade and the seawall



Source: <https://www.bbc.co.uk/news/uk-wales-50069665>

3 Wave Overtopping Assessment

To undertake an overtopping assessment, information on the existing extreme wave and water levels are required.

3.1 Joint Probability Analysis between Waves and Water Levels

The following joint probability of extreme waves and water levels have been extracted from (Royal Haskoning, 2010) a location offshore from Colwyn Bay.

Table 3.1: Joint probability of design waves and water levels

Return periods	WL (mOD) Sop	Tm (s)	Hs (m)	
1	2.84	0.03	6.35	2.18
	3.29	0.03	6.01	1.96
	3.75	0.03	5.58	1.71
	4.21	0.03	4.95	1.37
	4.67	0.03	2.89	0.54
10	2.84	0.03	7.70	3.15
	3.29	0.03	7.70	3.15
	3.75	0.03	7.61	3.08
	4.21	0.03	7.38	2.91
	4.67	0.03	7.02	2.65
	5.13	0.03	5.63	1.81
50	3.29	0.03	8.21	3.56
	3.75	0.03	8.17	3.54
	4.21	0.03	8.03	3.42
	4.67	0.03	7.82	3.25
	5.13	0.03	7.35	2.88
	5.58	0.03	5.58	1.71
100	3.29	0.03	8.42	3.74
	3.75	0.03	8.34	3.68
	4.21	0.03	8.25	3.60
	4.67	0.03	8.03	3.42
	5.13	0.03	7.70	3.15
	5.58	0.03	7.04	2.65
200	3.29	0.03	8.68	3.97
	3.75	0.03	8.67	3.96
	4.21	0.03	8.60	3.90
	4.67	0.03	8.41	3.74
	5.13	0.03	8.04	3.42
	5.58	0.03	7.57	3.05

Source: (Royal Haskoning, 2010) (part of table)

The offshore mean wave periods available in (Royal Haskoning, 2010) presented in Table 3.1 were propagated from the offshore location to the project area (toe of the proposed rock revetment) by applying the Goda shoaling formula. The effect of beach level fluctuations on the waves has also been included, including a 0.5m beach drawdown (section 2.6). An increase to the extreme water levels of Table 3.1 by 0.59m (section 2.4) was applied to assess the extreme water levels in 50 years' time accounting for sea level rise.

The results of the joint probability analysis of the design waves and water levels are shown in Table 3.2 and Table 3.3.

Table 3.2: Joint probability of design waves and water levels (present day)

Return period (joint probability) [yrs]	WL [mOD] (present day)	Extreme Wave Return Period R [yrs]	Tm [s]	Hs (toe) [m] Profile 1	Hs (toe) [m] Profile 2	Hs (toe) [m] Profile 3	Hs (toe) [m] Profile 4
1	2.84	0.45	8.90	1.76	1.68	2.43	2.22
	3.29	0.38	8.50	1.98	1.91	2.22	2.24
	3.75	0.33	8.05	2.00	2.07	2.01	2.05
	4.21	0.28	7.43	1.54	1.56	1.48	1.50
	4.67	0.21	5.92	0.56	0.57	0.55	0.55
10	2.84	2.68	10.66	1.88	1.80	2.55	2.34
	3.29	2.68	10.66	2.12	2.06	2.80	2.59
	3.75	1.93	10.54	2.36	2.31	3.05	2.85
	4.21	1.16	10.23	2.59	2.56	3.09	3.09
	4.67	0.73	9.75	2.82	2.80	2.93	2.95
50	5.13	0.35	8.23	2.00	2.03	1.94	1.96
	3.29	33.30	11.34	2.17	2.12	2.86	2.65
	3.75	28.54	11.31	2.42	2.38	3.11	2.91
	4.21	15.37	11.12	2.66	2.63	3.36	3.15
	4.67	6.11	10.85	2.88	2.87	3.45	3.39
	5.13	1.09	10.17	2.99	3.08	3.03	3.07
100	5.58	0.33	8.05	1.86	1.88	1.81	1.83
	3.29	108.34	11.62	2.20	2.14	2.88	2.67
	3.75	72.22	11.52	2.44	2.40	3.13	2.93
	4.21	50.00	11.40	2.68	2.65	3.38	3.18
	4.67	15.37	11.12	2.91	2.89	3.62	3.42
	5.13	2.68	10.66	3.12	3.12	3.34	3.36
	5.58	0.73	9.75	2.88	2.98	2.90	2.94

Source: MML

Table 3.3: Joint probability of design waves and water levels (in 50 years)

Return period (joint probability) [years]	WL [mOD] (in 50 years)	Extreme Wave Return Period R [yrs]	Tm [s]	Hs (toe) [m] Profile 1	Hs (toe) [m] Profile 2	Hs (toe) [m] Profile 3	Hs (toe) [m] Profile 4
1	3.43	0.45	8.90	2.09	2.02	2.44	2.46
	3.88	0.38	8.50	2.18	2.25	2.20	2.24
	4.34	0.33	8.05	1.92	1.96	1.86	1.89
	4.8	0.28	7.43	1.50	1.52	1.46	1.47
	5.26	0.21	5.92	0.55	0.56	0.55	0.55
10	3.43	2.68	10.66	2.20	2.14	2.88	2.67
	3.88	2.68	10.66	2.44	2.40	3.14	2.93
	4.34	1.93	10.54	2.68	2.66	3.27	3.18
	4.8	1.16	10.23	2.91	2.90	3.09	3.11
	5.26	0.73	9.75	2.88	2.98	2.92	2.95
	5.72	0.35	8.23	1.97	1.99	1.91	1.93
50	3.88	33.30	11.34	2.49	2.46	3.19	2.98
	4.34	28.54	11.31	2.74	2.72	3.45	3.24
	4.8	15.37	11.12	2.98	2.97	3.63	3.49
	5.26	6.11	10.85	3.21	3.21	3.45	3.47
	5.72	1.09	10.17	2.99	3.09	2.98	3.02
	6.17	0.33	8.05	1.83	1.85	1.79	1.80
100	3.88	108.34	11.62	2.52	2.48	3.21	3.01
	4.34	72.22	11.52	2.76	2.74	3.46	3.26
	4.8	50.00	11.40	3.00	2.99	3.71	3.52
	5.26	15.37	11.12	3.23	3.23	3.63	3.65
	5.72	2.68	10.66	3.27	3.38	3.31	3.36
	6.17	0.73	9.75	2.89	2.98	2.87	2.90

Source: MML

3.2 Scenarios

The following scenarios have been considered as part of the wave overtopping assessment (both for present day and in 50 years, including beach drawdown):

- Case 1: Existing structure and foreshore geometry (Baseline) including beach drawdown
- Case 2: Revetment up to existing crest level of seawall
- Case 3: Revetment up to +7.00m OD, promenade at +7.00m OD
- Case 4: Revetment up to +7.50m OD, promenade at +7.00m OD
- Case 5: Revetment up to +7.50m OD with crest and crest wall up to +8.15m OD and promenade at +7.00m OD)

The crest width of the revetment was set at 5m and its slope at 1V to 3H.

3.3 Wave Overtopping Formulae

Overtopping hazards are assessed by determining the volume of water that passes over the crest of the defence. Hazards driven by overtopping can be linked to a number of flow parameters. The outputs of overtopping analysis undertaken utilising the EurOtop Manual 2018 (Van der Meer, et al., 2018) are:

- Mean overtopping discharge (q), defined as the average overtopping volume from all waves, it is estimated in litres per second per metre length of seawall.
- Individual maximum overtopping volume (V_{max}), is defined as the maximum discharge from a single wave in litres per metre length of seawall.

These parameters (q and V_{max}) are checked against defined criteria to establish the performance of differing geometric structure configurations. In the latest EurOtop V_{max} is the preferred parameter to define overtopping hazard as this represents the maximum wave overtopping based on the structure geometry, wave conditions and typical wave distributions. Definition of the criteria for V_{max} are less established and therefore the overtopping assessment will make use of both parameters, refer to Section 3.4.

When defining the required overtopping performance of a structure it is important to consider:

- The frequency of the overtopping event; and,
- The receptors (assets, people...) at risk behind the overtopping point.

The frequency of the overtopping events, assessed by the return periods set in the joint probability analysis should relate to the expectations of the users of the structures, highway and promenade and the requirements of the asset owners/ managers.

The EurOtop Manual gives empirical formulations, or neural net/gaussian interpolation methods, that predict either the best fit to the test data or upper bound. The upper bound values of the predictions were used.

The EurOtop Manual II – 2018 Equations 5.12 & 5.13, as shown below, are used to determine the overtopping discharge on the smooth revetment sections of the scheme (armour slope smoother than 1V to 2H).

Figure 3.1: Equations for overtopping discharge of smooth revetment

$$\frac{q}{\sqrt{g \cdot H_{m0}^3}} = \frac{0.026}{\sqrt{\tan \alpha}} \gamma_b \cdot \xi_{m-1,0} \cdot \exp \left[- \left(2.5 \frac{R_c}{\xi_{m-1,0} \cdot H_{m0} \cdot \gamma_b \cdot \gamma_f \cdot \gamma_\beta \cdot \gamma_v} \right)^{1.3} \right] \quad 5.12$$

with a maximum of:
$$\frac{q}{\sqrt{g \cdot H_{m0}^3}} = 0.1035 \cdot \exp \left[- \left(1.35 \frac{R_c}{H_{m0} \cdot \gamma_f \cdot \gamma_\beta \cdot \gamma^*} \right)^{1.3} \right] \quad 5.13$$

Source: (Van der Meer, et al., 2018).

The following EurOtop Manual II – 2018 Equation 6.6, as shown below, is used to determine the overtopping discharge on the steep revetment sections of the scheme (armour slope equal or steeper than 1V to 2H).

Figure 3.2: Equation for overtopping discharge of steep revetment

$$\frac{q}{\sqrt{g \cdot H_{m0}^3}} = 0.1035 \cdot \exp \left[- \left(1.35 \frac{R_c}{H_{m0} \cdot \gamma_f \cdot \gamma_\beta} \right)^{1.3} \right] \text{ for steep slopes 1:2 to 1:4/3} \quad 6.6$$

Source: (Van der Meer, et al., 2018).

The overtopping discharge at the vertical wall sections of the scheme have been determined by the EurOtop Manual II – 2018 Equation 7.2, as shown below:

Figure 3.3: Equation for overtopping discharge of vertical wall

$$\frac{q}{\sqrt{g \cdot H_{m0}^3}} = 0.054 \cdot \exp \left[- \left(2.12 \frac{R_c}{H_{m0}} \right)^{1.3} \right] \quad 7.2$$

Source: (Van der Meer, et al., 2018).

Inputs to the calculations comprise the water levels, wave heights and wave periods for each profile that resulted from the joint probability analysis, both at present day and in 50 years, the structure geometry and the beach profile for each of the profiles investigated (including beach drawdown).

The main assumptions for the calculation are as follows:

- Storm duration = 6 hours.
- Roughness of revetment $\gamma_r = 0.55$ for two-layer rock armour with impermeable core (EurOtop II)
- Concrete surface of vertical walls
- Waves acting perpendicular to the structure
- No berm
- Bullnose (Return Wall) width $Br = 0.5\text{m}$ and height $hr = 1\text{m}$ at Access Build-out.

3.4 Wave Overtopping Criteria

The following criteria set out in EurOtop II Manual (Van der Meer, et al., 2018) and in the EurOtop Manual (Pullen, et al., 2007), have been reviewed to assess the level of risk associated with wave overtopping for the different scenarios. The discharge limits act as guidelines to assess the frequency of extreme waves exceeding the level of the proposed sea defences.

Table 3.4: Overtopping limits for structural design of breakwaters, seawalls, dikes

Hazard type and reason	Mean discharge q (l/s per m)	Max volume V _{max} (l per m)
Rubble mound breakwaters; H _{m0} > 5 m; no damage	1	2,000-3,000
Rubble mound breakwaters; H _{m0} > 5 m; rear side designed for wave overtopping	5-10	10,000-20,000

Source: (Van der Meer, et al., 2018).

Table 3.5: Overtopping limits for people and vehicles (EurOtop II)

Hazard type and reason	Mean discharge q (l/s per m)	Max volume V _{max} (l per m)
People at structures with possible violent overtopping, mostly vertical structures	No access for any predicted overtopping	No access for any predicted overtopping
People at seawall / dike crest. Clear view of the sea. H _{m0} = 3 m H _{m0} = 2 m H _{m0} = 1 m H _{m0} < 0.5 m	0.3 1 10-20 No limit	600 600 600 No limit
Cars on seawall / dike crest, or railway close behind crest H _{m0} = 3 m H _{m0} = 2 m H _{m0} = 1 m	<5 10-20 <75	2000 2000 2000
Highways and roads, fast traffic	Close before debris in spray becomes dangerous	Close before debris in spray becomes dangerous

Source: (Van der Meer, et al., 2018).

Table 3.6: Tolerable discharge comparison between EurOtop Manual I & II

Return Period	Tolerable Discharge	Comment	Reference
1 in 1 year	$q < 1$ l/s per m $V_{max} < 600$ l/m.	For people and vehicles - People at seawall / dike crest. Clear view of the sea. $H_{m0} = 2$ m.	EurOtop (2018): Table 3.3
1 in 1 year	$q < 1-10$ l/s per $V_{max} < 500$ l/m at low level.	Trained staff, well shod and protected, expecting to get wet, overtopping flows at lower levels only, no falling jets, low danger of fall from walkway.	EurOtop (2007): Table 3.2
1 in 200 year	-	No limits given for vertical structures or promenades	EurOtop (2018)
1 in 200 year	$q < 200$ l/s per m	No damage to paved or armoured promenade behind seawall.	EurOtop (2007): Table 3.5

Source: (Van der Meer, et al., 2018).

Table 3.7: Overtopping limits for damage to the defence crest (EurOtop Manual I – 2007)

Hazard type and reason	Mean discharge
	q (l/s/m)
Embankment seawalls/sea dikes	
No damage if crest and rear slope are well protected	50–200
No damage to crest and rear face of grass covered embankment of clay	1–10
No damage to crest and rear face of embankment if not protected	0.1
Promenade or revetment seawalls	
Damage to paved or armoured promenade behind seawall	200
Damage to grassed or lightly protected promenade or reclamation cover	50

Source: (Pullen, et al., 2007).

Table 3.8: Overtopping limits for people and vehicles (EurOtop Manual I – 2007)

Hazard type and reason	Mean discharge	Max volume ⁽¹⁾
	q (l/s/m)	V _{max} (l/m)
Trained staff, well shod and protected, expecting to get wet, overtopping flows at lower levels only, no falling jet, low danger of fall from walkway	1–10	500 at low level
Aware pedestrian, clear view of the sea, not easily upset or frightened, able to tolerate getting wet, wider walkway ⁽²⁾ .	0.1	20–50 at high level or velocity

Source: (Pullen, et al., 2007).

In principle the overtopping limits are taken from the latest industry standard guidance, EurOtop Manual 2018 (Van der Meer, et al., 2018) as shown above. However, for areas of promenade and carriageway landward of the crest no limits are given in the current version of the guidance and the limits from the previous version of the guidance have been adopted, as shown in Table 3.9. Those values are defined to ensure that the paved promenade is not damaged during extreme events behind the crest of the revetment/ seawall.

Table 3.9: Recommended discharge limits for assets

Surface	q [l/m/s]	Return period (years)
Paved	200	100
Grass	50	100

For pedestrian and vehicle access near the crest of the structure because the area does not provide essential access, but only amenity access, the overtopping limits will be assessed for the 1 in 1-year and 1 in 10-year wave and water level conditions. The risk for pedestrians and vehicles will be assessed as part of a risk assessment and mitigation measures such as promenade or road closure will be assessed.

Table 3.10: Recommended discharge limits for users

User	Vmax [l/m]	Return period (years)
Pedestrian	600	1 - 10
Vehicle	2,000	1 - 10

Overtopping measurements vary widely even within a single series of tests in physical modelling. It would not be unreasonable to expect the results of a physical model to be between a half and twice the predicted value for the structure. Strict adherence to the specified overtopping limits, particularly as they are upper bound predictions, is not appropriate as in many instances this may result in impractical structures. For instance, if a wave wall was designed as a standard height parapet and the predictions exceeded the limit by 20% that would be deemed acceptable. However, when criteria are relaxed the risk consequences should be fully understood and supported through risk assessment.

3.5 Wave Overtopping Results

The estimated overtopping results are presented in Table 3.11 to Table 3.15 below per return period and profile location. The results cover the different scenarios described in section 3.2 and consider both present day and 50-year situations at each profile, including beach drawdown. The calculations are provided in Appendix A.

Table 3.11: Overtopping results – Case 1

	Return period (joint probability) [yrs]	Present Day		In 50 years		Pass (P)/ Exceed (E) criteria
		q [l/m/s]	Vmax [l/m]	q [l/m/s]	Vmax [l/m]	
Profile 1	1	53	11,852	82	16,596	E
	10	421	43,706	656	52,180	E
	50	683	52,981	918*	55,452*	E
	100	789	54,551	955*	55,789*	E
Profile 2	1	125	17,384	194	22,341	E
	10	236	21,581	295*	25,126*	E
	50	275*	22,665*	336**	26,138**	E
	100	287*	22,983*	354**	26,552**	E
Profile 3	1	96	20,623	188	33,267	E
	10	689	57,450	948*	62,159*	E
	50	1,071*	61,692*	1,343**	62,130**	E
	100	1,206**	62,725**	**	**	E
Profile 4	1	81	17,883	131	23,505	E
	10	590	54,901	869*	49,452*	E
	50	899*	60,195*	1,301**	51,090**	E
	100	935*	60,605*	1,458**	51,435**	E

* risk of flooding of the promenade (water level close to crest level of the seawall)

** frequently flooded (water level exceeds crest level of promenade)

Table 3.12: Overtopping results – Case 2

	Return period (joint probability) [yrs]	Present Day		In 50 years		Pass/ Exceed criteria
		q [l/m/s]	Vmax [l/m]	q [l/m/s]	Vmax [l/m]	
Profile 1	1	16	141	46	673	P/E
	10	391	1,225	802	18,124	E
	50	772	2,351	1,313*	27,422*	E
	100	860	3,001	1,545*	38,332*	E
Profile 2	1	73	179	135	2,683	P/E
	10	784	1,890	1,473*	26,085*	E
	50	1,430*	4,128*	1,669**	39,311**	E
	100	1,461*	4,550*	1,688**	41,343**	E
Profile 3	1	67	157	128	2,216	P/E
	10	899	2,392	1,453*	25,621*	E
	50	1,285*	5,350*	1,909**	43,843**	E
	100	1,680*	6,077*	2,067**	48,876**	E
Profile 4	1	42	157	85	1,756	P/E
	10	689	2,016	1,206	23,150	E
	50	982	4,192	1,631*	40,335*	E
	100	1,401	5,298	1,979**	44,522**	E

* risk of flooding of the promenade (water level close to crest level of the seawall)

** frequently flooded (water level exceeds crest level of promenade)

Table 3.13: Overtopping results – Case 3

	Return period (joint probability) [yrs]	Present Day		In 50 years		Pass/ Exceed criteria
		q [l/m/s]	Vmax [l/m]	q [l/m/s]	Vmax [l/m]	
Profile 1	1	0	125	1	423	P
	10	27	709	67	10,329	E
	50	73	1,289	143	17,292	P
	100	95	1,665	229	26,030	P/E
Profile 2	1	0	154	1	815	P/E
	10	25	686	76	11,722	E
	50	88	1,508	158	18,659	P
	100	122	1,670	251	28,442	P/E
Profile 3	1	0	277	1	443	P
	10	36	867	70	10,729	E
	50	105	2,105	164	22,593	P
	100	140	2,696	237	26,749	P/E
Profile 4	1	0	201	1	485	P
	10	37	896	74	11,125	E
	50	95	1,942	167	22,951	P
	100	147	2,405	246	27,455	P/E

* risk of flooding of the promenade (water level close to crest level of the seawall)

** frequently flooded (water level exceeds crest level of promenade)

Table 3.14: Overtopping results – Case 4

	Return period (joint probability) [yrs]	Present Day		In 50 years		Pass/ Exceed criteria
		q [l/m/s]	Vmax [l/m]	q [l/m/s]	Vmax [l/m]	
Profile 1	1	0	89	0	252	P
	10	13	575	35	7,143	P/E
	50	39	958	81	12,520	P
	100	54	1,010	138	19,809	P
Profile 2	1	0	120	0	563	P
	10	12	557	41	8,434	P/E
	50	48	1,122	91	13,574	P
	100	68	1,200	154	22,345	P
Profile 3	1	0	215	0	265	P
	10	18	692	37	7,477	E
	50	60	1,622	98	17,052	P
	100	83	2,077	144	20,478	P
Profile 4	1	0	153	0	294	P
	10	19	714	39	7,810	E
	50	54	1,496	100	17,376	P
	100	86	1,795	150	21,136	P

* risk of flooding of the promenade (water level close to crest level of the seawall)

** frequently flooded (water level exceeds crest level of promenade)

Table 3.15: Overtopping results – Case 5

	Return period (joint probability) [yrs]	Present Day		In 50 years		Pass/ Exceed criteria
		q [l/m/s]	Vmax [l/m]	q [l/m/s]	Vmax [l/m]	
Profile 1	1	0	16	0	51	P
	10	3	1,264	8	2,465	E
	50	9	2,945	20	5,437	P
	100	14	4,068	42	8,655	P
Profile 2	1	0	25	0	75	P
	10	2	1,194	11	3,160	E
	50	12	3,691	27	5,973	P
	100	17	4,167	53	10,567	P
Profile 3	1	0	53	0	109	P
	10	4	1,744	9	2,726	E
	50	17	5,818	36	8,758	P
	100	26	8,012	52	11,919	P
Profile 4	1	0	34	0	118	P
	10	4	1,837	10	3,000	E
	50	15	5,200	38	9,117	P
	100	25	6,774	54	12,380	P

* risk of flooding of the promenade (water level close to crest level of the seawall)

** frequently flooded (water level exceeds crest level of promenade)

4 Interpretation of Results and Recommendations

4.1 Interpretation of Results

The initial overtopping results for the existing structures and geometries were presented in Table 3.11 (**Case 1**). For the 1 in 10-year return period, at present day, the maximum mean overtopping discharge q estimated is 689 l/m/s with a maximum overtopping volume V_{\max} of 57,450 l/m and flooding occurring in 50 years when considering the sea level rise (Profile 3). These values are significantly higher than the limits proposed by guidelines and impose risk to public health and safety. Existing structures are at high risk of flooding and damage during extreme events as overtopping values significantly exceed the overtopping criteria presented in section 3.4.

Case 1 – Existing structure and foreshore geometry (Baseline) including beach drawdown

- Extremely high wave discharge volumes (both mean and peak)
- Promenade flooded at profiles 2, 3 and 4 from 1 in 10 year events and from 1 in 50 year events at profile 1 (higher crest level).
- Exceeds defined overtopping limits
- Unsafe for the public for all extreme events
- Severe damage to the promenade, the highway and the highway equipment

For Case 2, the mean overtopping discharges are comparable to Case 1 in terms of mean discharge value with a more noticeable reduction in terms of the maximum volume. Those values still pose risks to public health and safety and leave the protected structures at high risk of flooding and damage during extreme events.

Case 2 – Revetment up to existing crest level of seawall

- Extremely high wave discharge volumes (both mean and peak)
- Promenade flooded at profiles 2, 3 from 1 in 10 year events and from 1 in 50 year events at profiles 1 and 4.
- Mean overtopping discharges comparable to Case 1. Maximum overtopping volumes are divided by 13 in average compared to Case 1 at present day.
- Exceeds defined overtopping limits
- Unsafe for the public for all extreme events
- Severe damage to the promenade, the highway and the highway equipment

For **Case 3**, the mean discharges are significantly reduced compared to the existing defence. However, the maximum overtopping volumes remain over the criteria set in section 3.4 with high risks associated to public safety and potential damage to protected structures.

The mean overtopping discharge q remains under the limit for structures of 200 l/m/s (exceeded only for 1 in 100 year events in 50 years' time) and the maximum overtopping volume is reduced under the limit of 600 l/m (pedestrians) for 1 in 1 year events at present day.

Case 3 – Revetment up to +7.00m OD, promenade at +7.00m OD

- Overtopping results are significantly reduced and meet most of the criteria set at present day
- Mean overtopping discharges are reduced by 90% in average compared to Case 1 (Baseline) at present day. Maximum overtopping volumes are reduced by 97% in average compared to Case 1 at present day.
- Exceeds defined mean overtopping discharge limit for assets in 50 years' time for 1 in 100 year events.
- Exceeds maximum overtopping limit for vehicles at present day and just meets limit for pedestrians for 1 in 1 year events in 50 years' time.

For **Case 4**, the mean overtopping discharges are significantly reduced compared to Case 1, with the mean overtopping discharge q remaining under the limit for structures of 200 l/m/s for all cases and the maximum overtopping volume reduced under the limit of 600 l/m (pedestrians) for 1 in 1 year events.

Case 4 – Revetment up to +7.50m OD, promenade at +7.00m OD

- Overtopping results are significantly reduced and meet all the criteria set at present day and in 50 years' time
- Mean overtopping discharges are reduced by 94% in average compared to Case 1 (Baseline) at present day. Maximum overtopping volumes are reduced by 98% in average compared to Case 1 at present day.
- Meets defined mean overtopping discharge limit for assets in all return periods
- Meets maximum overtopping limit for vehicles at present day and meets limit for pedestrians for 1 in 1 year events in 50 years' time. Exceeds that limit for 1 in 10 year events and beyond.

For **Case 5**, the mean overtopping discharges are significantly reduced compared to Case 1, with the mean overtopping discharge q being under the limit for structures of 200 l/m/s for all cases and reducing the maximum overtopping volume under the limit of 600 l/m (pedestrians) for 1-1 year events, in close range of the 1 in 10 year events.

Case 5 – Revetment up to +7.50m OD with crest and crest wall up to +8.15m OD (with associated promenade at +7.00m OD)

- Overtopping results are significantly reduced and meet the criteria set at present day and in 50 years' time
- Mean overtopping discharges are reduced by 99% in average compared to Case 1 (Baseline) at present day.
- Meets defined mean overtopping discharge limit for assets in all return periods
- Meets limit for pedestrians for 1 in 1 year events in 50 years' time. Exceeds that limit for 1 in 10 year events and beyond.

4.2 Potential Mitigations and Adaptations

Road Closure

Mitigation measures such as promenade/ road closure during severe storms are required to keep the crest level at a reasonable level. In case of extreme storm events beyond 1 in 10-year return period, road closure might be required. Barriers would be reinstalled to prevent vehicular access to the promenade and an agreed mitigation for barring non-motorised users (pedestrians, cyclists etc) from entering the promenade such as VMS signage or physical barriers.

Climate Resilience

It is recommended that the new promenade proposed be adaptable for the future (beyond 50 years). Considering the effects of sea level rise, it is likely that a raising of the sea defences be required after a certain time. This is judged as a more cost-efficient approach rather than raising the promenade to 120-year design criteria at present day.

This would materialise as a setback distance left in the promenade to build a new crest wall or building a crest wall which can be raised in the future. The crest of the rock revetment has been designed so that it can also be raised in the future as required.

Raising the road and the promenade after 50 years is more challenging, that is why it is recommended to carry out those works at present day as highway infrastructure is less adaptable than the coastal defence.

4.3 Summary

The results for **Case 1 and Case 2** (keeping the existing crest level of the seawall) are well above the defined overtopping limits (section 3.4) and would not be safe for users as well as for the integrity of the promenade, road and embankment. Severe damages would be caused during extreme events, as it is already happening, and the frequency and severity of those damages is likely to increase with sea level rise. The railway embankment is likely to suffer damages when the promenade/road is flooded during the 1 in 50 and 1 in 100-year events.

Case 3 (revetment crest at +7.00m OD) represents a significant improvement compared to **Case 1 and Case 2** as it prevents the promenade from flooding and reduces the overtopping volumes to more reasonable values, particularly for the 1 in 1 year events. However even with the widening of the crest, this scenario is not estimated to be sufficient to meet the defined overtopping criteria in 50 years' time.

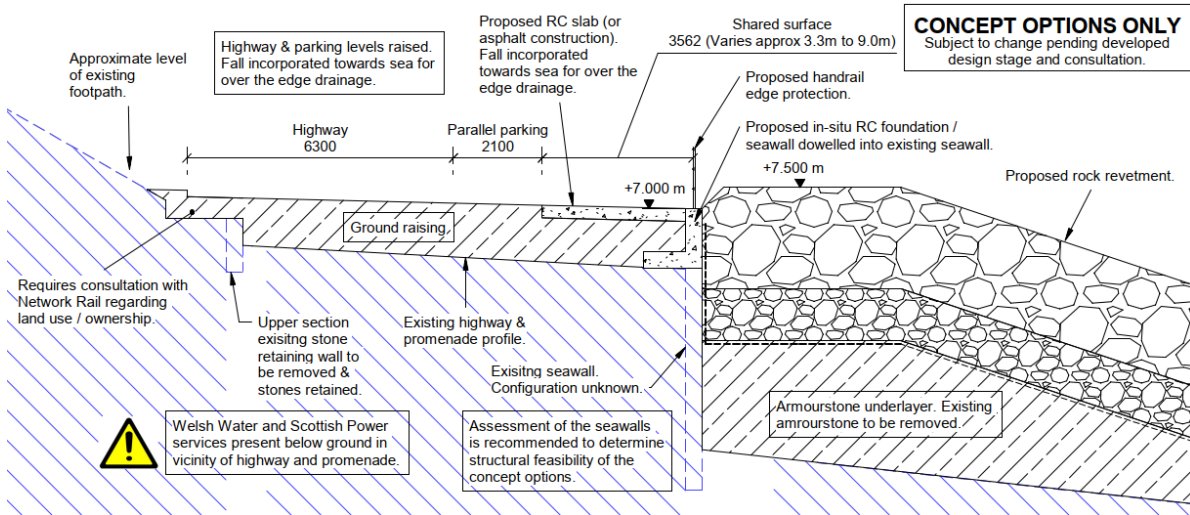
The results for **Case 4 and Case 5** (revetment crest at +7.50m OD, and crest wall at +8.15m OD for **Case 5**) are either within or in close range of the defined overtopping limits at present day and in 50 years' time.

Including certain mitigations (road closure for 1 in 10-year events) and potential for future adaptations, **Case 4** is considered to be the most suitable option to take forward. **Case 4** meets the criteria set for paved assets and generates very significant reduction in wave discharges compared to the existing defences, while still being feasible, cost efficient and adaptable. Crest levels below +7.50m OD are unlikely to meet the defined overtopping criteria which ensure durability of the assets/ structures and the safety of the public.

4.4 Outline Recommended Crest Level and Promenade Level

Based on the results presented and considering the levels of the existing structures at both extremities of the promenade (Porth Eirias and Splash Point), **Case 4** is the recommended design solution to protect the promenade from wave overtopping.

Figure 4.1: Illustration of proposed promenade raising and rock revetment crest



Mitigation measures such as promenade/ road closure are required to keep the crest level at the reasonable level proposed.

Physical modelling studies are recommended to validate the empirical formulae extracted from the EurOtop Manual used in this present study.

5 References

- Met Office Hadley Centre. (2018). *UK Climate Projections (UKCP 18)*. Retrieved from Met Office: <https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index>
- Mott MacDonald. (2020). *Colwyn Bay Old Promenade Coastal Defence. Basis of Design*.
- Mott MacDonald. (2020). *Colwyn Bay Old Promenade Coastal Defence: Wave Overtopping Assessment*.
- Pullen, T., Allsop, N. W., Bruce, T., Kortenhaus, A., Schüttrumpf, H., & Meer, J. W. (2007). *EurOtop. Wave Overtopping of Sea Defences and Related Structures: Assessment Manual*. Die Küste.
- Royal Haskoning. (2010). *Detailed Modelling Studies for Colwyn Bay Coastal Defence Scheme, Phase 1 Interim Modelling Technical Note*.
- Royal Haskoning. (2010). *Detailed Modelling Studies for Colwyn Bay Coastal Defence Scheme, Physical Model Tests of New Linear Defences*.
- Van der Meer, J., Allsop, N., Bruce, T., De Rouck, J., Kortenhaus, A., Pullen, T., . . . Zanuttigh, B. (2018). *EurOtop. Manual on wave overtopping of sea defences and related structures. An overtopping manual largely based on European research, but for worldwide application*. Retrieved from www.overtopping-manual.com

Appendices

A. Overtopping Calculations

29

A. Overtopping Calculations

Project

Colwyn Bay Old Promenade Coastal
Defence



Wave Overtopping Formulae	Dvn/dept	MNC/PCO	Job no/file no	415437	
	Calculated by	NS	Date	10/02/2020	Sheet no
	Checked by	FL	Date	15/02/2020	1 of 2

Wave Overtopping Formulae

Overtopping Discharge for Smooth Revetment:

$$\frac{q}{\sqrt{g \cdot H_{m0}^3}} = \frac{0.026}{\sqrt{\tan \alpha}} \gamma_b \cdot \xi_{m-1,0} \cdot \exp \left[- \left(2.5 \frac{R_c}{\xi_{m-1,0} \cdot H_{m0} \cdot \gamma_b \cdot \gamma_f \cdot \gamma_\beta \cdot \gamma_v} \right)^{1.3} \right] \quad 5.12$$

with a maximum of:
$$\frac{q}{\sqrt{g \cdot H_{m0}^3}} = 0.1035 \cdot \exp \left[- \left(1.35 \frac{R_c}{H_{m0} \cdot \gamma_f \cdot \gamma_\beta \cdot \gamma^*} \right)^{1.3} \right] \quad 5.13$$

Overtopping Discharge for Steep Revetment:

$$\frac{q}{\sqrt{g \cdot H_{m0}^3}} = 0.1035 \cdot \exp \left[- \left(1.35 \frac{R_c}{H_{m0} \cdot \gamma_f \cdot \gamma_\beta} \right)^{1.3} \right] \quad \text{for steep slopes 1:2 to 1:4/3} \quad 6.6$$

Overtopping Discharge for Vertical Wall:

$$\frac{q}{\sqrt{g \cdot H_{m0}^3}} = 0.054 \cdot \exp \left[- \left(2.12 \frac{R_c}{H_{m0}} \right)^{1.3} \right] \quad 7.2$$

Parameters:

q	= wave overtopping discharge (l/m/s)	γ_b	= influence factor for a berm
g	= gravitational acceleration constant (m/s ²)	γ_f	= influence factor for roughness elements on a slope
H_{m0}	= Offshore Wave Height (m)	γ_β	= influence factor for oblique wave attack
α	= angle between overall structure slope and horizontal (°)	γ_v	= influence factor for a wall at the end of a slope
$\xi_{m-1,0}$	= Breaker Parameter	γ^*	= influence factor for non breaking waves for a storm wall on a slope or promenade
R_c	= crest freeboard of structure (m)		

Project

Colwyn Bay Old Promenade Coastal
Defence



Wave Overtopping Formulae	Dvn/dept	MNC/PCO	Job no/file no	415437	
	Calculated by	NS	Date	10/02/2020	Sheet no
	Checked by	FL	Date	15/02/2020	2 of 2

Maximum Overtopping Volume (Revetment):

$$V_{max} = \alpha \cdot [\ln(N_{ow})]^{1/b} \quad 5.57$$

α, b = parameters of the Weibull distribution calculated from equations 5.53 & 5.54

N_{ow} = given by $P_{ov} \times N_w$ calculated from EurOtop II (2018) equations 5.52 & 5.56

Maximum Overtopping Volume (Vertical Wall):

$$V_{max} = a(\ln N_{ow})^{1/b} \quad 7.27$$

Calculated in accordance to EurOtop II (2018) equations 7.24 - 7.33

Reduction factor due to wide crest:

$$C_r = 3.06 \exp(-1.5G_o/H_{m0}) \quad \text{with maximum } C_r = 1 \quad 6.8$$

Return wall (Bullnose) reduction factor K_{bn} :

$$K_{bn} = \frac{q_{\text{with_bullnose}}}{q_{\text{without_bullnose}}} \quad 7.23$$

Calculated in accordance to EurOtop II (2018) figures 7.21& 7.23 and equations 7.21 & 7.22

Project
Colwyn Bay Old Promenade Coastal
Defence



Calculations for Overtopping Assessment Profile 1 (Beach Drawdown)	Dvn/dept	MNC/PCO	Job no/file no	415437	Sheet no 1 of 5
	Calculated by	NS	Date	10/02/2020	
	Checked by	NC	Date	31/03/2020	

OVERTOPPING CALCULATIONS: PROFILE 1

Existing structure and foreshore geometry - Case 1

Crest Level: +6.13 mOD Revetment Crest: +3 mOD
Toe Level: +0.89 mOD Revetment Slope: 1: 5.15 m

Return period (joint probability) [yrs]	Present Day			In 50 years (including SLR)		
	Freeboard R_c [m]	q [l/m/s]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	V_{max} [l/m]
1	3.29	0	2	2.70	52	9,453
	2.84	36	7,102	2.25	89	16,556
	2.38	53	11,852	1.79	82	16,596
	1.92	27	10,206	1.33	55	9,597
	1.46	1	1,021	0.87	2	1,637
10	3.29	0	4	2.70	78	11,168
	2.84	59	8,744	2.25	168	21,503
	2.38	133	17,959	1.79	316	34,906
	1.92	251	30,364	1.33	522	47,815
	1.46	421	43,706	0.87	656	52,180
50	1.00	211	23,388	0.41	27	2,401
	2.84	70	9,442	2.25	193	22,570
	2.38	156	19,087	1.79	361	36,272
	1.92	295	31,893	1.33	600	49,292
	1.46	497	45,383	0.87	918	55,452
100	1.00	683	52,981	0.41	73	3,171
	0.55	20	1,837	-0.04	*	*
	2.84	75	9,749	2.25	204	23,030
	2.38	164	19,423	1.79	375	36,670
	1.92	311	32,397	1.33	627	49,766
100	1.46	520	45,862	0.87	955	55,789
	1.00	789	54,551	0.41	89	3,208
	0.55	59	3,499	-0.04	*	*

* With $R_c < 0$ flooding occurs, water level above crest. No overtopping can be defined.

Project
 Old Colwyn Bay Promenade Coastal
 Defence



Calculations for Overtopping Assessment Profile 1 (Beach Drawdown)	Dvn/dept	MNC/PCO	Job no/file no	415437
	Calculated by	NS	Date	10/02/2020
	Checked by	NC	Date	31/03/2020

Sheet no
 2 of 5

Revetment to existing wall crest level, 1:3 Slope, 5m crest width - Case 2

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R_c [m]	q [l/m/s]	$R_{0.2\%}$ [m]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	$R_{0.2\%}$ [m]	V_{max} [l/m]
1	3.29	1	3.54	37	2.70	11	4.05	445
	2.84	5	3.82	132	2.25	37	4.12	1,061
	2.38	16	3.77	141	1.79	46	3.64	673
	1.92	9	2.95	44	1.33	39	2.90	165
	1.46	0	1.20	0	0.87	0	1.19	0
10	3.29	1	4.00	57	2.70	16	4.54	679
	2.84	9	4.41	181	2.25	69	4.93	2,565
	2.38	46	4.78	310	1.79	213	5.30	7,177
	1.92	153	5.09	599	1.33	504	5.59	15,003
	1.46	391	5.35	1,225	0.87	802	5.44	18,124
50	1.00	250	3.80	250	0.41	588	3.74	3,933
	2.84	11	4.61	205	2.25	77	5.14	3,038
	2.38	53	5.02	362	1.79	232	5.54	8,487
	1.92	171	5.37	728	1.33	539	5.88	17,852
	1.46	422	5.68	1,508	0.87	1,031	6.18	30,159
100	1.00	772	5.70	2,351	0.41	1,313	5.70	27,422
	0.55	425	3.55	247	-0.04	*	*	*
	2.84	12	4.70	216	2.25	81	5.23	3,266
	2.38	55	5.09	379	1.79	238	5.61	8,908
	1.92	177	5.46	776	1.33	551	5.97	18,872
100	1.46	432	5.77	1,599	0.87	1,047	6.27	31,716
	1.00	860	6.01	3,001	0.41	1,545	6.24	38,332
	0.55	1,094	5.45	2,652	-0.04	*	*	*

* With $R_c < 0$ there is flooding, water level above crest. No overtopping defined.

Project
Old Colwyn Bay Promenade Coastal
Defence



Calculations for Overtopping Assessment Profile 1 (Beach Drawdown)	Dvn/dept	MNC/PCO	Job no/file no	415437
	Calculated by	NS	Date	10/02/2020
	Checked by	NS	Date	10/02/2020
			Sheet no	3 of 5

Revetment to +7.0m OD, 1:3 Slope, 5m crest width - Case 3

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]
1	4.16	0	3.54	10	3.57	0	4.05	165
	3.71	0	3.82	79	3.12	1	4.12	423
	3.25	0	3.77	125	2.66	0	3.64	233
	2.79	0	2.95	20	2.20	0	2.90	41
	2.33	0	1.20	0	1.74	0	1.19	0
10	4.16	0	4.00	17	3.57	0	4.54	239
	3.71	0	4.41	114	3.12	2	4.93	1,031
	3.25	1	4.78	268	2.66	11	5.30	3,310
	2.79	7	5.09	406	2.20	40	5.59	8,058
	2.33	27	5.35	709	1.74	67	5.44	10,329
50	1.87	4	3.80	150	1.28	10	3.74	1,502
	3.71	0	4.61	134	3.12	3	5.14	1,217
	3.25	2	5.02	299	2.66	13	5.54	3,912
	2.79	8	5.37	472	2.20	47	5.88	9,575
	2.33	32	5.68	853	1.74	128	6.18	18,788
100	1.87	73	5.70	1,289	1.28	143	5.70	17,292
	1.42	5	3.55	123	0.83	13	3.50	1,593
	3.71	0	4.70	143	3.12	3	5.23	1,309
	3.25	2	5.09	309	2.66	14	5.61	4,110
	2.79	9	5.46	497	2.20	49	5.97	10,131
100	2.33	33	5.77	900	1.74	133	6.27	19,755
	1.87	95	6.01	1,665	1.28	229	6.24	26,030
100	1.42	100	5.45	1,413	0.83	193	5.46	18,907

Project
Colwyn Bay Old Promenade Coastal
Defence



Calculations for Overtopping Assessment Profile 1 (Beach Drawdown)	Dvn/dept	MNC/PCO	Job no/file no	415437
	Calculated by	NS	Date	10/02/2020
	Checked by	NC	Date	31/03/2020
				Sheet no 4 of 5

Revetment to +7.5m OD, 1:3 Slope, 5m crest width - Case 4

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard	q	R _{u2%}	V _{max}	Freeboard	q	R _{u2%}	V _{max}
	R _c [m]	[l/m/s]	[m]	[l/m]	R _c [m]	[l/m/s]	[m]	[l/m]
1	4.66	0	3.54	3	4.07	0	4.05	92
	4.21	0	3.82	45	3.62	0	4.12	252
	3.75	0	3.77	89	3.16	0	3.64	129
	3.29	0	2.95	10	2.70	0	2.90	19
	2.83	0	1.20	0	2.24	0	1.19	0
10	4.66	0	4.00	7	4.07	0	4.54	131
	4.21	0	4.41	69	3.62	1	4.93	611
	3.75	0	4.78	240	3.16	5	5.30	2,092
	3.29	3	5.09	379	2.70	20	5.59	5,456
	2.83	13	5.35	575	2.24	35	5.44	7,143
50	2.37	1	3.80	142	1.78	4	3.74	819
	4.21	0	4.61	83	3.62	1	5.14	718
	3.75	1	5.02	268	3.16	6	5.54	2,462
	3.29	4	5.37	425	2.70	24	5.88	6,458
	2.83	16	5.68	672	2.24	73	6.18	13,673
100	2.37	39	5.70	958	1.78	81	5.70	12,520
	1.92	2	3.55	107	1.33	5	3.50	834
	4.21	0	4.70	90	3.62	1	5.23	771
	3.75	1	5.09	277	3.16	7	5.61	2,585
	3.29	4	5.46	442	2.70	26	5.97	6,831
100	2.83	17	5.77	705	2.24	76	6.27	14,369
	2.37	52	6.01	1,231	1.78	138	6.24	19,809
	1.92	54	5.45	1,010	1.33	113	5.46	13,986

Project
Colwyn Bay Old Promenade Coastal
Defence



Calculations for Overtopping Assessment Profile 1 (Beach Drawdown)	Dvn/dept	MNC/PCO	Job no/file no	415437	
	Calculated by	NS	Date	10/02/2020	Sheet no
	Checked by	NC	Date	31/03/2020	5 of 5

Revetment to +7.5m OD, 1:3 Slope, 5m crest width with crest wall to +8.15m OD - Case 5

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R _c [m]	q [l/m/s]	R _{u2%} [m]	V _{max} [l/m]	Freeboard R _c [m]	q [l/m/s]	R _{u2%} [m]	V _{max} [l/m]
1	5.31	0	3.54	0	4.72	0	4.05	15
	4.86	0	3.82	5	4.27	0	4.12	51
	4.40	0	3.77	16	3.81	0	3.64	21
	3.94	0	2.95	0	3.35	0	2.90	2
	3.48	0	1.20	0	2.89	0	1.19	0
10	5.31	0	4.00	0	4.72	0	4.54	23
	4.86	0	4.41	12	4.27	0	4.93	142
	4.40	0	4.78	86	3.81	1	5.30	591
	3.94	0	5.09	379	3.35	4	5.59	1,821
	3.48	3	5.35	1,264	2.89	8	5.44	2,465
50	3.02	0	3.80	88	2.43	0	3.74	151
	4.86	0	4.61	15	4.27	0	5.14	170
	4.40	0	5.02	106	3.81	1	5.54	703
	3.94	1	5.37	461	3.35	5	5.88	2,175
	3.48	3	5.68	1,505	2.89	20	6.18	5,437
100	3.02	9	5.70	2,945	2.43	21	5.70	4,790
	2.57	0	3.55	71	1.98	0	3.50	135
	4.86	0	4.70	17	4.27	0	5.23	184
	4.40	0	5.09	113	3.81	1	5.61	741
	3.94	1	5.46	495	3.35	6	5.97	2,311
100	3.48	4	5.77	1,596	2.89	21	6.27	5,732
	3.02	14	6.01	4,068	2.43	42	6.24	8,655
	2.57	13	5.45	3,297	1.98	30	5.46	5,492

Project
Colwyn Bay Old Promenade Coastal
Defence



Calculations for Overtopping Assessment Profile 2 (Beach Drawdown)	Dvn/dept	MNC/PCO	Job no/file no	415437	
	Calculated by	NS	Date	10/02/2020	Sheet no
	Checked by	NC	Date	31/03/2020	1 of 5

OVERTOPPING CALCULATIONS: PROFILE 2
Existing structure and foreshore geometry - Case 1

Crest Level: +5.5 mOD Revetment Crest: +3.3 mOD
Toe Level: +1.89 mOD Revetment Slope: 1: 3.85 m

Return period (joint probability) [yrs]	Present Day			In 50 years (including SLR)		
	Freeboard R_c [m]	q [l/m/s]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	V_{max} [l/m]
1	2.66	0	17	2.07	95	12,199
	2.21	0	120	1.62	194	22,341
	1.75	125	17,384	1.16	14	1,646
	1.29	5	849	0.70	11	1,094
	0.83	2	1,261	0.24	2	161
10	2.66	0	34	2.07	140	14,069
	2.21	1	246	1.62	295	25,162
	1.75	236	21,581	1.16	40	2,677
	1.29	31	2,408	0.70	65	3,075
	0.83	53	3,021	0.24	90	1,978
	0.37	34	2,362	-0.22	*	*
50	2.21	1	317	1.62	336	26,138
	1.75	275	22,665	1.16	45	2,751
	1.29	37	2,497	0.70	75	3,133
	0.83	62	3,098	0.24	114	1,991
	0.37	92	2,535	-0.22	*	*
100	-0.08	*	*	-0.67	*	*
	2.21	1	354	1.62	354	26,552
	1.75	287	22,983	1.16	47	2,772
	1.29	39	2,525	0.70	78	3,151
	0.83	65	3,119	0.24	118	1,996
100	0.37	98	2,551	-0.22	*	*
	-0.08	*	*	-0.67	*	*

* With $R_c < 0$ flooding occurs, water level above crest. No overtopping can be defined.

Project

Colwyn Bay Old Promenade Coastal
Defence


Calculations for

Dvn/dept MNC/PCO

Job no/file no 415437

Overtopping Assessment
Profile 2 (Beach Drawdown)

Calculated by NS

Date 10/02/2020

Sheet no

Checked by NC

Date 31/03/2020

2 of 5

Revetment to existing wall crest level, 1:3 Slope, 5m crest width - Case 2

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]
1	2.66	2	3.40	47	2.07	34	3.40	1,089
	2.21	18	3.71	120	1.62	135	3.71	2,683
	1.75	73	3.87	179	1.16	176	3.87	1,523
	1.29	52	2.99	54	0.70	189	2.99	475
	0.83	1	1.21	0	0.24	46	1.21	0
10	2.66	4	3.87	76	2.07	47	3.87	1,603
	2.21	28	4.31	182	1.62	175	4.31	5,071
	1.75	122	4.71	382	1.16	469	4.71	12,110
	1.29	354	5.03	881	0.70	962	5.03	21,950
	0.83	784	5.32	1,890	0.24	1,473	5.32	26,085
	0.37	659	3.84	480	-0.22	*	*	*
50	2.21	33	4.51	212	1.62	192	4.51	5,955
	1.75	137	4.95	465	1.16	502	4.95	14,252
	1.29	386	5.32	1,093	0.70	1,013	5.32	26,106
	0.83	830	5.65	2,350	0.24	1,669	5.65	39,311
	0.37	1,430	5.84	4,128	-0.22	*	*	*
	-0.08	*	*	*	-0.67	*	*	*
100	2.21	36	4.60	226	1.62	199	4.60	6,375
	1.75	142	5.02	492	1.16	512	5.02	14,932
	1.29	397	5.41	1,171	0.70	1,031	5.41	27,574
	0.83	846	5.75	2,497	0.24	1,688	5.75	41,343
	0.37	1,461	6.01	4,550	-0.22	*	*	*
	-0.08	*	*	*	-0.67	*	*	*

* With $R_c < 0$ there is flooding, water level above crest. No overtopping defined.

Project

Colwyn Bay Old Promenade Coastal Defence



Calculations for

Overtopping Assessment
Profile 2 (Beach Drawdown)

Dvn/dept MNC/PCO
Calculated by NS
Checked by NC

Job no/file no 415437
Date 10/02/2020
Date 31/03/2020
Sheet no 3 of 5

Revetment to +7.0m OD, 1:3 Slope, 5m crest width - Case 3

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]
1	4.16	0	3.40	5	3.57	0	3.40	279
	3.71	0	3.71	55	3.12	1	3.71	815
	3.25	0	3.87	154	2.66	0	3.87	229
	2.79	0	2.99	23	2.20	0	2.99	41
	2.33	0	1.21	0	1.74	0	1.21	0
10	4.16	0	3.87	10	3.57	0	3.87	354
	3.71	0	4.31	88	3.12	2	4.31	1,319
	3.25	1	4.71	246	2.66	10	4.71	3,853
	2.79	6	5.03	385	2.20	39	5.03	8,863
	2.33	25	5.32	686	1.74	76	5.32	11,722
50	1.87	4	3.84	158	1.28	10	3.84	1,532
	3.71	0	4.51	106	3.12	2	4.51	1,516
	3.25	1	4.95	277	2.66	13	4.95	4,479
	2.79	8	5.32	449	2.20	46	5.32	10,432
	2.33	30	5.65	830	1.74	129	5.65	19,839
100	1.87	88	5.84	1,508	1.28	158	5.84	18,659
	1.42	5	3.58	129	0.83	13	3.58	1,621
	3.71	0	4.60	115	3.12	3	4.60	1,614
	3.25	1	5.02	287	2.66	13	5.02	4,687
	2.79	8	5.41	474	2.20	49	5.41	11,009
100	2.33	32	5.75	878	1.74	134	5.75	20,837
	1.87	95	6.01	1,662	1.28	251	6.01	28,442
	1.42	122	5.60	1,670	0.83	207	5.60	20,018

Project

Colwyn Bay Old Promenade Coastal
Defence


Calculations for

Dvn/dept MNC/PCO

Job no/file no 415437

Overtopping Assessment
Profile 2 (Beach Drawdown)

Calculated by NS

Date 10/02/2020

Sheet no

Checked by NC

Date 31/03/2020

4 of 5

Revetment to +7.5m OD, 1:3 Slope, 5m crest width - Case 4

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]
1	4.66	0	3.40	1	4.07	0	3.40	154
	4.21	0	3.71	29	3.62	0	3.71	563
	3.75	0	3.87	120	3.16	0	3.87	124
	3.29	0	2.99	12	2.70	0	2.99	19
	2.83	0	1.21	0	2.24	0	1.21	0
10	4.66	0	3.87	4	4.07	0	3.87	209
	4.21	0	4.31	50	3.62	1	4.31	854
	3.75	0	4.71	213	3.16	5	4.71	2,606
	3.29	2	5.03	361	2.70	20	5.03	6,311
	2.83	12	5.32	557	2.24	41	5.32	8,434
50	2.37	1	3.84	149	1.78	4	3.84	833
	4.21	0	4.51	62	3.62	1	4.51	969
	3.75	0	4.95	242	3.16	6	4.95	2,995
	3.29	3	5.32	407	2.70	24	5.32	7,357
	2.83	15	5.65	656	2.24	73	5.65	14,920
100	2.37	48	5.84	1,122	1.78	91	5.84	13,754
	1.92	2	3.58	112	1.33	5	3.58	848
	4.21	0	4.60	69	3.62	1	4.60	1,027
	3.75	1	5.02	251	3.16	6	5.02	3,126
	3.29	4	5.41	424	2.70	25	5.41	7,749
100	2.83	16	5.75	689	2.24	77	5.75	15,647
	2.37	52	6.01	1,230	1.78	154	6.01	22,345
	1.92	68	5.60	1,200	1.33	124	5.60	15,020

Project

Colwyn Bay Old Promenade Coastal
Defence


Calculations for

Overtopping Assessment
Profile 2 (Beach Drawdown)

Dvn/dept MNC/PCO

Calculated by NS

Checked by NC

Job no/file no

415437

Date

10/02/2020

Sheet no

Date

31/03/2020

5 of 5

Revetment to +7.5m OD, 1:3 Slope, 5m crest width with crest wall to +8.15m OD - Case 5

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]
1	5.31	0	3.40	0	4.72	0	3.95	9
	4.86	0	3.71	2	4.27	0	4.23	75
	4.40	0	3.87	25	3.81	0	3.71	27
	3.94	0	2.99	1	3.35	0	2.93	2
	3.48	0	1.21	0	2.89	0	1.20	0
10	5.31	0	3.87	0	4.72	0	4.44	16
	4.86	0	4.31	7	4.27	0	4.87	117
	4.40	0	4.71	68	3.81	1	5.25	537
	3.94	0	5.03	334	3.35	4	5.57	1,755
	3.48	2	5.32	1,194	2.89	11	5.59	3,160
50	3.02	0	3.84	100	2.43	0	3.78	167
	4.86	0	4.51	10	4.27	0	5.08	143
	4.40	0	4.95	86	3.81	1	5.50	647
	3.94	1	5.32	414	3.35	5	5.86	2,119
	3.48	3	5.65	1,440	2.89	20	6.19	5,486
100	3.02	12	5.84	3,691	2.43	27	5.85	5,973
	2.57	0	3.58	80	1.98	0	3.53	148
	4.86	0	4.60	12	4.27	0	5.17	156
	4.40	0	5.02	92	3.81	1	5.58	685
	3.94	1	5.41	447	3.35	6	5.96	2,260
100	3.48	3	5.75	1,533	2.89	21	6.28	5,798
	3.02	13	6.01	4,061	2.43	53	6.41	10,567
	2.57	17	5.60	4,167	1.98	38	5.60	6,629

Project
Colwyn Bay Old Promenade Coastal
Defence



Calculations for	Dvn/dept	MNC/PCO	Job no/file no	415437	Sheet no
Overtopping Assessment	Calculated by	NS	Date	10/02/2020	1 of 5
Profile 3 (Beach Drawdown)	Checked by	NC	Date	31/03/2020	

OVERTOPPING CALCULATIONS: PROFILE 3
Existing structure and foreshore geometry - Case 1

Crest Level: +5.47 mOD Vertical Wall
Toe Level: +0.0 mOD Beach Slope: 1:51.3

Return period (joint probability) [yrs]	Present Day			In 50 years (including SLR)		
	Freeboard R_c [m]	q [l/m/s]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	V_{max} [l/m]
1	2.63	98	16,850	2.04	188	33,267
	2.18	96	20,623	1.59	196	29,461
	1.72	98	17,379	1.13	185	22,762
	1.26	55	9,073	0.67	166	26,220
	0.80	2	1,391	0.21	29	3,534
10	2.63	140	19,207	2.04	246	28,357
	2.18	267	32,226	1.59	571	54,472
	1.72	456	46,975	1.13	825	64,790
	1.26	605	56,421	0.67	948	62,159
	0.80	689	57,450	0.21	**	**
50	0.34	373	32,990	-0.25	*	*
	2.18	302	33,492	1.59	424	37,273
	1.72	517	48,466	1.13	955	64,476
	1.26	802	60,392	0.67	1,343	62,130
	0.80	1,071	61,692	0.21	**	**
100	0.34	1,034	43,157	-0.25	*	*
	-0.11	*	*	-0.70	*	*
	2.18	317	34,033	1.59	524	44,563
	1.72	535	48,897	1.13	**	**
	1.26	836	60,873	0.67	**	**
100	0.80	1,206	62,725	0.21	**	**
	0.34	**	**	-0.25	*	*
	-0.11	*	*	-0.70	*	*

* With $R_c < 0$ flooding occurs, water level above crest. No overtopping can be defined.

** Out of equation boundaries. Relatively too large waves

Project

Colwyn Bay Old Promenade Coastal
Defence

Calculations for

Dvn/dept MNC/PCO

Job no/file no 415437

Overtopping Assessment
Profile 3 (Beach Drawdown)

Calculated by NS

Date 10/02/2020

Sheet no

Checked by NC

Date 31/03/2020

2 of 5

Revetment to existing wall crest level, 1:3 Slope, 5m crest width - Case 2

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]
1	2.63	35	4.58	304	2.04	97	4.60	1,788
	2.18	47	4.18	222	1.59	128	4.15	2,216
	1.72	67	3.78	157	1.13	153	3.55	1,376
	1.26	43	2.86	43	0.67	177	2.83	448
	0.80	1	1.18	0	0.21	51	1.18	0
10	2.63	46	5.11	404	2.04	204	5.63	4,141
	2.18	150	5.51	792	1.59	476	6.03	10,273
	1.72	376	5.87	1,627	1.13	853	6.21	18,799
	1.26	645	5.86	2,288	0.67	1,130	5.86	24,585
	0.80	899	5.52	2,392	0.21	1,453	5.50	25,621
	0.34	628	3.71	392	-0.25	*	*	*
50	2.18	163	5.73	913	1.59	503	6.26	11,928
	1.72	403	6.14	1,904	1.13	976	6.66	23,554
	1.26	812	6.48	3,640	0.67	1,565	6.89	36,754
	0.80	1,285	6.56	5,350	0.21	1,909	6.56	43,843
	0.34	1,419	5.76	3,928	-0.25	*	*	*
	-0.11	*	*	*	-0.70	*	*	*
100	2.18	169	5.83	969	1.59	515	6.36	12,697
	1.72	411	6.21	1,992	1.13	989	6.74	24,597
	1.26	827	6.58	3,844	0.67	1,640	7.09	39,848
	0.80	1,419	6.88	6,636	0.21	2,067	6.89	48,876
	0.34	1,680	6.35	6,077	-0.25	*	*	*
	-0.11	*	*	*	-0.70	*	*	*

* With $R_c < 0$ there is flooding, water level above crest. No overtopping defined.

Project

Colwyn Bay Old Promenade Coastal
Defence

Calculations for

Overtopping Assessment
Profile 3 (Beach Drawdown)

Dvn/dept MNC/PCO

Calculated by NS

Checked by NC

Job no/file no

415437

Date

10/02/2020

Sheet no

Date

31/03/2020

3 of 5

Revetment to +7.0m OD, 1:3 Slope, 5m crest width - Case 3

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]
1	4.16	0	4.58	277	3.57	1	4.60	420
	3.71	0	4.18	193	3.12	1	4.15	443
	3.25	0	3.78	129	2.66	0	3.55	195
	2.79	0	2.86	13	2.20	0	2.83	34
	2.33	0	1.18	0	1.74	0	1.18	0
10	4.16	0	5.11	319	3.57	2	5.63	1,122
	3.71	3	5.51	498	3.12	10	6.03	3,334
	3.25	14	5.87	749	2.66	31	6.21	7,103
	2.79	28	5.86	921	2.20	52	5.86	9,748
	2.33	36	5.52	867	1.74	70	5.50	10,729
50	1.87	3	3.71	130	1.28	9	3.66	1,377
	3.71	4	5.73	537	3.12	12	6.26	3,861
	3.25	16	6.14	842	2.66	42	6.66	9,347
	2.79	52	6.48	1,464	2.20	103	6.89	17,480
	2.33	105	6.56	2,105	1.74	164	6.56	22,593
100	1.87	79	5.76	1,387	1.28	142	5.68	17,180
	1.42	4	3.47	108	0.83	12	3.44	1,498
	3.71	4	5.83	557	3.12	13	6.36	4,113
	3.25	17	6.21	872	2.66	43	6.74	9,768
	2.79	55	6.58	1,538	2.20	114	7.09	19,347
100	2.33	140	6.88	2,696	1.74	194	6.89	26,305
	1.87	142	6.35	2,331	1.28	237	6.31	26,749
	1.42	104	5.47	1,452	0.83	189	5.42	18,601

Project
Colwyn Bay Old Promenade Coastal
Defence



Calculations for Overtopping Assessment Profile 3 (Beach Drawdown)	Dvn/dept	MNC/PCO	Job no/file no	415437
	Calculated by	NS	Date	10/02/2020
	Checked by	NC	Date	31/03/2020

Sheet no
4 of 5

Revetment to +7.5m OD, 1:3 Slope, 5m crest width - Case 4

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]
1	4.66	0	4.58	215	4.07	0	4.60	265
	4.21	0	4.18	145	3.62	0	4.15	266
	3.75	0	3.78	93	3.16	0	3.55	106
	3.29	0	2.86	6	2.70	0	2.83	15
	2.83	0	1.18	0	2.24	0	1.18	0
10	4.66	0	5.11	253	4.07	1	5.63	734
	4.21	1	5.51	490	3.62	5	6.03	2,276
	3.75	7	5.87	680	3.16	16	6.21	4,999
	3.29	14	5.86	771	2.70	27	5.86	6,819
	2.83	18	5.52	692	2.24	37	5.50	7,477
	2.37	1	3.71	125	1.78	3	3.66	735
50	4.21	2	5.73	521	3.62	6	6.26	2,623
	3.75	8	6.14	745	3.16	23	6.66	6,668
	3.29	29	6.48	1,177	2.70	62	6.89	13,063
	2.83	60	6.56	1,622	2.24	98	6.56	17,052
	2.37	43	5.76	1,031	1.78	80	5.68	12,420
	1.92	1	3.47	96	1.33	4	3.44	769
100	4.21	2	5.83	535	3.62	7	6.36	2,791
	3.75	9	6.21	766	3.16	24	6.74	6,964
	3.29	30	6.58	1,230	2.70	70	7.09	14,566
	2.83	83	6.88	2,077	2.24	120	6.89	20,233
	2.37	82	6.35	1,738	1.78	144	6.31	20,478
	1.92	56	5.47	1,039	1.33	110	5.42	13,701

Project

Colwyn Bay Old Promenade Coastal
Defence


Calculations for

Dvn/dept MNC/PCO

Job no/file no

415437

Overtopping Assessment
Profile 3 (Beach Drawdown)

Calculated by NS

Date

10/02/2020

Sheet no

Checked by NC

Date

31/03/2020

5 of 5

Revetment to +7.5m OD, 1:3 Slope, 5m crest width with crest wall to +8.15m OD - Case 5

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]
1	5.31	0	4.58	53	4.72	0	4.60	109
	4.86	0	4.18	31	4.27	0	4.15	57
	4.40	0	3.78	17	3.81	0	3.55	14
	3.94	0	2.86	0	3.35	0	2.83	1
	3.48	0	1.18	0	2.89	0	1.18	0
10	5.31	0	5.11	74	4.72	0	5.63	501
	4.86	0	5.51	336	4.27	2	6.03	1,559
	4.40	1	5.87	1,123	3.81	7	6.21	3,092
	3.94	3	5.86	1,798	3.35	8	5.86	2,865
	3.48	4	5.52	1,744	2.89	9	5.50	2,726
	3.02	0	3.71	63	2.43	0	3.66	115
50	4.86	0	5.73	385	4.27	3	6.26	1,762
	4.40	2	6.14	1,292	3.81	11	6.66	4,582
	3.94	8	6.48	3,433	3.35	31	6.89	8,854
	3.48	17	6.56	5,818	2.89	36	6.56	8,758
	3.02	10	5.76	3,274	2.43	21	5.68	4,699
	2.57	0	3.47	53	1.98	0	3.44	107
100	4.86	0	5.83	410	4.27	3	6.36	1,861
	4.40	2	6.21	1,349	3.81	12	6.74	4,765
	3.94	8	6.58	3,612	3.35	37	7.09	10,384
	3.48	26	6.88	8,012	2.89	52	6.89	11,919
	3.02	24	6.35	6,492	2.43	46	6.31	9,357
	2.57	14	5.47	3,427	1.98	28	5.42	5,200

Project
Colwyn Bay Old Promenade Coastal
Defence



Calculations for Overtopping Assessment Profile4 (Beach Drawdown)	Dvn/dept	MNC/PCO	Job no/file no	415437	
	Calculated by	NS	Date	10/02/2020	Sheet no
	Checked by	NC	Date	31/03/2020	1 of 5

OVERTOPPING CALCULATIONS: PROFILE 4
Existing structure and foreshore geometry - Case 1

Crest Level: +5.75 mOD Vertical Wall
Toe Level: +1.13 mOD Beach Slope: 1: 45 m

Return period (joint probability) [yrs]	Present Day			In 50 years (including SLR)		
	Freeboard R_c [m]	q [l/m/s]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	V_{max} [l/m]
1	2.91	54	9,756	2.32	132	21,583
	2.46	79	15,511	1.87	131	23,505
	2.00	81	17,883	1.41	111	16,501
	1.54	40	9,145	0.95	85	10,205
	1.08	0	1,505	0.49	8	1,774
10	2.91	82	11,534	2.32	211	25,882
	2.46	172	21,930	1.87	381	39,981
	2.00	317	35,557	1.41	622	53,510
	1.54	517	49,417	0.95	753	57,692
	1.08	590	54,901	0.49	869	49,452
	0.62	289	27,427	0.03	**	**
50	2.46	197	23,034	1.87	427	41,266
	2.00	363	36,997	1.41	700	54,873
	1.54	595	51,042	0.95	1,050	61,352
	1.08	899	60,195	0.49	1,301	51,090
	0.62	899	54,257	0.03	**	**
	0.17	*	*	-0.42	*	*
100	2.46	209	23,510	1.87	448	41,810
	2.00	377	37,418	1.41	724	55,262
	1.54	622	51,566	0.95	1,092	61,726
	1.08	935	60,605	0.49	1,458	51,435
	0.62	1,122	55,633	0.03	**	**
	0.17	*	*	-0.42	*	*

* With $R_c < 0$ flooding occurs, water level above crest. No overtopping can be defined.

** Out of equation boundaries. Relatively too large waves

Project

Colwyn Bay Old Promenade Coastal
DefenceM
MOTT
MACDONALD

Calculations for

Overtopping Assessment
Profile4 (Beach Drawdown)

Dvn/dept MNC/PCO

Calculated by NS

Checked by NC

Job no/file no

415437

Date

10/02/2020

Sheet no

Date

31/03/2020

2 of 5

Revetment to existing wall crest level, 1:3 Slope, 5m crest width - Case 2

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]
1	2.91	11	4.25	212	2.32	63	4.62	1,402
	2.46	28	4.20	217	1.87	85	4.21	1,756
	2.00	42	3.83	157	1.41	93	3.59	1,011
	1.54	22	2.90	43	0.95	94	2.85	289
	1.08	0	1.19	0	0.49	8	1.18	0
10	2.91	16	4.76	268	2.32	98	5.31	2,463
	2.46	67	5.18	466	1.87	271	5.71	6,907
	2.00	204	5.55	949	1.41	604	6.08	15,065
	1.54	478	5.86	1,887	0.95	891	5.89	21,574
	1.08	689	5.55	2,016	0.49	1,206	5.55	23,150
	0.62	435	3.74	318	0.03	859	3.69	5,195
50	2.46	75	5.40	535	1.87	291	5.94	8,068
	2.00	223	5.81	1,118	1.41	639	6.34	17,626
	1.54	513	6.16	2,260	0.95	1,170	6.69	30,593
	1.08	982	6.47	4,192	0.49	1,631	6.59	40,335
	0.62	1,170	5.83	3,475	0.03	1,684	5.74	31,860
	0.17	691	3.50	326	-0.42	*	*	*
100	2.46	79	5.49	567	1.87	299	6.03	8,613
	2.00	229	5.88	1,172	1.41	649	6.42	18,433
	1.54	525	6.26	2,395	0.95	1,188	6.79	32,257
	1.08	998	6.57	4,418	0.49	1,784	6.93	45,225
	0.62	1,401	6.38	5,298	0.03	1,979	6.37	44,522
	0.17	1,506	5.53	3,645	-0.42	*	*	*

* With $R_c < 0$ there is flooding, water level above crest. No overtopping defined.

Project

Colwyn Bay Old Promenade Coastal
Defence

Calculations for

Dvn/dept MNC/PCO

Job no/file no 415437

Sheet no

Overtopping Assessment
Profile4 (Beach Drawdown)

Calculated by NS

Date 10/02/2020

3 of 5

Checked by NC

Date 31/03/2020

Revetment to +7.0m OD, 1:3 Slope, 5m crest width - Case 3

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]
1	4.16	0	4.25	140	3.57	1	4.62	435
	3.71	0	4.20	201	3.12	1	4.21	485
	3.25	0	3.83	143	2.66	0	3.59	211
	2.79	0	2.90	15	2.20	0	2.85	36
	2.33	0	1.19	0	1.74	0	1.18	0
10	4.16	0	4.76	178	3.57	1	5.31	760
	3.71	1	5.18	374	3.12	7	5.71	2,488
	3.25	7	5.55	554	2.66	27	6.08	6,465
	2.79	28	5.86	919	2.20	53	5.89	9,950
	2.33	37	5.55	896	1.74	74	5.55	11,125
	1.87	3	3.74	137	1.28	9	3.69	1,422
50	3.71	2	5.40	404	3.12	8	5.94	2,898
	3.25	9	5.81	621	2.66	31	6.34	7,556
	2.79	33	6.16	1,073	2.20	89	6.69	15,704
	2.33	95	6.47	1,942	1.74	167	6.59	22,951
	1.87	87	5.83	1,487	1.28	147	5.74	17,658
	1.42	4	3.50	113	0.83	12	3.46	1,532
100	3.71	2	5.49	419	3.12	9	6.03	3,096
	3.25	10	5.88	643	2.66	33	6.42	7,909
	2.79	35	6.26	1,129	2.20	93	6.79	16,562
	2.33	99	6.57	2,042	1.74	198	6.93	26,709
	1.87	147	6.38	2,405	1.28	246	6.37	27,455
	1.42	111	5.53	1,542	0.83	194	5.47	18,979

Project
Colwyn Bay Old Promenade Coastal
Defence



Calculations for Overtopping Assessment Profile4 (Beach Drawdown)	Dvn/dept	MNC/PCO	Job no/file no	415437	Sheet no
	Calculated by	NS	Date	10/02/2020	4 of 5
	Checked by	NC	Date	31/03/2020	

Revetment to +7.5m OD, 1:3 Slope, 5m crest width - Case 4

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]
1	4.66	0	4.25	87	4.07	0	4.62	276
	4.21	0	4.20	153	3.62	0	4.21	294
	3.75	0	3.83	108	3.16	0	3.59	115
	3.29	0	2.90	7	2.70	0	2.85	16
	2.83	0	1.19	0	2.24	0	1.18	0
10	4.66	0	4.76	117	4.07	1	5.31	477
	4.21	1	5.18	345	3.62	3	5.71	1,641
	3.75	3	5.55	525	3.16	14	6.08	4,491
	3.29	14	5.86	770	2.70	28	5.89	6,984
	2.83	19	5.55	714	2.24	39	5.55	7,810
	2.37	1	3.74	131	1.78	3	3.69	765
50	4.21	1	5.40	373	3.62	4	5.94	1,903
	3.75	4	5.81	572	3.16	17	6.34	5,230
	3.29	17	6.16	877	2.70	52	6.69	11,530
	2.83	54	6.47	1,496	2.24	100	6.59	17,376
	2.37	47	5.83	1,106	1.78	84	5.74	12,847
	1.92	1	3.50	100	1.33	5	3.46	792
100	4.21	1	5.49	387	3.62	4	6.03	2,030
	3.75	5	5.88	588	3.16	18	6.42	5,471
	3.29	18	6.26	917	2.70	55	6.79	12,155
	2.83	56	6.57	1,568	2.24	123	6.93	20,603
	2.37	86	6.38	1,795	1.78	150	6.37	21,136
	1.92	61	5.53	1,106	1.33	114	5.47	14,053

Project

Colwyn Bay Old Promenade Coastal
Defence
M
M
 MOTT
 MACDONALD

Calculations for

Dvn/dept MNC/PCO

Job no/file no

415437

Sheet no

Overtopping Assessment
Profile4 (Beach Drawdown)

Calculated by NS

Date

10/02/2020

5 of 5

Checked by NC

Date

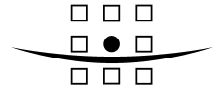
31/03/2020

Revetment to +7.5m OD, 1:3 Slope, 5m crest width with crest wall to +8.15m OD - Case 5

Return period (joint probability) [yrs]	Present Day				In 50 years (including SLR)			
	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]	Freeboard R_c [m]	q [l/m/s]	$R_{u2\%}$ [m]	V_{max} [l/m]
1	5.31	0	4.25	13	4.72	0	4.62	118
	4.86	0	4.20	34	4.27	0	4.21	69
	4.40	0	3.83	21	3.81	0	3.59	16
	3.94	0	2.90	0	3.35	0	2.85	1
	3.48	0	1.19	0	2.89	0	1.18	0
10	5.31	0	4.76	24	4.72	0	5.31	235
	4.86	0	5.18	147	4.27	1	5.71	865
	4.40	1	5.55	596	3.81	5	6.08	2,527
	3.94	3	5.86	1,794	3.35	8	5.89	3,008
	3.48	4	5.55	1,837	2.89	10	5.55	3,000
	3.02	0	3.74	71	2.43	0	3.69	127
50	4.86	0	5.40	173	4.27	1	5.94	992
	4.40	1	5.81	697	3.81	6	6.34	2,914
	3.94	4	6.16	2,108	3.35	23	6.69	6,932
	3.48	15	6.47	5,200	2.89	38	6.59	9,117
	3.02	12	5.83	3,618	2.43	23	5.74	5,095
	2.57	0	3.50	59	1.98	0	3.46	117
100	4.86	0	5.49	187	4.27	1	6.03	1,054
	4.40	1	5.88	732	3.81	7	6.42	3,043
	3.94	4	6.26	2,230	3.35	24	6.79	7,294
	3.48	16	6.57	5,463	2.89	54	6.93	12,380
	3.02	25	6.38	6,774	2.43	50	6.37	10,076
	2.57	15	5.53	3,731	1.98	31	5.47	5,562

Appendix 10.4 – Detailed Modelling Study for Colwyn Bay Coastal Defence Scheme

A COMPANY OF



ROYAL HASKONING



Colwyn Bay Detailed Modelling Study for Coast Defence Scheme

Phase 1 Interim Modelling Technical Note

Conwy County Borough Council
Bodlondeb
Conwy
LL32 8DU



ROYAL HASKONING

18 June 2010
Final Report
9T3344

Burns House
Harlands Road
Haywards Heath, West Sussex RH16 1PG
United Kingdom
+44 (0)1444 458551 Telephone
01444 440665 Fax
info@haywards-heath.royalhaskoning.com E-mail
www.royalhaskoning.com Internet

Document title Colwyn Bay Detailed Modelling Study for
Coast Defence Scheme
Phase 1 Interim Modelling Technical Note
Document short title Technical Note
Status Final Report
Date 18 June 2010
Project name Detailed Modelling Studies For Colwyn Bay
Coastal Defence Scheme
Project number 9T3344
Client Conwy County Borough Council
Reference 9T3344/R/1

We would like acknowledge the assistance of Alan Williams, Coastal Engineering UK Ltd., in the oversight of the numerical and physical modelling studies undertaken and in the preparation of this report.

Drafted by Alec Sleigh, Keming Hu
Checked by Paul Winfield
Date/initials check
Approved by Hamish Hall
Date/initials approval

CONTENTS

	Page
1 BACKGROUND TO SCHEME DEVELOPMENT	1
2 ABOUT THE COLWYN BAY FRONTAGE	4
3 STUDY METHODOLOGY	6
4 HISTORIC BEACH DATA ANALYSIS	7
5 DESCRIPTION OF MODELS	10
6 BEACH STABILITY AND RECHARGE BEACH PROFILE	17
7 BEACH PLAN EVOLUTION AND DEVELOPMENT OF CONTROL STRUCTURE OPTIONS	23
8 DISCUSSIONS OF RESULTS	35
9 CONCLUSIONS AND RECOMMENDATIONS	47
10 REFERENCES	49
APPENDIX A – MODELLING SOFTWARE LITPROF, LITLINE AND LITMOD	
APPENDIX B – MODEL DATA	
APPENDIX C – LITLINE AND LITMOD RESULTS	
APPENDIX D – SCHEME DRAWINGS	

1 BACKGROUND TO SCHEME DEVELOPMENT

The development of proposals for improved coastal defences across the Colwyn Bay frontage arose primarily from the amalgamation of proposals in two documents:

- Colwyn Bay Waterfront Strategy
- Colwyn Bay Coastal Defence Strategy

The Waterfront Strategy was produced in 2002 by consultant Mott MacDonald Ltd, which provides recommendations for regenerating the Waterfront area of Colwyn Bay. The strategy splits the shoreline into 4 zones and provides specific recommendations for potential activities within each zone.

The ability to regenerate the Waterfront however was reliant on carrying out improvements to the ageing coastal defences that date from the early 1900s and which are in need of an overhaul if they are to provide an adequate future coastal defence function. This must be set in a context of a trend of lowering beach levels across the frontage that has been on-going for most of the 20th century.

The Shoreline Management Plan (SMP) for sub-cell 11a [Liverpool Bay (Great Orme, Llandudno to Formby Point)] which included the Colwyn Bay frontage, was adopted by Conwy County Borough Council in 2000. The SMP identified that the appropriate future coastal defence policy for the area was one of maintaining and, where appropriate, improving the defences in their current location – “Hold the Line”. The SMP also advocated that a Strategy for the Coastal Defence should be prepared to identify how this policy would most appropriately be implemented.

In 2006 preparation of a strategy covering the shoreline from the Little Orme to Tan Penmaen Head commenced. The Colwyn Bay frontage was identified as the key area where public investment in improved coastal defences was necessary, if an appropriate level of coastal and flood protection was to be provided to the significant property and infrastructure that was at risk from defence deterioration and failure. One of the catalysts for the strategy was damage to the defences that occurred during a storm in February 2005.

The first stage of Strategy development examined the existing database of information in relation to the Strategy frontage and provided a baseline of current conditions applying, allied to an understanding of the historical mechanisms and behaviour that had shaped the frontage.

Issues that affect the future management of the coast were defined from reference to previous strategic planning initiatives and from specific consultation with local, regional and national organisations. A Steering Group was set up to oversee and manage development of the strategy, which enabled coordination with numerous other initiatives in Colwyn Bay such that on-going development of the strategy was carried out in tandem with other initiatives rather than in isolation where the risk of any future coastal defence provision could detract from the effectiveness of other initiatives and investment in the town. Consequently a more holistic approach to management of the coast

developed which provided potential access to alternative funding streams that would not otherwise be available.

The Strategy identified a range of options that could be implemented across the frontage from a minimum investment option of continuing to maintain existing defence assets through to options that would sustain or improve the standard of defences.

Early public consultation on potential options identified that there was a strong desire to implement proposals that provided improved beach conditions in parts of the bay and subsequently an assessment of options, including beach recharge, linear defences and other potential solutions, was carried out during the second phase of Strategy development in 2007.

Preliminary examination of the technical feasibility of improving beach levels suggested that a scheme could be implemented. Assessment of the economic justification indicated that the additional economic benefits that provision of a sustainable recharged beach would provide, could outweigh the initial increased construction costs of such a form of defence, as well as ensuring that the coastal defence provision did not detract from the initiatives and investment of others tasked with regeneration of the town.

It was identified that a joint regeneration/coastal defence funding package would be necessary if such proposals were to be implemented.

Concurrently with the Coastal Defence Strategy development, Conwy County Borough Council commissioned landscape architecture and urban design consultants to develop visions for the development of the Colwyn Bay Waterfront, based on the Waterfront Strategy, in association with the improved coastal defence measures. This commission and the resultant Promenade Environmental Improvements Concept Design document enabled Conwy County Borough Council to secure £8 million of investment to provide a regenerated promenade along the entire Colwyn Bay Waterfront, with grant funding provided to Conwy County Borough Council through the European Convergence Funding Programme, with match funding provided by WAG DE&T.

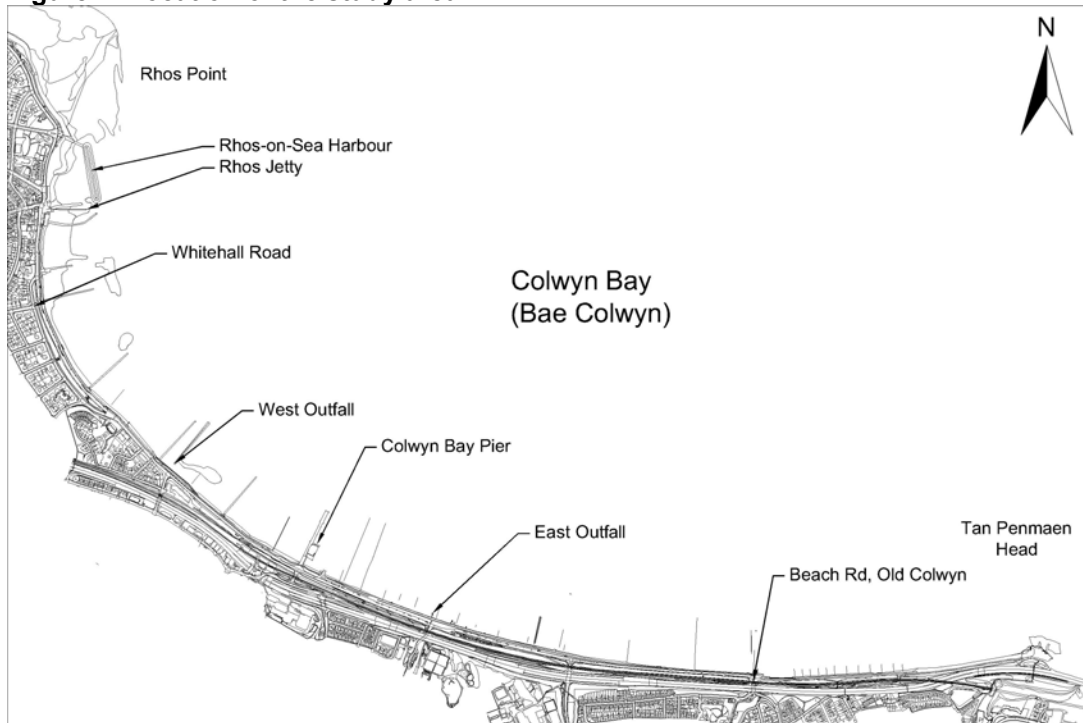
Pursuant to presentation of the Strategy and development of the Waterfront proposals, the Council was able to secure further funding from the European Convergence Funding Programme with match funding provided by the Welsh Assembly Government, for the first phase of the coastal defence element of the Colwyn Bay Waterfront Project.

With this approval in place the Council commissioned Royal Haskoning, in joint venture with Laboratório Nacional de Engenharia Civil (LNEC), Portugal, to carry out detailed numerical and physical modelling studies to test various schemes for providing coastal defences along the Colwyn Bay frontage between Rhos Jetty and Beach Road Old Colwyn (see **Figure 1**).

This report presents the output of the modelling study carried out to date, provides detailed results pertaining to the phase 1 coastal defence area of the frontage and provides recommendations of the appropriate form of coastal defence for this area, based on the study results. This report is intended to support development of the first phase of the coastal defence element of the project and allow delivery of the works in

accordance with the grant funding expenditure profile agreed between Conwy County Borough Council and its funding partners.

Figure 1: Location of the study area



2 ABOUT THE COLWYN BAY FRONTAGE

2.1 Study Frontage

The Colwyn Bay frontage extends from Rhos Jetty in the west and Beach Road in the East (see **Figure 1**). The so-called Rhos-on-Sea Harbour, which in fact, is a shallow area protected by a detached breakwater, is at the boundary of the numerical model and just outside of the model domain. The Colwyn Bay Pier is almost in the middle of the study frontage. Presently there are two outfalls about 600m on either side of the Colwyn Bay Pier which discharge water from local streams. Along this frontage there are a number of short timber groynes which are in poor condition and also a number of low rock groynes.

2.2 Tides

Tides within Liverpool Bay are semi-diurnal, i.e. the water level rises and falls twice a day, with a time difference between successive high or low waters of between 12 and 13 hours.

Table 1 presents the predicted astronomical tides at the Colwyn Bay frontage based on corrections from Liverpool, which is the Standard Port for the site (Admiralty Tide Table). The data in **Table 1** does not include surge residual effects, due to changes in meteorological conditions (including barometric pressure, wind and wave set up). It was estimated that 1 in 50 year surge in Colwyn Bay is between 1.25-1.5m (Pugh 1987)^[1].

Table 1: Astronomic Tides in Colwyn Bay

		Chart Datum	Ordnance Datum
Highest Astronomical Tide	HAT	8.78	4.68
Mean High Water Spring Tide	MHWST	7.80	3.70
Mean High Water Neap Tide	MHWNT	6.10	2.00
Mean Tide Level	MYL	4.21	0.11
Mean Low Water Neap Tide*	MTLWNT	2.29	-1.81
Mean Low Water Spring Tide*	MTLWST	0.66	-3.44
Lowest Astronomical Tide	LAT	-0.24	-4.34
Spring Tide Range		7.14	
Neap Tide Range		3.81	

Note: *MLWNT and MLWST for Colwyn Bay calculation by interpolation between Llandudno and Hilbre Island

2.3 Waves

Waves in Liverpool Bay are generally locally wind generated or as a result of longer period swell waves that have propagated into the Irish Sea from the Atlantic Ocean via the St Georges Channel and Cardigan Bay to the south or the north channel between Scotland and Northern Ireland, to the north. The Colwyn Bay frontage is largely sheltered from the waves propagated from southern Irish Sea.

Generally approximately 50% of the waves are generated from directions 250°- 330° WCB with over 30% from the directions of largest fetch.

Table 2 presents the extreme wave conditions at offshore and inshore locations (see **Figure 2**) provided by the Colwyn Borough Sea Defence Review (HR Wallingford, 1991)^[2].

Table 2: Extreme wave conditions in Colwyn Bay

Return Period (years)	Offshore		Nearshore point			
			Point D		Point E	
	Hs(m)	Tm(s)	Hs(m)	Tm(s)	Hs(m)	Tm(s)
1	4.78	10.1	2.04	6.6	3.25	8.3
10	5.56	10.9	2.27	7.0	3.84	9.1
50	6.11	11.4	2.43	7.2	4.24	9.5
100	6.33	11.6	2.5	7.3	4.4	9.7
200	6.57	11.8	2.57	7.4	4.57	9.9
500	6.88	12.1	2.66	7.5	4.80	10.1
1000	7.11	12.3	2.73	7.6	4.97	10.3

Figure 2: Locations of inshore point D and E



3 STUDY METHODOLOGY

3.1 Objectives of Study

Preliminary examination of the technical feasibility and economic and social benefits led to the recommended option of recharging the beach between Rhos Jetty and Beach Road Old Colwyn (**Figure 1**). The purpose of this study was to examine the robustness of the beach recharge schemes and effectiveness of beach control structures (such as groyne, fishtail and detached breakwaters) if any control structures are required.

A robust beach recharge scheme means that a recharged beach is able to sustain both cross-shore erosion under a short period maritime storm and longshore drift under long term wave climate. In this study, the failure of the scheme is defined as the point at which the beach berm is completely eroded away under either cross-shore or longshore transport.

3.2 Overall Approach

The study used both cross-shore and longshore sediment transport models to examine the recharge beach profiles and robustness of beach recharge and control schemes under cross-shore and longshore sediment transport. The numerical modelling study includes three parts as follows:

- Part 1: Data analysis has been carried out to understand the historic change of beach levels along the Colwyn Bay frontage and the problems that the Scheme is going to address. It is important to understand the historic change (from a real-scale model!) and whether the numerical models are able to re-predict the change.
- Part 2: Equilibrium beach profiles have been determined based on sediment property, foreshore slope and tidal range. The beach recharge profiles have been examined using the LITPROF cross-shore sediment transport model. The recommended beach recharge profiles were tested against the February 1990 storm event, the most severe storm in the last 30 years, to identify the beach, berm width and elevation required under storm conditions.
- Part 3: A series of LITMOD and LITLINE model runs have been carried out to examine the performance of the beach recharge schemes with and without beach control structures. LITMOD and LITLINE are both One Line models for predicting shoreline evolution, but each have limitations for specific conditions applying. Accordingly both models were used dependant on the arrangements being modelled, in order to reduce uncertainties arising from one or other of the model predictions.

4 HISTORIC BEACH DATA ANALYSIS

This section presents key findings of the data analysis of the historic beach survey data.

4.1 Beach Levels

The +2m OD beach level lines were presented in **(Figure 3)** extracted from the beach survey data collected between October 2001 and November 2007. It clearly shows that the +2m OD lines were more or less at the toe of the sea wall along the entire frontage. As the Mean High Water Neap Tide (MHWNT) level in Colwyn Bay is at +2m OD, it means that high water reaches the wall on almost every tide. In the later beach recharge scheme test, this would constitute a failure of a scheme.

From the 0m OD beach level lines **(Figure 4)**, further observation can be made as follows:

- The beach was retreating near Whitehall Road towards the west end;
- 0m OD lines were almost at the toe of the sea wall at some points near the west and east ends, which indicates that some hard defences were dangerously exposed to wave attack;
- The existing groynes had clear effect in 0m OD beach lines; and
- Beach levels in the middle section fluctuated to a marked degree between 2001 and 2007.

4.2 Shoreline/Beach Position

Figure 5 illustrates the advance or retreat of the shoreline position (0m OD) between 1956 and 2007. It demonstrates that the shoreline made some small advance between 1956 and 1980 but significant retreat occurred in the period of 1980-1990. The retreat was largely due to severe storms between 1988 and 1990. In the following 12 years, the beach made a marked recovery particularly in the middle section, but the beach conditions prior to 1988 were never fully restored. The shoreline position was more or less stable between 2002 and 2007,

4.3 Conclusions

From the historic beach data analysis, the following conclusions may be drawn:

- Severe storms were the main cause of beach retreat in the Colwyn Bay. This is confirmed by visual evidence which identified reductions in beach levels at the toe of the existing structures of up to a metre following storm events, e.g. February 2002, February 2005 and most recently in March 2010. The latter two of these required emergency works to protect the toe and prevent failure of the defences.
- Near the west and east ends of the studied coastline, the beach was suffering steady retreat resulting in the 0m OD (mean sea level) line being dangerously close to the hard defences in places;
- The shore position and beach conditions in middle section were more dynamic but relatively stable comparing to other parts of the coastline.

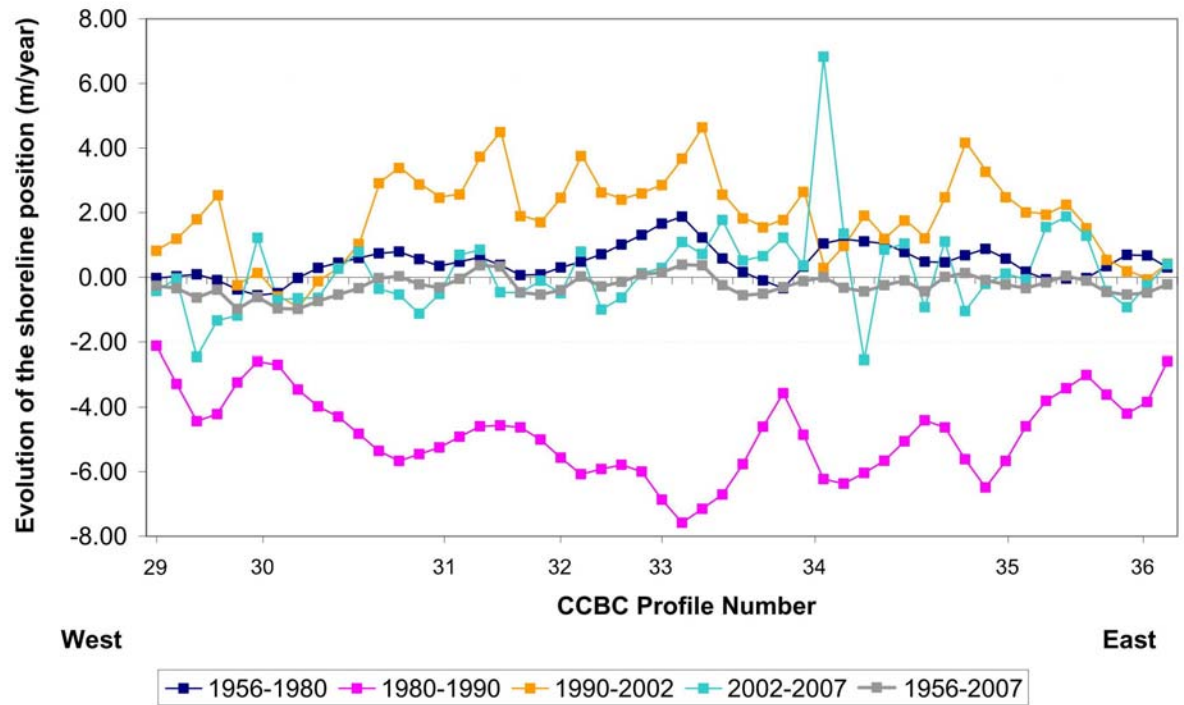
Figure 3: +2m (OD) beach level lines (October 2001 to November 2007).



Figure 4: +0m (OD) beach level line (October 2001 to November 2007).



Figure 5: Advance/retreat of the shoreline position (0m OD) (1956 – 2007)



5 DESCRIPTION OF MODELS

5.1 Beach Model and Software Selection

Table 3 summarises the beach models that were constructed and software chosen for examining the proposed beach recharge schemes. LITPROF, LINTLINE and LITMOD belong to the most advanced beach modelling software commercially available.

Table 3: Beach models and software

Beach Models	Tasks	Software
Beach Cross-shore Sediment Transport Model	To investigate beach stability under storm weather	LITPROF
Beach Longshore Sediment Transport Model	To simulate longshore sediment transport and beach plan evolution	LITMOD
		LITLINE

Beach Cross-shore Sediment Transport Model

LITPROF is a 2D-vertical process-based deterministic model. It is used to predict the potential retreat of beach profiles under an extreme maritime storm. Under an extreme maritime storm, cross-shore sediment (sand) movement is usually from the beach face seawards. The eroded beach profile may recover to the pre-storm conditions under normal wave climates if the upper beach level (berm) is not eroded down during a storm. LITPROF was used to examine the recharged beach profiles under a severe storm to test that the proposed beach recharge profile is recoverable after a severe storm.

Beach Longshore Sediment Transport Model

This study used both LITMOD and LITLINE, and both are One Line models for predicting shoreline evolution.

LITLINE is an advanced process-based deterministic model based on the calculation of longshore transport distribution along cross-shore profiles. However, LITLINE has the limitations that it cannot simulate some beach control structures including fish-tail groynes and submerged detached breakwaters.

LITMOD is a beach plan model based on empirical longshore sediment transport equations. LITMOD uses a constant water level which leads to one of its limitations, that the full tidal effect is not taken into account.

The main limitations of LITLINE and LITMOD are listed in **Table 4**.

Considering the limitations of each model, both LITMOD and LITLINE have been constructed, calibrated and used to evaluate various beach control options to ensure that the uncertainties of each model have been covered by the other.

LITMOD was developed by LNEC, while LITPROF and LITLINE were developed by DHI as part of the software package LITPACK. Further information of the modelling software can be found Appendix A.

Table 4: Summary of main imitations of LITLINE and LITMOD

LITLINE	LITMOD
It was not originally designed to model fishtail groynes and detached breakwaters	Can model both fishtail and detached breakwaters as well as straight groynes
Can use both constant and varied water levels	Use only a constant water level
Consider both d50 and sediment size spreading ($\sigma=(d^{84}/d^{16})^{1/2}$)	Does not consider sediment size spreading
Cannot model semi-submerged beach structures	Cannot model semi-submerged beach structures
Uncertainty in predicted beach development around the outer tip of a groyne if active transport zone is wider than the length a groyne	The uncertainty of this aspect is unknown
	Models diffraction effects as well as sediment blocking and by-passing of structures

5.2 Model Data

To construct the above described models requires input of wave, tide conditions, beach and sediment data. Details of the model data are described in Appendix B.

5.3 Model Calibration

Both LITLINE and LITMOD models were calibrated over a period of 4 years (October 2001 – October 2005) being the period for which coincident beach survey data and time series wave/tide data were available.

Both models consider the time series wave data but water level variation was not considered in LITMOD model. The existing groynes were included as fully emerged in both models.

The modelled beach lines (0m OD) were compared against the measured in **Figures 6-7** for the LITLINE model and **Figures 7-8** for the LITMOD model.

Figure 6 and **Figure 7** present the results of modelled beach evolution with and without the existing groynes. The LITLINE model exaggerated the effects of two groynes towards the west end of the model domain. The reason for the exaggeration was due to the active transport zone being much wider than the length of the groynes; in which situation LITLINE may not be able to represent the processes accurately. The LITLINE model however predicts behaviour reasonably well in the middle section of the frontage.

The results of the LITLINE model seem to confirm the observation that the existing groynes have some effect on holding the beach and shoreline position.

Figure 8 and **Figure 9** show that the LITMOD model over-predicted the effect of the existing groynes resulting in slightly excessive accumulation of sediment to the west of the groynes and erosion to the east of the groynes. This was because the existing groynes were considered as fully emerged in the model but in reality sediment could bypass the groynes from the top of the groynes during high water periods.

Table 5 presents the modelled longshore sediment transport from 1987 to 2005 by the LITLINE model driven by the 19 year time series of wave and water level data. It gave a mean net eastwards longshore sediment transport rate of 103,539 m³/year, which compares favourably with previous assessments provided by the 110,000 m³/year given by HR Wallingford (1988) [3].

The following conclusions may be drawn from the model calibration process:

- The modelled beach lines compare reasonably well with the measured after considering that the groynes were represented as fully emerged in both models
- LITLINE exaggerated the effect of the existing groynes in the western end which highlights uncertainty of the LITLINE model in the area close to the west end.
- Both models produced reliable results in the middle section of the frontage.

Table 5: Modelled longshore sediment transport

<i>Year</i>	<i>Net transport capacity (m³.year⁻¹)</i>	<i>Gross transport capacity (m³.year⁻¹)</i>
1987	127 631	145 338
1988	172 814	181 486
1989	107 703	124 369
1990	187 525	197 562
1991	102 758	121 126
1992	109 601	120 214
1993	94 198	114 435
1994	85 602	98 035
1995	81 195	93 440
1996	56 418	76 876
1997	51 876	65 255
1998	89 781	99 160
1999	104 735	115 108
2000	90 092	99 613
2001	103 308	116 863
2002	70 965	85 328
2003	84 167	95 621
2004	121 427	127 797
2005	125 435	131 944
Average	103 539	116 293

Note; Positive transport rate means sediment is transported from west to east.

5.4 Influence of Tidal Currents

No inshore tidal current data was available for this modelling study and the influence of tidal currents were not considered in neither cross-shore nor longshore sediment transport modelling. It is believed that the effect of tidal currents is weak in the area of

upper beach in particular in the area protected by beach control structures. Tidal currents may have significant effect in foreshore area (lower beach).

Figure 6: Results of LITLINE model calibration after 1 year simulation (2001-2002)

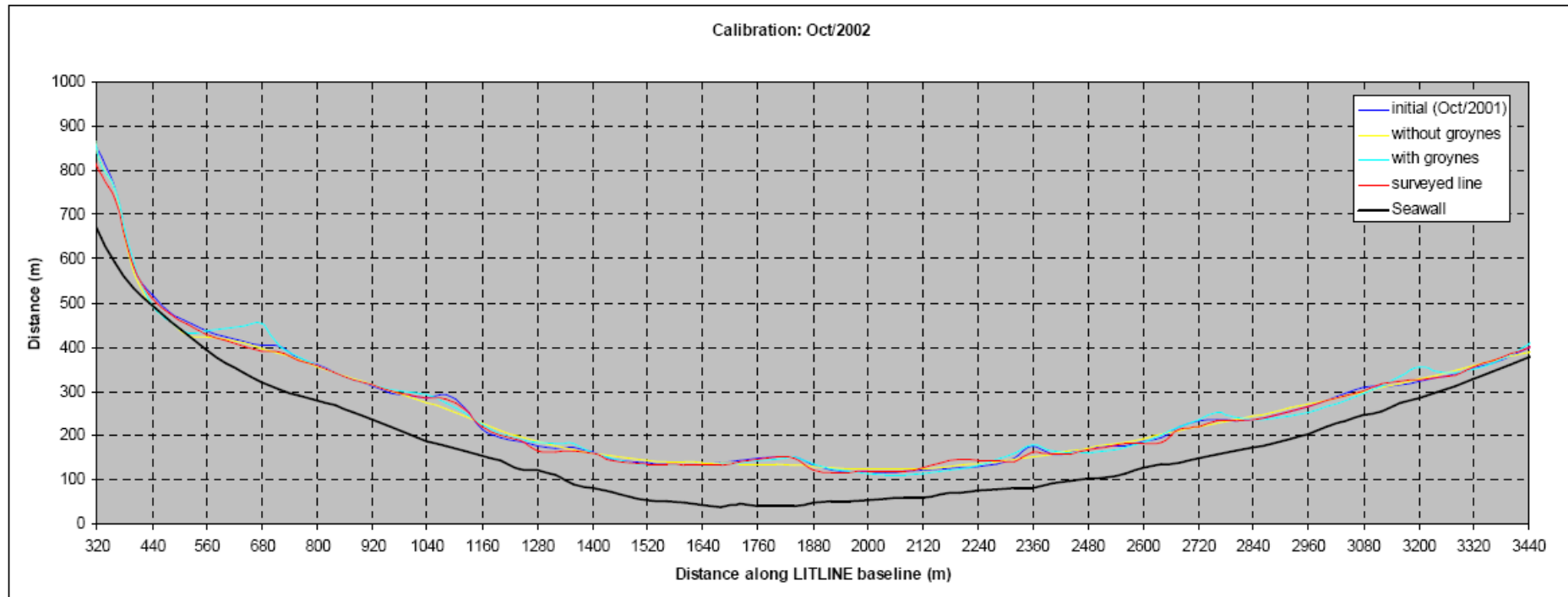


Figure 7: Results of LITLINE model calibration after 4 year simulation (2001-2005)

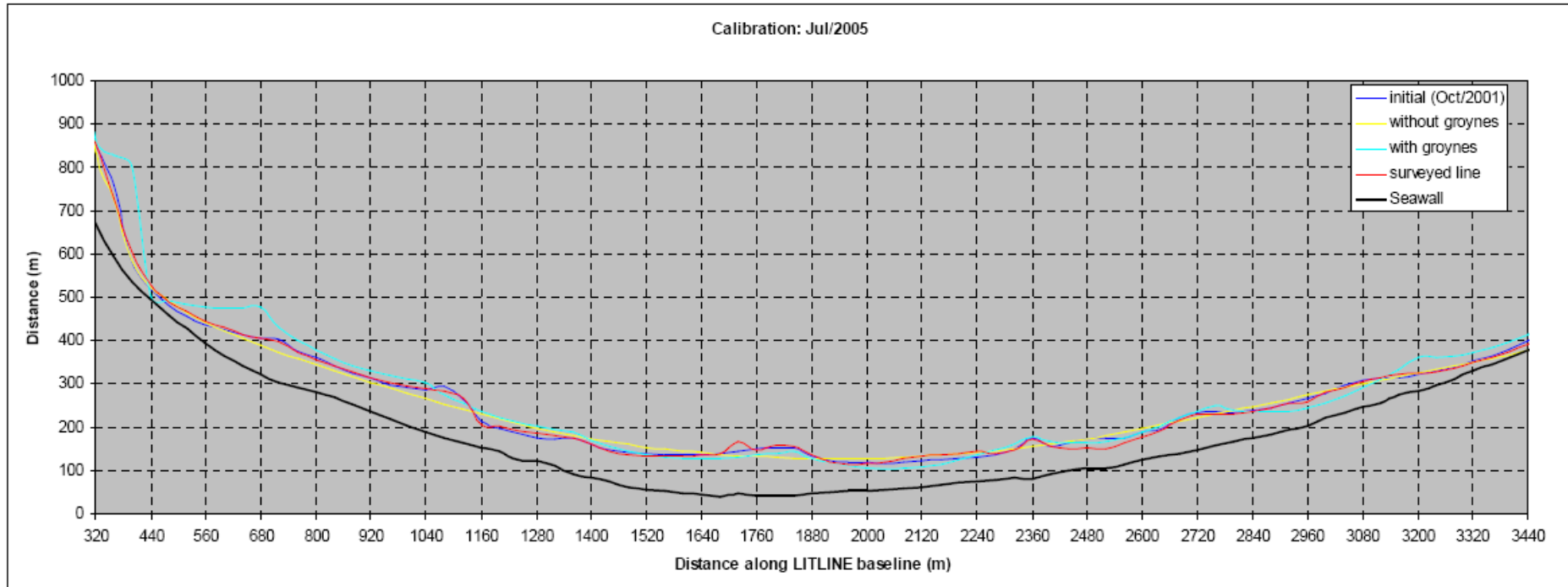


Figure 8: Results of LITMOD model calibration after 1 year simulation (2001-2002)

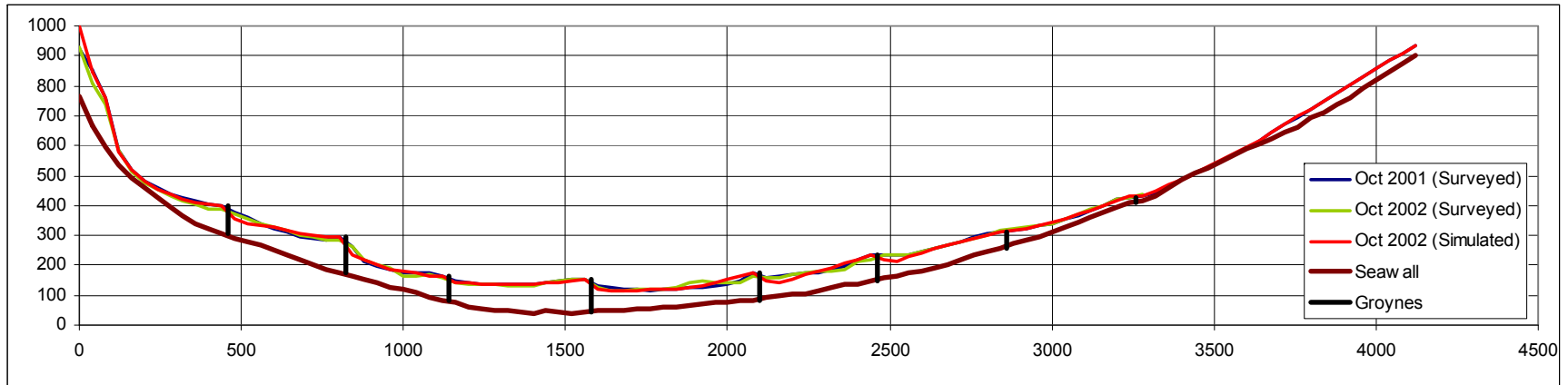
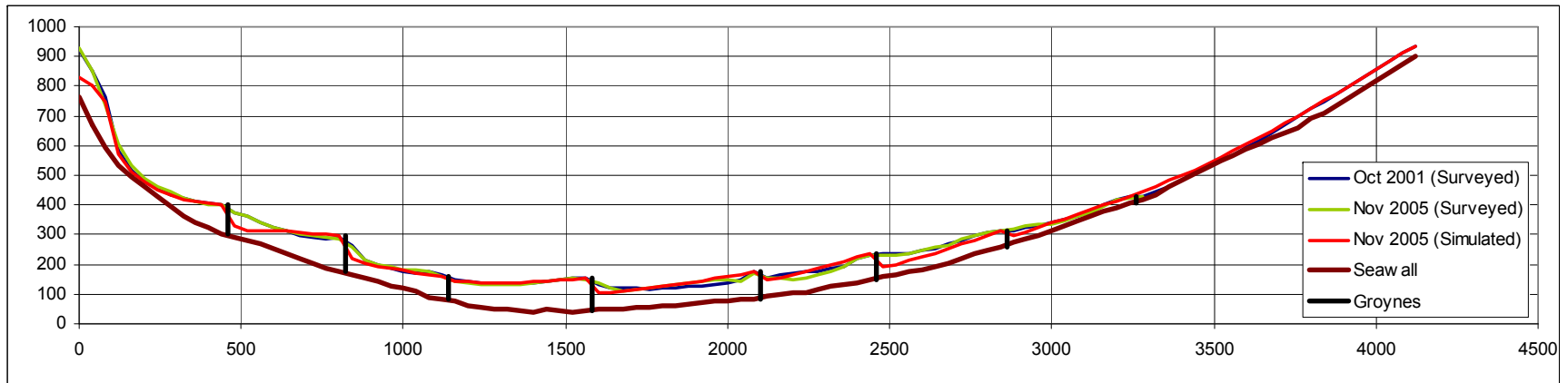


Figure 9: Results of LIMOD model calibration after 4 year simulation (2001-2005)



6 BEACH STABILITY AND RECHARGE BEACH PROFILE

It is important that an appropriate beach recharge profile is adopted which is able to accommodate profile changes that would occur under a storm conditions. This would give the beach a chance to recover under normal wave climate after storms, if the upper beach berm is not completely lost. Loss of the beach berm would expose the existing sea wall and allow for wave reflections which would cause additional impacts that are beyond the ability of the modelling to replicate.

6.1 Potential Source of Recharge Material

The most important factors in determining a stable beach recharge profile are the properties of recharge material including sediment size and density.

The most likely sources of beach recharge are existing licensed dredging areas within Liverpool Bay and sediment information from these areas was obtained. Based on these data (ref Appendix B), two potential recharge gradings were identified for consideration in the beach profile analysis (**Table 6**).

“Source 2” material is coarser than “Source 1” in average but larger d_{50} is mainly due to more shingle material, which results in a wider grading or larger size spreading (σ).

Table 6: Recharge sediment source and property

Recharge Material	d_{50} (mm)	Size Spreading (σ) (d_{84}/d_{16}) ^{1/2}	Comments
Source 1	0.25	1.72	Typical sediment property in the middle of the licensed dredging Areas 392 and 457 (see Appendix B)
Source 2	0.45	2.10	Coarser sediment available from nearer the outer boundaries of the licensed dredging Areas 392 and 457.

Note: Sediment transport models can consider either sand or shingle recharge but not mixed beaches. The behaviour of shingle sized material (>2.00mm) within a sand transport model, cannot be accurately represented.

6.2 Equilibrium Beach Profiles

An equilibrium beach results from a balance of destructive (under storms) and constructive (under normal wave climate) forces acting on the beach. Though an equilibrium beach profile (EBP) is unlikely to be unique and constant, due to the continuous changes in the factors affecting the forces such as increases in sea level or storms, the beach profile is likely to be more stable if a recharged beach profile follows an EBP.

If a beach is recharged to a profile other than the EBP, the beach will, over time, tend towards the EBP. The offshore extent of the EBP identifies the active zone of littoral drift.

For the two sediment gradings examined these were identified as follows:

- D_{50} of 0.25mm: Approximately 600 metres from the existing sea wall
- D_{50} of 0.45mm: Approximately 480 metres from the existing sea wall

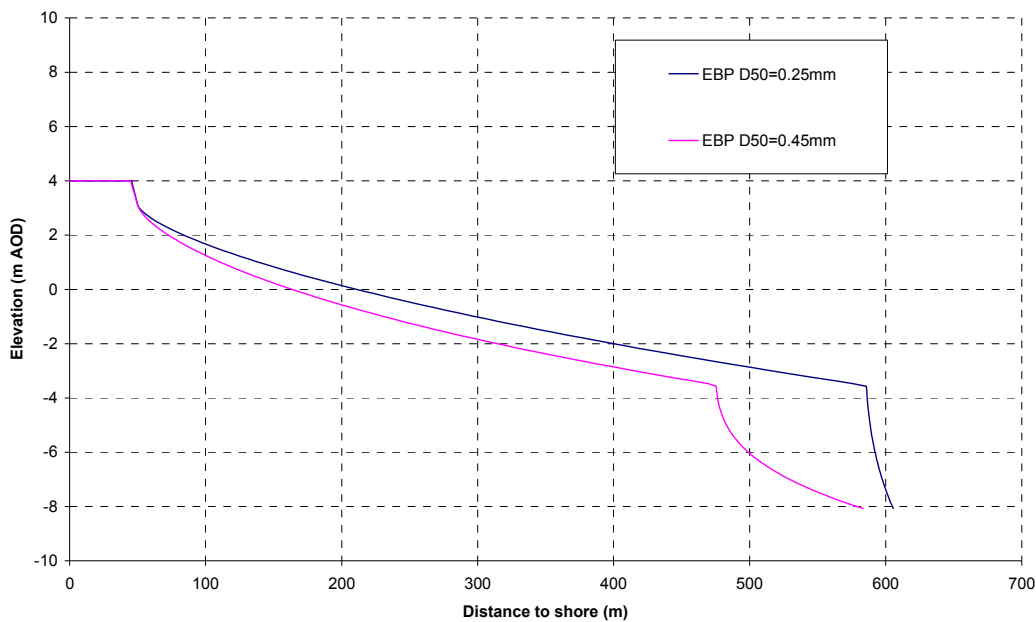
Based on the available sediment data (existing and source), an Equilibrium beach profile for Colwyn Bay was determined. This EBP identified was based on the Dean EBP (1977)^[4], as modified by Bernabeu et al, 2003)^[5]. This modified profile is more applicable for sites with a high tidal range and considers several factors including d_{50} , foreshore slope, sediment fall velocity (including sediment density) and tidal range.

From this profile an initial EBP with the following characteristics was evaluated for cross shore deformation under storm conditions:

- Berm width: 50m
- Berm elevation: +4.0mOD (just above Mean High Water Spring tide level)
- Closure depth: ~-3.7mOD (about low water spring tide level)

The derived EBPs for these conditions for the two recharge material sources are presented in **Figure 10**.

Figure 10: Equilibrium beach profiles



6.3 LITPROF Model Results and Recommended Recharge Profiles

The initial EBPs for d_{50} of 0.25mm and 0.45mm were tested with the “February 1990” event occurred between 26th February and 1st March 1990, which represented the worst maritime storm in the last 30 years in the Colwyn Bay and one for which recorded wave and tide data was available within the time series. The wave and tide conditions are illustrated in **Figure 11**.

The model results (**Figure 12** and **Figure 13**) show that only the 10m berm was left “untouched” for the EBP for $d_{50}=0.25\text{mm}$ but almost the entire berm was under erosion for the EBP for $d_{50}=0.45\text{mm}$. The reason for more erosion with a $d_{50}=0.45\text{mm}$ is due to larger size spreading (σ). This means that the d_{50} is unduly influenced by the coarser portion of the grading whereas the behaviour of the material is more influenced by the finer sediment in the grading.

The model results suggest that there is no benefit in using “Source 2” material over “Source 1” material. Although the average sediment size of “Source 2” material is coarser than “Source 1” material, “Source 2” material is more mixed with finer and coarser material. Furthermore it is likely that source 1 material will practically be easier to source, as it is representative of the material currently dredged from the areas under consideration.

The results of profile deformation (ref figures 12 and 13) identified that the active zone of cross shore movement was, in both cases, within 300 metres of the sea wall. As can be seen by reference to section 6.2 above, the active zone of cross-shore transport is narrower than the active zone of longshore transport.

Evaluation of the initial results suggested that improvement in performance might be gained by modifying the level and/or crest of the berm, although any improvement in performance could be offset by unwanted side effects such as increased wind blown sand effects. Increasing the berm elevation could potentially provide a narrower berm width but there would be a corresponding increase in recharge quantity. Also it was identified that whilst the EBP represented the natural profile the beach would want to adopt, placing material to such a profile would not be practical and a straight grade would represent the initial gradient with the beach subsequently modified to the EBP over time.

To test this behaviour and provide the necessary information to support design definition, revised profile with the following criteria, as shown in **Figure 14**, were defined:

- Berm width: 50m
- Berm elevation: Sloping from +5.0mOD at the sea wall to +4.0m OD at the seaward edge
- Seward gradients: Uniform slopes of 1:35 and 1:30 for d_{50} of 0.25mm and 0.45mm respectively*.
- Closure depth: ~-3.7mOD (about low water spring tide level), as previously.

* The slopes were determined to ensure that the recharge volumes within the active zone of cross-shore transport (approximately 300m from shore, as defined previously) are equal to those of the EBPs.

Figure 11: Wave/tide conditions in Colwyn Bay during the February 1990 Storm

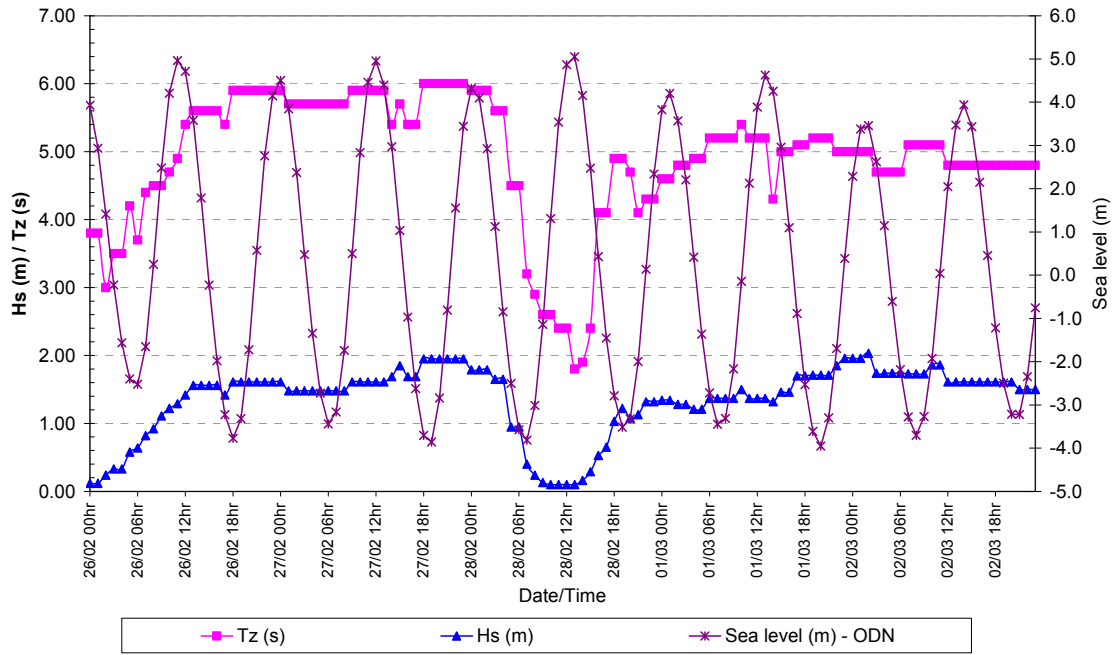


Figure 12: Results of LITPROF results on the modified EBP for $d_{50}=0.25\text{mm}$

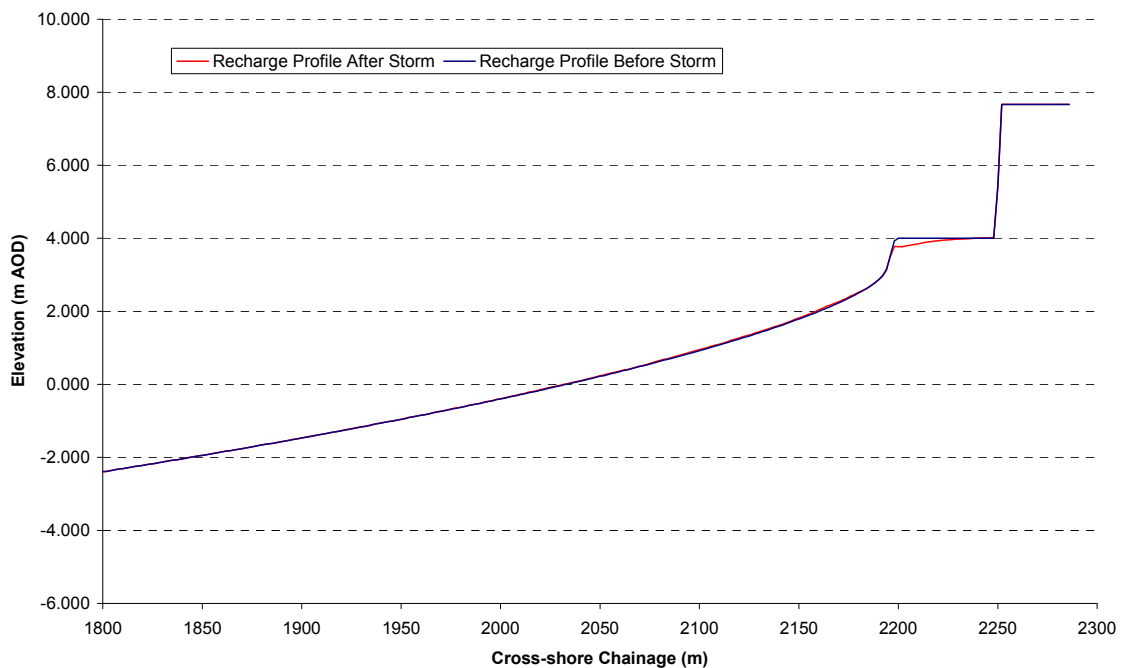


Figure 13: Results of LITPROF results on the modified EBP for $d_{50}=0.45\text{mm}$

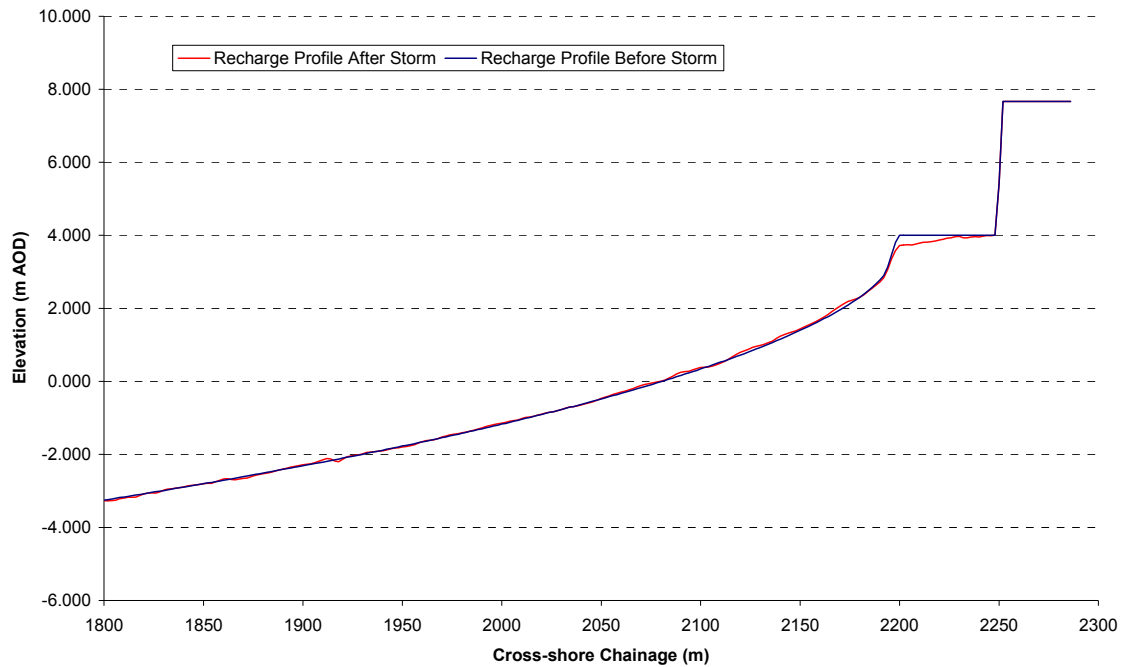
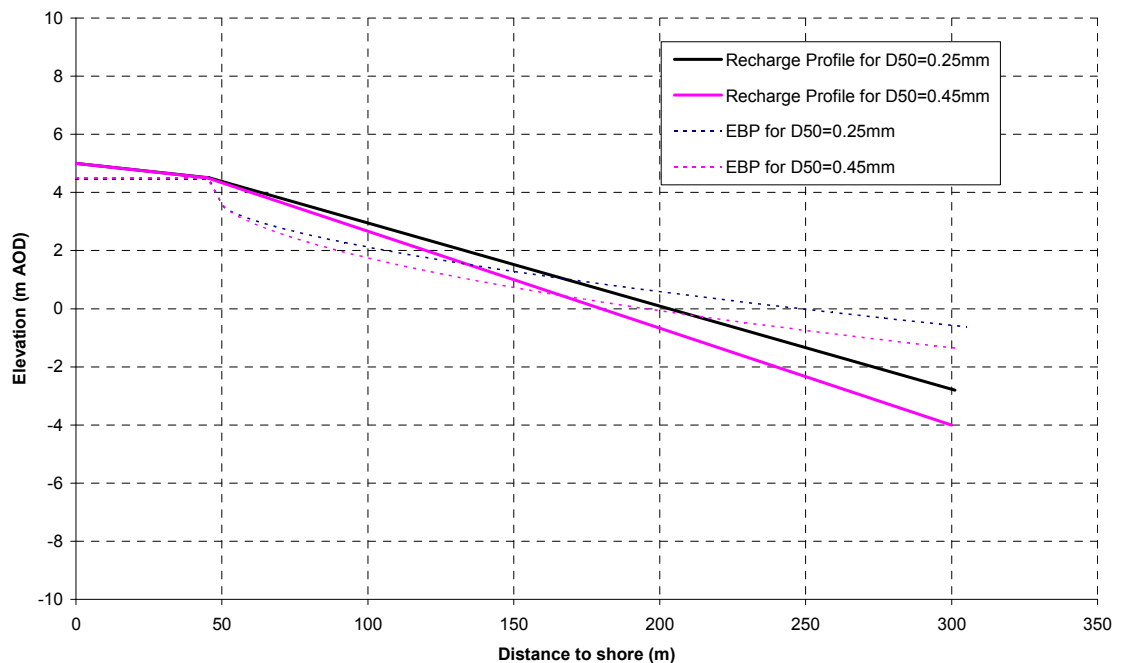


Figure 14: Recommended beach recharge profiles



The LITPROF results of the modified recharge profiles are presented in **Figures 15-16**. These revised profiles provided a 25% reduction in the berm width impacted by the storm compared to the lower EBP profile for the 0.25mm d_{50} sediment size but no change for the 0.45mm d_{50} sediment size, whilst providing for a zone of beach recharge that does not extend beyond the inter-tidal area.

Figure 15: LITPROF result on the recommended recharge profile ($d_{50}=0.25\text{mm}$)

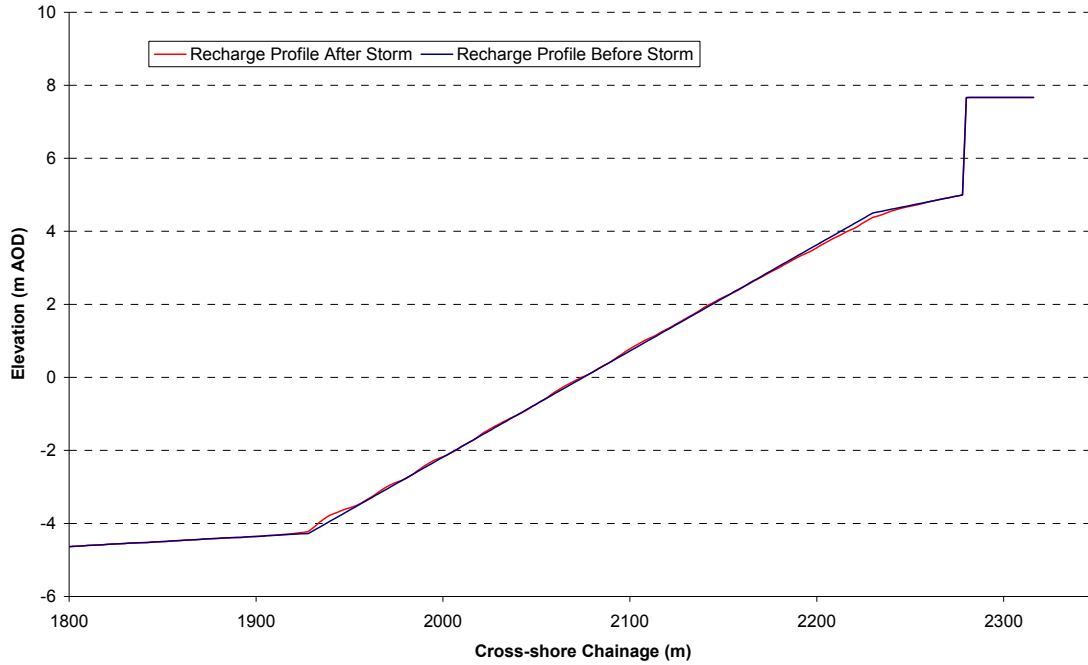
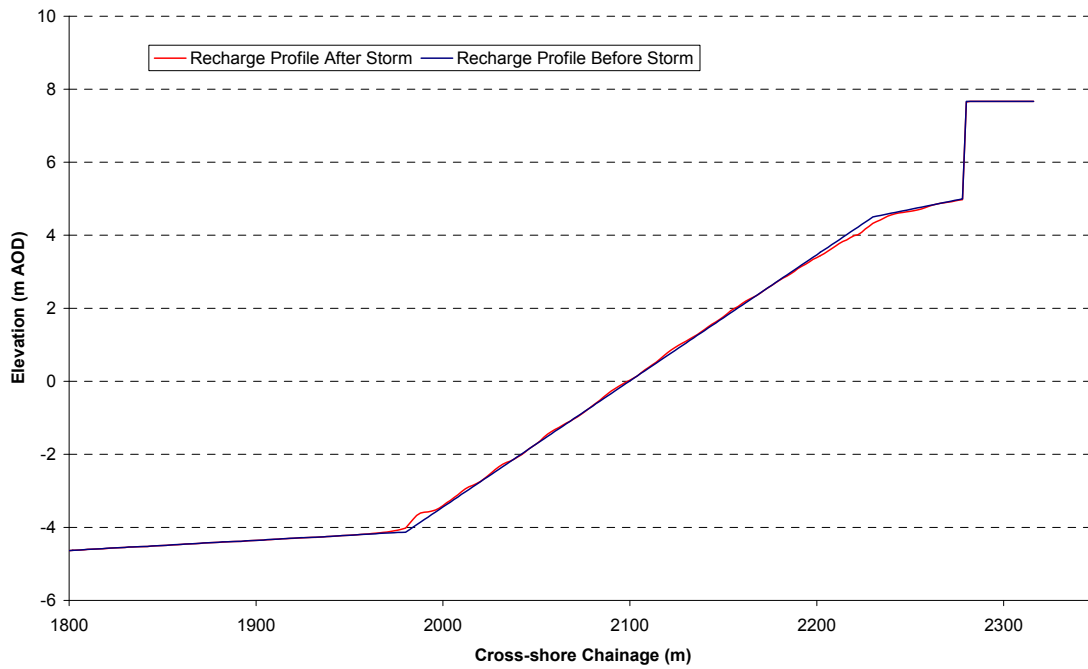


Figure 16: LITPROF results on the recommended recharge profile ($d_{50}=0.45\text{mm}$)



7 Beach Plan Evolution and Development of Control Structure Options

This section presents and discusses the results of the beach plan evolution modelling carried out following model calibration, as discussed in section 5, and to complement the cross-shore evaluation discussed in section 6 above.

This work provides an evaluation of the predicted long term change in the beach under a range of beach recharge scenarios in order to identify the most suitable arrangements for the construction and retention of healthy beaches along the Colwyn Bay frontage.

The different schemes modelled evolved as the work progressed with the results of the earlier model runs being used in order to assist in the definition of the later schemes.

As identified in section 2 above, different models were utilised dependant on the particular scheme being evaluated. These are summarised in **Table 7** along with the model tests that have been completed.

Full details relating to each of the schemes modelled are provided in Appendix C.

Figure 17 illustrates the beach monitoring profiles along the Colwyn Bay frontage which are referenced in the description of the recharge schemes in this section.

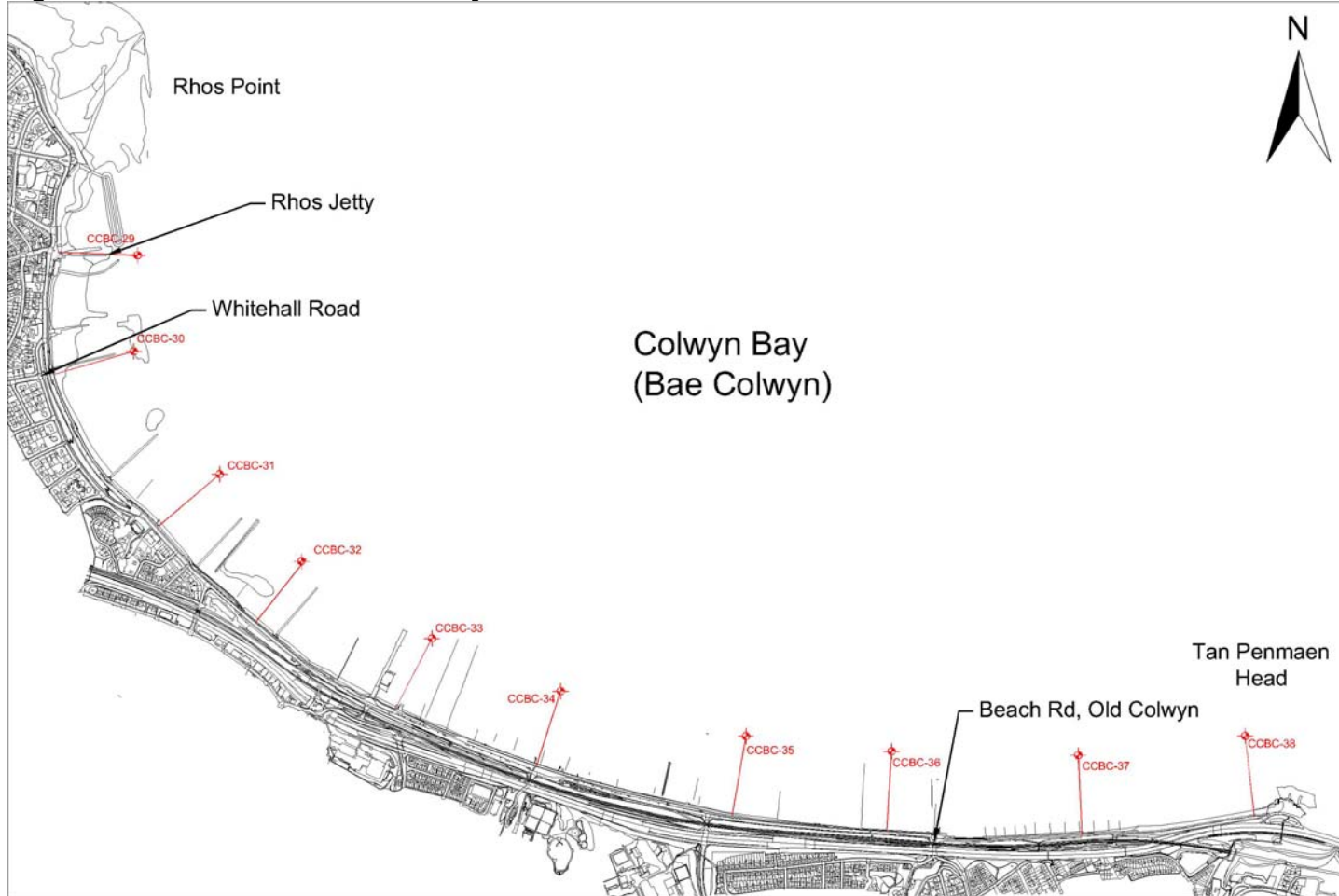
Table 7: Completed LITLINE and LITMOD tests

Test No	Test Name	LITLINE	LITMOD	Description
1	Option A1	✓	✓	Without any beach control structures
2	Option A2	✓	✓	Without any beach control structures ($d_{50}=0.45\text{mm}$; $\sigma=2.1$)
3	Option 1	x	✓	Single fish-tail groyne
4	Option 2	x	✓	2 fishtail groynes (1.1km apart)
5	Option 3	✓	✓	2 groynes (like Option 1 but without fishtail heads)
6	Option 4	x	✓	3 detached breakwaters
7	Option 5a	x	✓	2 fishtail groynes (1.35km apart)
8	Option 5b	x	✓	2 fishtail groynes (1.6km apart)
9	Option 6	✓	x	Single groyne (like Option 1 but without fishtail head)

Unless noted otherwise the beach plan shape figures presented for all runs illustrate the 0.0m OD beach contour.

The recharge volumes were estimated by digital terrain modelling using ArcGIS software based on the equilibrium beach profiles identified compared to the latest foreshore monitoring survey available (May 2009).

Figure 17: Illustration of Beach Survey Profiles



7.1 Beach Recharge without Control Structures (Options A1 and A2)

The first scheme was modelled comprised the recharging of the beach across the whole frontage without any control structures in order to evaluate to evaluate the movement of an unrestrained recharged beach. With no control structures, both LITLINE and LITMOD models were used for these options with model run A1 referring to the smaller sediment ($d_{50}=0.25\text{mm}$) and model run A2 to the larger sediment ($d_{50}=0.45\text{mm}$) in order to examine the impact this may have on behaviour..

The recharge was curtailed at profile ref CCBC35 approx, located approximately 650m west of the boundary with the private Network Rail defences to the east. The choice of this boundary was twofold:

- To identify immediate downdrift impacts of termination in relation to frontages under Conwy CBC jurisdiction
- To accord with preliminary arrangements identified in the Colwyn Bay Coastal Defence Strategy

Both the models predicted similar behaviour with the following key points arising (ref figures C1-C4 in Appendix C):

- Gradual beach retreat at the western end of the frontage
- Relatively stable beach in the middle section between chainage 700m and 1700m
- Significant retreat of the eastern end of the recharged frontage
- Beach advancement to the east of the recharged section, reducing in magnitude towards the east

Evaluation of the difference in behaviour of the two grain sizes showed little difference in the overall behaviour pattern observed in both models apart from a lower rate of loss associated with the coarser material. This is more pronounced in the LITMOD results, which do not consider the impact of the grading of the material (sediment spreading).

Considering the conclusions drawn from the cross shore profile analysis in relation to grain size and material suitability and availability, as reported in section 6, and the impacts of grain size on longshore drift behaviour identified above, the remaining schemes were evaluated on the basis of single grain size conditions i.e.

- mean grain size (d_{50}) = 0.25mm and,
- Spreading (σ) = 1.72.

The modelling estimated losses over the first ten years after recharge of 575,000m³ for $d_{50} = 0.25\text{mm}$ and 400,000m³ for $d_{50} = 0.45\text{mm}$.

In summary the principal positives and negatives of Options A1 and A2 are shown below:

Positive aspects	(1)	beach remains generally stable in the middle section
	(2)	no cost in beach control structures
Negative aspects	(a)	risk of losing beach by longshore drift under severe storms
	(b)	implication of two outfall inflows has not been studied

Having established how an unrestrained beach would behave and confirmed that longshore drift would see a gradual depletion of material from the recharged section, the next phase of modelling comprised evaluation of the impacts of controlling beach movement by the provision of a range of beach control structures.

7.2 Beach Recharge with a Single Fishtail Groyne (Option 1)

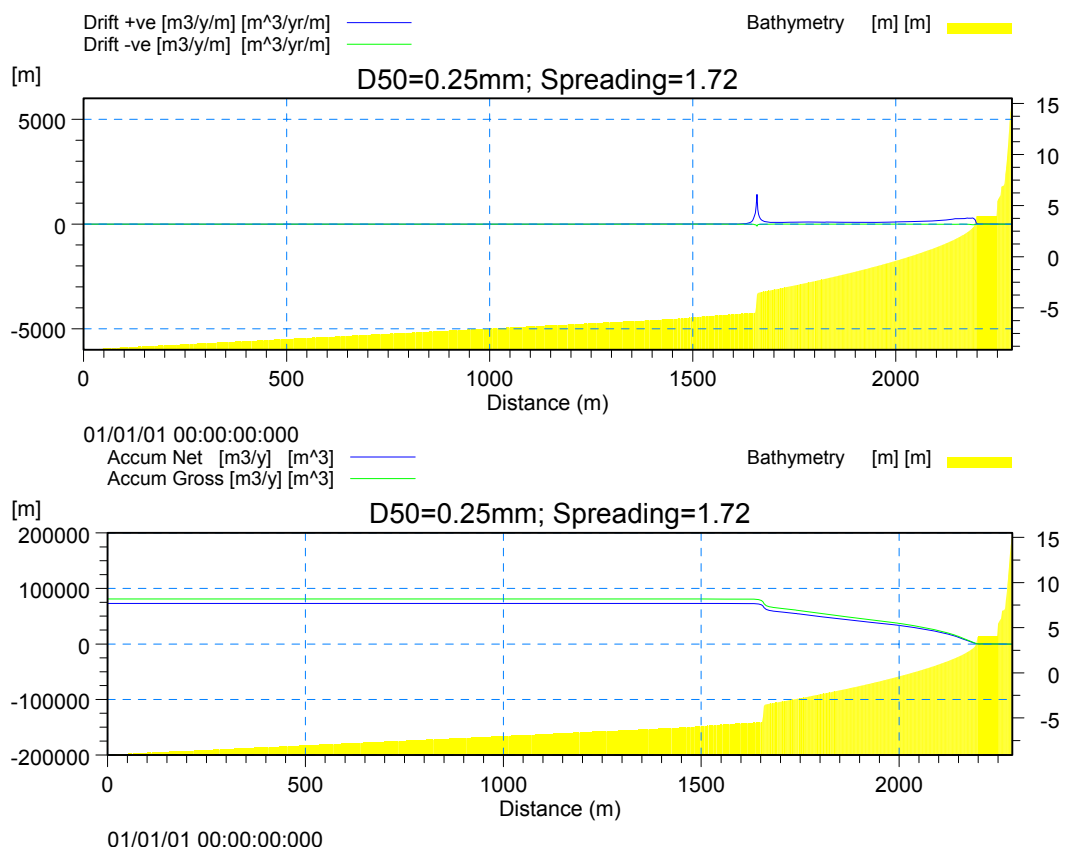
The first beach control option considered the positioning of a single fishtail style groyne towards the eastern end of the frontage. The location of the groyne was fixed by the following:

- The east boundary of the stable central area of beach identified in the “unrestrained” option
- The location of the outlet to the Nant Y Groes stream, which discharges at profile CCBC34 approx (ref fig. 17), approximately 1300 metres west of the council’s boundary at Beach Rd.

The length of the groyne was determined from consideration of the active zone of longshore drift, as discussed in section 6.2 above, balancing the requirements of

- providing effective control of the recharge beach
- providing for some by passing of drift across the lower sections of the active zone. **Figure 18** below provides the cross shore distribution of longshore drift for the recharged beach. A structure of 250m length would cover approximately 40% of the active zone and allow by passing of just over 50% of the total drift across the section
- constructability and costs.

Figure 18: Cross shore Longshore Drift distribution



LITMOD was used to evaluate the behaviour for this scenario, the key points arising from which are provided below (ref figure C5 in Appendix C):

- the model predicted a stable beach west of the groyne over a length of about 1150 metres (to midway between profile refs CCBC-31 and CCBC32).
- The groyne clearly interferes with drift across the upper part of the active zone, causing downdrift erosion over about 600-700 metres east of the groyne's location.
- At the western end the recession identified in the unrestrained beach scenario is replicated. Despite significant retreat in the west end, the beach width would however still be wider than its current situation after 19 years of simulated conditions.

The modelling estimated losses ten years after recharge of 450,000m³.

In order to test the sensitivity of the results to the length of groyne a 300 metre long groyne was modelled (ref figure C5A). The following key points apply to the results:

- Similar behaviour to the west of the groyne as for the 250m long option
- Reduced losses after 10 years of 300,000m³
- Greater impacts down drift of the groyne over a greater length, extending across the Network Rail section. The greater length of groyne provides for approximately a 10% increase in the blockage of drift with just under 50% of the drift effectively by passing the structure

In summary the principal positives and negatives of Options 1 (ref LNEC Test 3) are shown below:

Positive aspects	(1)	Holds a stable across the central section of frontage
	(2)	Relatively low cost in beach control structures
	(3)	No apparent negative impact on beach conditions downdrift of the Conwy frontage for 250m long option
	(4)	Reduced losses compared to unrestrained option, which are better the longer the groyne
Negative aspects	(a)	Significant beach retreat still identified in the west end (near Whitehall Road)
	(b)	Downdrift effect puts more pressure on the sea defence on the immediate east side of the fishtail groyne. This is greater the longer the on/offshore extent of the fishtail groyne

7.3 Beach Recharge with Two Fishtail Groynes (Option 2)

Option 2 examined the impacts of providing a second fishtail groyne further to the west to investigate if this structure would assist in holding the beach at the western end and halt the predicted recession taking place here.

The location of the second groyne was fixed by the following:

- The western boundary of the stable central area of beach identified in Option 1.

The spacing between the two groynes was approximately 1230 metres. The length of the second groyne was initially kept as the same length as in Option 1 i.e. 250 metres

LITMOD was used to evaluate the behaviour for this scenario, the key points arising from which are provided below (ref figure C6 in Appendix C):

- the model maintained a stable beach between the two groyne structures
- Recession behaviour west of the western groyne predicted to not be significantly different to that identified in Option 1 – suggested that a second groyne would have little impact on overall behaviour.
- Behaviour downdrift of the eastern groyne similar to that predicted under Option 1.

The modelling estimated losses ten years after recharge of 450,000m³.

As in Option 1, in order to test the sensitivity of the results to the length of groyne, twin 300 metre long groynes were modelled (ref figure C6A). The following key points apply to the results:

- Similar overall behaviour to the 250 metre long option with stable central beach and continued recession at the western end.
- A small enlargement of stretch of the beach near the East fishtail.
- Reduced losses after 10 years of 300,000m³
- Greater impacts down drift of the groyne over a greater length, extending across the Network Rail section. The greater length of groyne provides for approximately a 10% increase in the blockage of drift with just under 50% of the drift effectively by passing the structure

In summary the principal positives and negatives of Option 2 (ref LNEC Test 4) are shown below:

Positive aspects	(1)	Holds a stable across the central section of frontage
	(2)	No apparent negative impact on beach conditions downdrift of the Conwy frontage for 250m long option
	(3)	Reduced losses compared to unrestrained option, which are better the longer the groynes
Negative aspects	(a)	Significant beach retreat still identified in the west end (near Whitehall Road)
	(b)	Downdrift effect puts more pressure on the sea defence on the immediate east side of the fishtail groyne. This is greater the longer the on/offshore extent of the easterly

		fishtail groyne
	(c)	Increased cost of control structures for little apparent benefit

As a further test on whether increasing the spacing between the two groynes would be beneficial in holding the beach at the western end two further runs were completed (ref Options 5 & 5A) keeping the groyne length at 250 metres but increasing the spacing between the groynes by 225 and 450 metres (to 1450 and 1675 metres respectively), keeping the easterly groyne in its original position but moving the location of the west structure.

The key points arising from these simulations are provided below (ref figure C7 and C7A in Appendix C):

- Across the central section between the groynes, a large part of the beach remained stable but there was progressive waterline retreat occurred at the west end of the cell between the groynes which increased with increase in separation
- Whilst the length of frontage updrift of the west groyne decreased with separation the behaviour pattern remained.
- Impacts downdrift of the east structure remain as previously identified for Option 1
- In both cases losses from the frontage were as previously identified in Option1 at 450,000m³ after ten years.

7.4 Beach Recharge with Two Groynes (Option 3)

Both LITLINE and LITMOD can model the effects of shore normal groyne. Having examined the behaviour of the fishtail groyne options, this option was examined in order to identify the following:

- The difference in predicted behaviour for cross shore intervention provided by the two models, including the impacts of including for variable water level.
- The difference between straight and fishtail cross shore groynes.

For this examination the two groyne structures were kept at 250 metres long with the spacing of the structures used as adopted in Option 2, with a spacing of approximately 1230 metres.

Firstly comparison of the predictions from the two models shows significantly different behaviour with the following key points applying:

- In the vicinity of the western groyne LITLINE is showing accretion to seaward, whereas LITMOD shows the structure holding the beach on the western flank but with a step in water line across the groyne
- In the section between the groynes LITLINE predicts accretion across the western third of the frontage and significant erosion in the first five years after recharge but some recovery thereafter. LITMOD predicts that the two groynes will hold the beach between the structures.
- On the downdrift side of the east groyne, LITLINE predicts accretion over the first 500 metres but erosion thereafter. LITMOD predicts some downdrift starvation, similar to that predicted by the fishtail groyne option

The results of the LITLINE model (**Figure C8**) show some sediment bypass at low tides that is not fully represented in the LITMOD model. This sediment bypass may be the cause of the predicted beach retreat in the east half of the middle section. Overall however the LITLINE results around the groyne structures are not believed to be realistic principally due to one of the limitations of LITLINE, when the active transport zone is much wider than a beach control structure. The results of LITLINE in this case should be evaluated with caution due to this limitation.

In comparing two LITMOD results between Option 2 (Figure C7) and Option 3 (Figure C9), it can be seen that the overall behaviour predictions are similar with the following key points applying:

- Recession to the west of the west groyne is replicated in both scenarios
- A stable beach is held by the two structures, although there appears to be more movement with slight recession at the west end and slight accretion at the east end, indicative of drift across the frontage
- The shore normal groyne does not provide as much shelter for drift as the Fishtail and hence there is a step in the water line level across the groyne???
- The eastern groyne provides a barrier to upper zone drift, starving the beaches across the remainder of the Conwy frontage. Generally across the Network Rail frontage, the impact is neutral.

- Overall losses from the frontage in 10 years after recharge are slightly lower at 425,000m³ compared to the 450,000m³ for the fishtail option.

As with Options 1 & 2, in order to test the sensitivity of the results to the length of groyne, twin 300 metre long groynes were modelled (ref figure C9A).

There is little discernible difference in behaviour of the two options apart from:

- a greater step in the water line across the western groyne.
- reduced losses after 10 years of 300,000m³

In summary the principal positives and negatives of Options 3 are shown below:

Positive aspects	(1)	holds a generally stable beach between two groynes
	(2)	Lower cost for control structures a no cross head included
Negative aspects	(a)	significant beach retreat in the west end (near Whitehall Road)
	(b)	downdrift effect puts more pressure on the sea defence on the east side of the east fishtail groyne
	(c)	greater movement downdrift of beach between the two structures
	(d)	Increased risk of beach retreat in the middle section between two groynes

7.5 Beach Recharge with a Single Groyne (Option 6)

Given the uncertainty associated with the LITLINE predictions in Option 3 the option of providing a single shore normal groyne was evaluated using this model only to see whether the impacts identified were the same and in particular whether the bypassing identified in the LITLINE run of option 3 was replicated.

A single 250 metre long groyne structure was provided at the same east groyne location used in the previous layouts.

The key points arising from the predictions for this layout (ref figure C10 in Appendix C) are:

- The single groyne is effective in providing a barrier to drift and holding a beach to the west
- Across the frontage immediately west of the groyne the frontage, the model predicts retreat in the first 5 years west of the groyne, reducing in magnitude moving away from the groyne, followed by recovery thereafter.
- Further to the west the recession as observed in other layouts modelled is reproduced.
- East of the groyne the behaviour of accretion immediately downdrift changing to erosion and subsequently a neutral affect, as identified by Option 3, is reproduced

Overall since the groyne is considerably shorter than the active width of the beach profile the local change in the longshore sediment transport due to a change in the coastline orientation around the groyne may be exaggerated (as alerted by the model developers). This lack of validity of the shoreline evolution around the groyne is thus extended to the total extension of the shoreline in the study area (in Figure 1), as identified in Option 3.

Comparing Option 1 and Option 6, the results of both models suggest that a single groyne-type beach control structure is effective in maintaining a healthy beach over most of the re-nourished frontage, except the west end where local erosion suggests the influence of other factors, possibly the existing Rhos-on-Sea breakwater. Overall, the results of Option 6 provide confirmation of the model results of Option 1 despite the uncertainty of beach development around the tip of the groyne, due to the limitation of the LITLINE model, as discussed in Section 5.1.

7.6 Beach Recharge with Three Detached Breakwaters (Option 4)

As an alternative to shore connected structures the use of offshore breakwaters, similar to the existing structure at Rhos-on-Sea was examined.

The behaviour of beaches provided behind breakwaters is particularly sensitive to the length to spacing ratio of the structures and the elevation of the structures.

The layout comprised three offshore structures each 280 metres long uniformly spaced across the frontage, angled obliquely to the shoreline approximately 200-350m off the existing defences.

LITMOD was used to evaluate the behaviour for this scenario, the key points arising from which are provided below (ref figure C11 in Appendix C):

- The detached-breakwaters induce a large variation of the beach width.
- The beach fill presents a good durability as a result of the low deficit of littoral drift of this stretch.
- After 10 years of simulation, there is a total of 1 100 m of the beach still presenting levels above + 4.5 m OD but in places the berm has been lost completely
- A loss of sand of 500 000 m³, during the first 10 years after filling, was computed by the model.

The model results show the development of tombolos and disappearance of berms. The results suggest the need for longer detached breakwaters or shorter distance between the breakwaters and the shore, whichever is likely to strengthen the development of tombolos.

In summary the principal positives and negatives of Option 4 are shown below:

Positive aspects	(1)	Less downdrift effect to the area where the linear defence is proposed
	(2)	Detached breakwaters would provide extra protection from cross-shore erosion
Negative aspects	(a)	Significant beach retreat (particularly berm) in some places
	(b)	Tombolos appears behind the breakwaters which may cause concern in H&S and poorer water quality
	(c)	Detached breakwaters are expensive to construct
	(d)	Visual impact particularly at low tides
	(e)	Greater uncertainty in the numerical modelling due to stronger 2D/3D effects and LITMOD is a One-line model

8 SUMMARY & DISCUSSION

8.1 Background

Based on the results of historic beach data analysis and model calibration, the study has demonstrated that the main process of beach loss in Colwyn Bay is longshore drift. The cross-shore transport process helps to accelerate the longshore drift by drawing down material from the upper beach and widening the cross-shore transport zone. The cross-shore transport process thus reduces beach levels at toe of the existing defences. This local scour of the upper beach principally occurs due to the reflection of wave energy by the sea wall.

The historical data also suggests that storms are the main cause of beach loss rather than there being on-going losses of beach material on a day to day basis. During these storms there is considerable movement of the beach and associated significant wave overtopping of the existing seawall that can cause damage to property and infrastructure.

A beach level high enough to prevent wave action during storms from reaching the seawall, together with a beach profile of sufficient volume for it to change under storm attack without excessive drawdown and consequent exposure of the sea wall, will provide an effective flood defence.

Present beach levels across the frontage are generally low in comparison with levels over 50 year earlier which were, from photographic evidence, up to 3.0 metres higher in places. Currently the Mean High Water contour resides on the existing coastal defences all the way round the Bay and if a beach is to provide improved coastal defence with the added benefit of improved amenity and impetus for regeneration of the town, artificial recharge of beach levels is required.

The principal objective of the modelling study has been to demonstrate the technical feasibility of such a course of action. To demonstrate this, the beach profile required to provide the necessary level of protection under storm conditions has firstly been defined. Subsequently the long term reaction and movement in plan of the beach has been examined to predict how it would react over time, with and without structures to control, its behaviour.

The modelling of beach behaviour is not a precise science, primarily because the exact future combinations of wind, tide and wave conditions that will apply cannot be predicted. Furthermore there are limitations in the applicability of the various numerical models that are available, with the more complicated the shoreline conditions – generally the more significant the uncertainties arising from the results.

Notwithstanding this the modelling carried out is has used the most up to date information and technology in order to define the most appropriate arrangements for the Colwyn Bay frontage.

8.2 Discussion

Sediment Sources and Grading

Where at all possible, recharging of beaches should be undertaken with material that is at least as coarse as the native material to be found at the site. Examination of potential suitable sources of material for use in beach recharge at Colwyn Bay has identified that there are a number of currently licensed commercial dredging areas within Liverpool Bay from which such material could be obtained (ref Appendix B).

Within these areas there is a range of mean size material available (with d_{50} typically between 0.2 and 0.8mm). The modelling however identified that it is the grading and in particular, the sediment spreading factor - $\sigma = \sqrt{(d_{84}/d_{16})}$ - which affects the behaviour of the recharged beach. Higher d_{50} are generally associated with higher spreading, which the modelling has identified leads to reduced resistance to movement. Furthermore where significant parts of the grading are classified as shingle (>2.0mm) then the ability of models used for sand transport to predict behaviour is questionable. Based on the available evidence and consideration of a range of d_{50} and σ values, the use of a material with a $d_{50} = 0.25\text{mm}$ and $\sigma = 1.5\text{-}2.0$ has been identified as being most abundantly available and preferable for use at Colwyn Bay.

Required Beach Profile

The modelling has determined an equilibrium beach profile for the frontage considering the tidal range applying and the characteristics of the available sediment for recharge, and based on examination of performance under the worst storm conditions that have occurred in the past 30 years at Colwyn Bay.

The following criteria apply in this respect:

- Suggested average berm level: 4.75m AOD
- Maximum suggested berm gradient: 1 in 60
- Minimum berm width: 35 metres, suggested 50 metres
- Placed beach profile to seaward of berm: 1 in 30-35

It is anticipated that the profile constructed at the time of recharge will have a 35-50 metre wide berm sloping from +5mODN at the seawall to a level of +4.5mODN at the seaward edge of the crest berm. Further seaward of the berm the beach would be formed to a uniform slope to enable immediate measurement of beach volume. Once any significant wave action had 'attacked' this unnaturally steep slope, it would tend towards the equilibrium profile, with the toe migrating seawards and the berm crest landward.

The initial berm width may be 'over' wide to allow for the rapid re-profiling of the beach following recharge. The final assessment of the initial berm width and beach slope will be defined in the detailed design phase. This will be optimised to minimise the initial losses from the system. Some 'cliffing' of the beach material may occur in the short term following the initial recharge.

Beach Evolution

Examination of how a recharged beach will behave in the long term has been carried out under two scenarios:

- Unrestrained (with no control structures) and
- Restrained (with control structure(s))

with a range of layouts tested, to determine a preferred arrangement.

Different models (LITLINE or LITMOD) were used for different layouts dependant on applicability of the specific model for the arrangements being modelled. Both models were calibrated against recorded beach change observations and produced reasonable agreement.

Unrestrained Scenario

The unrestrained scenario provides the baseline against which schemes that include restraint can be judged. In the unrestrained scenario the predicted behaviour was modelled with both models to identify if there were any significant differences in the performance. Both models identified similar behaviour.

The beach was recharged over the majority of its length and as expected the modelling indicated that there would be an ongoing loss of beach material from the frontage with significant retreat at the unconstrained ends of the nourished section. Average annual beach losses of about 60,000m³ per annum would be expected under this scenario, with the western section of the frontage most vulnerable to losses and the central section sustained by the throughput of material. Beyond the limits of the recharge the beaches would gain over time although that effect would reduce in magnitude moving away from the easterly recharge boundary.

The analysis of the historical beach data also indicates that a beach without control structures would be vulnerable to large losses under severe storm attack, from which the profiles may not, without appropriate recycling and or regular topping up, be able to recover.

The estimated volume of beach material required for this scenario is 4,000,000m³.

Restrained Scenarios

In examining arrangements for restraining beach movement and controlling losses from the beach a range of types of control structure have been considered:

- Fishtail groynes
- Shore normal groynes
- Offshore breakwaters

In defining appropriate arrangements under this scenario, the results of the earlier elements of the modelling work discussed above, together with knowledge of the specific physical and process arrangements applying at Colwyn Bay, were used to

provide appropriate criteria from which, primarily structure location and structure extent, have been defined, viz:

- Definition of cross- shore variability in longshore transport behaviour – from which the overall impact of the on/offshore structure extent can be determined
- The impact of specific existing physical features and how they might impact on future arrangements e.g. outfalls, river discharges etc

For all the “restrained scenarios” examined the estimated volume of beach material was the same - 2,500,000m³.

The following discussion highlights the key points arising from the model runs

Fishtail Groynes

Modelling of fishtail groynes (Options 1, 2 and 5) has indicated that provision of an easterly structure alone or in combination with a second structure to the west and substantial beach recharge between the easterly structure and Rhos Jetty will provide a stable beach over the central section of frontage.

The modelling investigated

- the difference between single and dual structures
- the impact of the changing the spacing between the structures
- the impact of altering the length of structures

The key negative impact associated with the provision of the shore connected structures is the retention of upper beach drift and the impact this has on preventing drift reaching the frontages downdrift of the easterly groyne. The location and length of the structures are key in this respect with the closer the structure is to the Council’s boundary and the greater the offshore extent, the greater the potential for impacts to occur over a greater length and to areas outside the Council’s jurisdiction.

A preferred location for an easterly structure was identified based on existing physical constraints to minimise the potential for disruption to the beach from external influences and this enabled the impacts of groyne length to be investigated.

A structure length of 250 metres allows for just over 50% of drift to by-pass the structure, plus any drift that might percolate through the structure (which the model cannot calculate). The modelling predicts that this would impact on beach evolution over a distance of up to a kilometre east of the structure but only within Conwy’s frontage. The provision of the groyne would reduce losses from the beach by approximately 25% compared to the unrestrained scenario.

Increasing the structure length by 50 metres would reduce the % of drift bypassing the structure by about 10%, but would impact the shoreline over a greater length downdrift, potentially extending into the Network Rail frontage. It is however estimated that the extra 50 metres length would reduce losses by 50% compared to the unrestrained scenario. This option would of course be more expensive to construct.

The provision of a single groyne (Option 1) identifies that there is a section of beach that remains stable in the centre of the frontage but that the western end would lose material to the east (sustaining the beach across the central frontage) faster than it would gain it from natural feed and hence recession would occur.

The provision of a second structure (Option 2) does not appear to address this but examination of alternative locations (Option 5) identifies that there is an optimum location for a second structure that provides for maximum beach control across the central section. The calculated losses from the system with the second groyne are the same as for the single structure.

The results of the modelling suggest that there is some uncertainty associated with the behaviour that is taking place at the western extremities. This is discussed in more detail below.

In conclusion the modelling of fishtail groyne structures suggests that there is little benefit in the provision of a second structure as it does not, uncertainties notwithstanding, address beach recession occurring at the western end and does not alter the expected losses from the system as whole. However, it is considered that this may, in part, be due to the large volume of material placed. Experience from similar projects, particularly the development of the Coastal Protection Scheme in Clacton-on-Sea^[6], have demonstrated that the spacing and length of the structures combined with the recharge volume all have a significant influence on the future plan shape development of the beach. The length of frontage protected by a single groyne will, therefore, be sensitive to the length of the structure and the associated volume of recharge.

In conclusion there is therefore a balance to be made between capital cost, initial volume of recharge, reduction in losses and therefore future need for topping up and magnitude/extent of downdrift impact.

Shore Normal Straight Groynes

Modelling of shore normal groynes provided the opportunity to examine whether these structures would provide the same degree of protection afforded by fishtail structures, without the additional costs associated with the outer arms of the fishtail structures. This form of construction also allowed for comparison of the two models used.

Starting from the same base position for an easterly groyne, modelling considered the provision of dual (Option 3) and single (Option 6) structures of varying length. Based on the results obtained and consideration of the impacts for fishtails on the location of a second structure, no sensitivity on the location of a westerly structure was carried out.

Overall the modelling provided similar results to the fishtails with the impacts in respect of downdrift starvation, overall losses from system and losses from the western end being of similar magnitude ($\pm 5\%$).

Significantly however the shore normal groynes exert less control over the central section of frontage than the fishtails, which has potential implications, particularly on the need and frequency for on-going beach management.

Detached Breakwaters

As an alternative to shore connected structures, the provision of detached breakwaters allows for consideration of structures that modify the wave and tide climate before it reaches the shoreline reducing the potential for sediment movement and encouraging natural deposition and retention of sediment.

A series of three detached breakwaters of similar scale to the existing Rhos-on-Sea structure were considered in association with a substantial recharge of the beach (Option 4). The layout comprised three offshore structures each 280 metres long uniformly spaced across the frontage, angled obliquely to the shoreline approximately 200-350m off the existing defences i.e. within the cross shore zone of active longshore drift.

The results from the model indicate that the detached breakwaters had a strong influence on the beach, with the development of tombolas (rather than salients) and variable beach behaviour with lengths where the recharged beach crest berm would be cut back to the seawall. Overall losses from the system, were less than for the unrestrained scenario but higher than for the shore connected options, averaging at 50,000m³ per annum.

Conversely, this form of construction did not induce the downdrift impact in relation to the frontage east of the scheme boundary, where beach levels were marginally improved.

The results suggest that with some optimisation an acceptable layout could be achieved e.g. by carrying out one or a combination of the following:

- increasing the number of structures or modifying the length to spacing ratio
- increasing the distance of the structures from the shoreline.
- reducing the effective crest level of the structures

Conclusions

The modelling has confirmed that beach recharge with or without control structures could be used to provide effective coastal defence across the Colwyn Bay frontage.

Without control structures greater losses will occur, increased beach management/recycling will be required and the frequency and magnitude of “topping up” exercises will be greater than if control measures are introduced.

The use of control structures reduces losses from the system and provides for more stability of conditions, notwithstanding that there will still be reprofiling /recycling required on a regular basis and specifically following storm conditions. Topping up will still be required but on a reduced frequency and/or magnitude.

Although a whole life cost assessment would be required to confirm whether beach recharge without control structures would be economically viable it is clear that technically and from an amenity perspective such an approach would not be recommended due to the greater inherent uncertainty it engenders.

Although the use of detached breakwaters to control beach movement is technically viable the results of the modelling suggest that more structures than modelled are likely to be required and the costs of such structures, by virtue of the lower ground formation levels applying and the different construction plant required, will be significantly greater than the shore connected alternatives considered.

The two forms of shore connected structures considered each have been identified as having similar impacts on the shoreline with the following key behaviour applying:

- Starvation of beaches downdrift of easterly control structure
- Stability of beach maintained across the central section of frontage
- Beach recession at the western end, irrespective of whether additional control structures are required

Discussion of these aspects with regard to on-going scheme development is provided below.

Beach Starvation

The impacts on the beach to the east of the control structure are similar for both forms of structure in that recession of the beach will take place over a length downdrift, which is a function of the type of structure and the on/offshore extent.

This impact will require mitigation. Notwithstanding that recharge provides a suitable solution in holding a beach across the majority of the frontage, works will still be required to modify defences across the remainder of the most easterly section of frontage, where existing defence levels provide insufficient protection to existing infrastructure. Complimentary physical modelling studies ^[7] have been carried out to examine the form of defence improvements that would be needed for a linear defence solution around the bay, if a beach recharge scheme could not be implemented. A preferred solution identified from this work would be implemented downdrift of any easterly beach control structure, as part of the overall scheme of works.

However such works alone might not be sufficient and it is considered that some additional nourishment on the down drift side of the control structure to mitigate against the losses may be required. It is likely that the fishtail solution will provide a better solution in this respect by virtue of the protection provided by the downdrift outer arm. However further additional modelling or empirical evaluation will be needed to confirm requirements in this respect.

Stability of Central Beach

The modelling has identified that a fishtail groyne provides for more effective beach control across the central section of frontage with shore normal groynes allowing for more movement of the beach.

A preferred location for the easterly boundary of the nourishment has been identified that accords with existing physical constraints and ensures that downdrift impacts can be appropriately managed within the frontage under CCBC jurisdiction. Furthermore the on/offshore extent of the control structures is critical to scheme performance and a length of 250 metres is considered appropriate to provide the necessary control on the updrift performance of the beach across the central section whilst allowing sufficient drift to by-pass the structure and constrain the downdrift impacts, as identified above.

Western Section of the Study Frontage

The behaviour in this section of frontage represents a significant uncertainty in the results of the modelling carried out to date as all of the model runs indicate that recession would take place here irrespective of whether additional control structures are provided.

It is considered that the modelling may not be fully addressing the process interactions that are taking place in this area possibly due to boundary issues, not modelling the influence of the existing Rhos-on-Sea detached breakwater, or potential other local process effects associated with the shoreline orientation and the interface of the existing sea defence structures and the local bathymetry.

Beach levels in this area have historically been at a lower level than anywhere else on the study frontage, apart from at the Old Colwyn end, although the reasons for this are not immediately clear.

On first consideration it would be expected that the existing Rhos-on-Sea Breakwater, which lies immediately to the north of this frontage, would provide a sheltering effect from the predominant north to north-westerly waves but not from the waves approaching from directions east of north. Conversely the behaviour may be due to a number of different local effects acting in combination, such as:

- the groyne effect of the existing slipway,
- the vertical nature of the existing defences,
- the curved plan-form of the seawall in this area focussing the waves reflected from it in such a way that a stable beach cannot be sustained without the construction of an appropriate beach control structure, e.g. a detached breakwater.

It is apparent that the modelling has not fully resolved behaviour in this area and that further investigation is required to understand what causes this behaviour. Only by understanding the mechanisms taking place, can the specific requirements for holding a beach in this area be determined, which may in turn influence the final design of the works to defend the central section of the study frontage.

In overall conclusion, the modelling results suggest that either of the forms of restraint examined could provide an appropriate solution, however on balance provision of shore connected fishtail groynes is considered to be the most suitable, as discussed above, but there are inherent impacts and uncertainties that require further investigation as the scheme is developed.

To address these impacts and uncertainties it is therefore recommended that a phased programme of construction would provide the best approach technically to scheme implementation. This is discussed in section 8.3 below.

8.3 Phased Approach

For schemes of this nature adoption of a phased approach to construction may be adopted for a variety of reasons viz.

- there are specific requirements relating to the order of construction e.g. control structures must be built before the beach is recharged
- for larger schemes availability of funds necessitates phasing
- the nature of recharge works may require specialist Contractors and/or plant to be used, which may be different from those used for other works

As identified in section 1 above, Conwy County Borough Council have been awarded funding from the European Convergence Funding Programme, match funded by the Welsh Assembly Government, to implement for the first phase of the coastal defence element of the Colwyn Bay Waterfront Project. The value of this funding is £4.5 million and is subject to the proposals meeting the necessary technical, economic and environmental criteria.

The Coastal Defence Strategy produced by Conwy County Borough Council ⁽⁸⁾, identified that the preferred approach to coastal defence, which accords with amenity development and regeneration objectives for the area was a scheme that comprised a mixture of beach recharge and linear defences.

The modelling work carried out to date has identified that such an approach is technically suitable but that there are specific elements that require further examination in order to confirm specific details.

Specifically the modelling work has confirmed the following in relation to a beach recharge scheme:

- The required design profile for a recharged beach
- The preferred downdrift boundary for a recharged beach
- The preferred approach to controlling movement of the beach at its downdrift boundary
- The optimum on/offshore extent and form for a downdrift beach control structure
- The need for linear defence works*

* The details of the requirements of this work are provided in the complimentary physical monitoring report ⁽⁷⁾.

On the basis of the above construction of a downdrift boundary structure potentially comprises part of an initial phase of works that could be constructed.

In order to determine the impacts the construction of a structure alone would have on the frontage two further model runs were carried out (Option 7 - ref Appendix C, Figures C12 and C13).

These tests examined the potential beach changes with a single fishtail groyne as Option 1 to test the impact of phasing construction but without beach recharge firstly for a period of 4 years, based on the conditions adopted for the calibration phase (2001-05), and secondly for a period of 19 years (as used in the other model simulations) after the control structure is constructed.

The results of the short term change are as shown in **Figure 19** below, which provides the following key points:

- The enlargement of the beach, as result of sand retention by the control structure, affecting a length approximately stretch of 500 m length to the west
- Beach starvation and associated recession on the downdrift side of the control structure.
- The western part of the beach remains relatively stable, with a small waterline retreat, as detected in the calibration phase.

<INSERT Figure 1 – Task 4, Option 7>

In consideration of the longer term change, which represents the condition should further funding cease, before recharge commenced, the following (ref Figure C13) applies:

- The enlargement of the beach, as result of sand retention by the control structure, affecting a length of 800 metres to the west of the structure.
- To the east of the control structure there is a small attenuation of erosion as result of a progressive increasing of sand bypassing.
- Further waterline retreat in the Western part of the frontage.

These impacts are generally as would be expected and confirm that construction of a control structure could be carried out as part of a first phase of works. However such works would also have to include the following elements in order to maintain the integrity of the defences across the frontage in the short term, prior to the full works are completed:

- Construction of a section of new linear defences immediately downdrift of the control structure to tie-in the control structure to the shoreline
- Relatively small-scale recharge of the foreshore downdrift of the control structure. Experience of similar arrangements on other RH projects suggests that the structure may induce both up-drift as well as down-drift erosion, as the existing beach material will be 'drawn' into the lee of the structure, although the modelling suggests that this would not happen here. It may however be prudent, subject to available funds, to undertake some limited beach recharge on the updrift as well as the downdrift sides.
- Modification of the existing linear defences updrift of the control structure, in advance of the beach recharge across this section (Provisional).

The elements of the scheme that require further investigation / development comprise:

1. Confirmation of physical parameters for the downdrift terminal control structure
2. Requirements for modifications to the existing defences to accord with beach recharge proposals e.g. heightening/strengthening of the defences, methods for mitigating against wind blown sand effects etc.
3. Identification of specific requirements for localised downdrift recharge to mitigate against beach starvation.
4. More detailed assessment of the behaviour at the western end of the frontage to identify the need for and most appropriate form for any beach control structures at this end of the frontage.

Preliminary consideration of items 1 & 2 are in progress as part of the present modelling study, whilst items 3 and 4 will require additional modelling / empirical assessment to confirm.

The final design of the initial control structure (Item 1) requires further empirical assessment to optimise the length and crest levels of the structure and beach profile.

Item 2 requires specific assessment to determine what modifications are necessary to the defences to accommodate the increased sand levels applying following recharge and the mitigation measures to deal with the corresponding side effects e.g. wind blown sand.

Item 3 is required to complete the phase 1 elements. This is not seen as being a major issue, but some measures may need to be identified in the Operation and Maintenance Manual for an adaptive management approach, based on the monitoring. This may warrant some bypassing or ongoing occasional down-drift recharge of beach material, if natural percolation through the rock structure or around the offshore end proves inadequate.

Item 4 is required to inform future phases.

The future elements of the scheme would be carried out in one or more phases, subject to the availability and timing of the future funding streams. However as identified above they would require further work to determine the exact extent. This will be fully assessed in the on-going design phase. Based on the work carried out to date they would comprise:

- The full recharge of the central section of the study frontage
- Extension of the rock revetment fronting the existing seawall to the eastern extremity of the study frontage.
- Completion of modification of the existing linear defences updrift of the downdrift control structure,
- The construction of additional control structures, if necessary

A vital aspect of all phases of the scheme will be to monitor and assess the behaviour of the beaches. This is particularly crucial following the construction phase 1, to ensure

that the single fishtail groyne does not critically adversely impact the beach and/or defences to the west and east of the new beach control structure.

The monitoring of the Phase 1 works may trigger the need for further small scale beach recharge before the programmed date for the implementation of the future recharge.

Similarly on-going monitoring between future phases and following scheme completion will be required to inform on-going scheme definition before completion and future management once the works are fully functional.

A summary of this initial phase and subsequent phases is provided in **Table 8** below.

Table 8: Phased approach to protect the Colwyn Bay frontage

Phases	Schemes
Phase 1	<ul style="list-style-type: none"> • Construct a single fishtail groyne • Construct a length of rock revetment to the east of the groyne • Undertake small-scale beach recharge in the west and east of the groyne to minimise the impact of the fishtail groyne
-	<ul style="list-style-type: none"> • Monitor beach profile and level changes along the whole study frontage and the ongoing performance/stability of the existing defences
Future Phase(s)	<ul style="list-style-type: none"> • Undertake additional modelling to confirm behaviour at western end of frontage and need, if appropriate, for additional beach control structures • Complete linear defences to eastern end • Modification to existing defences in central section • Undertake full beach recharge • If necessary construct further control structures
-	<ul style="list-style-type: none"> • Continued beach monitoring

Drawing D5a, in Appendix D, indicatively sets out the works that would comprise the first phase of construction. As identified above the linear defences to the east have been optimised by a parallel physical modelling study carried in the laboratory of LNEC, see Drawing D5b. Details of physical modelling results can be found in the separate report [7].

The new works to the eastern section of the seawall will need to be carried out in conjunction with other enhancement works of the promenade/hinterland as the rock revetment needs to work in conjunction with a wave return wall which will generally have a higher crest level than the existing seawall.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The main conclusions from the study may be summarised as follows:

- The modelling has confirmed that beach recharge with or without control structures could be used to provide effective coastal defence across the Colwyn Bay frontage.
- Without control structures greater losses will occur, increased beach management/recycling will be required and the frequency and magnitude of “topping up” exercises will be greater than if control measures are introduced.
- The use of either fishtail groynes, straight groynes or detached breakwaters to control the beach is technically possible and reduces losses from the system, requiring less frequent “topping-up”.
- Fishtail or straight groynes are likely to be more cost effective than detached breakwaters and are, therefore, preferred
- The choice between fishtail and straight groynes is less clear but, on balance, fishtail groynes are preferred as:
 - The structures are likely to be less susceptible to bypass losses as the beach shape in the vicinity of the control structure is more ‘smoothly shaped’ rather than forming in the ‘saw tooth’ shape associated with the straight groynes. There is the greater possibility of creating a salient along the shore connection thus helping to reduce the capacity for longshore losses.
 - The structures are more effective at holding the tidal and wave induced currents off the beach in the vicinity of the new beach control structures and hence at reducing the long shore loss of beach material in suspension
 - To a lesser extent, but worthy of note, the structures are less likely to cause significant localised down-drift problems (provided sufficient recharge material is placed down-drift of the structure) as the head of the groyne encourages a better beach orientation/smoothier shape on the down-drift side.
 - The fishtail structures are more conducive to holding a beach in the central section
- The modelling indicates that the schemes examined will not be able to hold a beach at the western end of the frontage, however there is significant uncertainty as to whether the model is accurately predicting behaviour in this location.
- The provision of cross shore control structures provides specific impacts that need addressing within on-going scheme design, namely:
 - Starvation of beaches downdrift of terminal control structure
 - Stability of beach maintained across the central section of frontage
 - Beach recession at the western end, irrespective of whether additional control structures are required
- Further investigation needs to be undertaken to understand why the beach levels at the western end of the study frontage are so low in spite of the apparent sheltering effect offered by the existing Rhos-on-Sea Breakwater.
- To address the impacts and uncertainties arising from the modelling carried out to date, it is recommended that a phased programme of construction would provide the best approach technically to scheme implementation.

- Modelling of a first phase of construction comprising construction of an easterly terminal control structure have indicated that adverse impacts can be appropriately managed by inclusion of the following:
 - Construction of a section of new linear defences immediately downdrift of the control structure to tie-in the control structure to the shoreline
 - Relatively small-scale recharge of the foreshore downdrift and potentially updrift of the control structure.
- The elements of the scheme that require further investigation / development comprise:
 1. Confirmation of physical parameters for the downdrift terminal control structure
 2. Requirements for modifications to the existing defences to accord with beach recharge proposals e.g. heightening/strengthening of the defences, methods for mitigating against wind blown sand effects etc.
 3. Identification of specific requirements for localised downdrift recharge to mitigate against beach starvation.
 4. More detailed assessment of the behaviour at the western end of the frontage to identify the need for and most appropriate form for any beach control structures at this end of the frontage.
- Items 1,2 & 3 above are in progress/ require further empirical assessment or modelling to inform phase 1 of the works
- Future phases of construction comprise:
 - The full recharge of the central section of the study frontage
 - Extension of the rock revetment fronting the existing seawall to the eastern extremity of the study frontage.
 - Completion of modification of the existing linear defences updrift of the downdrift control structure,
 - The construction of additional control structures, if necessary

9.2 Recommendations

It is recommended that:

- Appropriate empirical assessment/additional modelling are carried out as a matter of urgency to inform detailing of phase 1 works, as identified above.
- Detailing of works identified to be included as stage 1 is carried out asap
- To inform the final design, further investigation is instigated as soon as is practicable, to understand why the beach levels at the western end of the study frontage are so low in spite of the apparent sheltering effect offered by the existing Rhos-on-Sea detached breakwater.

10 REFERENCES

- [1] Pugh D. T (1987). Tides, Surges and Mean Sea-Level, John Wiley & Sons.
- [2] CMACS (2006). Colwyn Bay Strategy Plan. Natural Environment & Land Use. Baseline Report.
- [3] HR Wallingford (1988). Colwyn Bay Beach and Groyne Study – Report EX 1834, December.
- [4] Dean, R.G. (1977) Equilibrium beach profiles: U.S. Atlantic and Gulf coasts. Department of Civil Engineering. Ocean Engineering Report No. 12. University of Delaware, Newark, Delaware.
- [5] Bernabeu, A.M. et al (2002). An equilibrium profile model for tidal environments. Scientia Marina, Vol. 66. No 4.
- [6] Posford Haskoning (2002). Beach Plan Shape Modelling Report. March
- [7] LNEC and Royal Haskoning (2010). Detailed Modelling Studies For Colwyn Bay Coastal Defence Scheme: Physical Model Tests of New Linear Defences, Draft Report April.
- [8] Conwy County Borough Council (2007). Colwyn Bay Coastal Defence Strategy Plan. Stage 2: Strategic Assessment and Proposals – Draft for Consultation. November.

APPENDIX A – MODELLING SOFTWARE LITPROF, LITLINE AND LITMOD

LITDRIFT

Longshore Littoral Transport Model

The LITDRIFT model is part of the software package LITPACK (DHI, 2005) and allows calculating the longshore transport generated by the wave regime induced currents and other littoral currents.

It is a deterministic numerical model, based on the physical coastal processes, which uses a beach profile based approach (2D-vertical). The model estimates the longshore sediment transport, in suspension and bedload modes, which occurs within the design period. It allows the calculation of: the cross-shore distribution of the longshore transport, the closure depth of the beach, the extension of active zone of the beach and the sediment budget depending on the characterization parameters height and direction of the maritime wave regime components.

The different models that constitute the software package LITPACK require certain application conditions so that the assumptions imposed in the derivation of their mathematical formulation are verified and thus it is valid the application of the models. The application of the model LITDRIFT is valid in the following conditions:

- The cross-shore beach profile must be normal to the bathymetric lines, which are parallel to the coastline;
- The wave induced longshore currents should be insignificant at the first point of the beach profile;
- The cross-shore beach profile can have a varying sediment grading along the profile;
- The cross-shore beach profile can include zones in and out of the surf zone. The surf zone must include at least 10 calculation points.

In LNEC, the model LITDRIFT was used in the following studies:

- Study of the integrated solution for environmental rehabilitation of Rodrigo de Freitas lagoon and Leblon, Ipanema and Arpoador beaches (Vicente *et al.*, 2001).
- Study of the rehabilitation of Hac-Sá beach, in Macau (Oliveira *et al.*, 2003).
- Protection and valorization of the Portuguese coastal zone. Mathematical modelling of the hydrodynamics e sediment transport in the coastal (Oliveira *et al.*, 2002).

- Study of the maintenance and improvement of Porto Santo beach (Clímaco *et al.*, 2005).
- Feasibility study on the construction of a white-sand beach at Formosa beach – Funchal (Sancho *et al.*, 2005).
- Beach evolution in zones of restricted fetch: numerical and experimental analysis (Oliveira *et al.*, 2006; Oliveira and Vargas, 2008; Vargas *et al.*, 2008).

References:

Clímaco, M., Oliveira, F.S.B.F. and Vicente, C., 2005, *Maintenance and improvement of Porto Santo beach. III Congresso sobre Planeamento e Gestão das Zonas Costeiras dos Países de Expressão Portuguesa. Perspectivas de Gestão e Sustentabilidade da Zona Costeira. Maputo, Moçambique*. APRH, CD-ROM, 15 pp, (in Portuguese).

DHI, 2005. Litpack. *Noncohesive Sediment Transport in Currents and Waves. User Guide*. Danish Hydraulic Institute, Denmark.

Oliveira, F.S.B.F., Freire, P.M.S. and Lorangeiro, S.H.C.D., 2002. *Characterisation of the dynamics of Figueira da Foz beach*, Portugal. *Journal of Coastal Research*, No.36, pp. 552-563.

Oliveira, F.S.B.F., Vicente, C. and Clímaco, M., 2003, *Characterisation of the sediment dynamics of Hac-Sá beach. Macao*. EPMESC IX: Computational Methods in Engineering and Science, lu et al. (eds), pp. 779-786.

Oliveira, F.S.B.F., Vargas, C.I.C. e Coli, A.B., 2006, *Longshore sediment transport of an estuarine beach: numerical investigation*. Proceedings of 5th Symposium on the Atlantic Iberian Margin, Aveiro, Portugal, pp. 157-158.

Oliveira, F.S.B.F. and Vargas, C.I.C., 2008, *Evaluating the geomorphologic stability of an estuarine sandy beach*. Proceedings International Symposium on Integrated Coastal Zone Management, Arendal, Norway, Blackwell Publishing (in press).

Sancho, F., Oliveira, F.S.B.F. and Freire, P., 2005, *Study of the technical feasibility of Formosa beach restoration*. 4^{as} Jornadas Portuguesas de Engenharia Costeira e Portuária, Angra do Heroísmo, Portugal, CD-ROM, 17 pp (in Portuguese).

Vargas, I.C.C., Oliveira, F.S.B.F. e Carvalho, F.L.M., 2008, *Study of the morphodynamics of a low energy beach*. Hidráulica e Recursos Hídricos (in press and in Portuguese).

Vicente, C, Pereira, M.C., Oliveira, F.S.B.F., 2001, *Rodrigo de Freitas lagoon and beaches of Leblon, Ipanema and Arpoador: Integrated solution for environmental rehabilitation – Report 7: Detailed study of the selected solution. Book 1: Coastal dynamics.*, Report 08/01 - NET, Laboratório Nacional de Engenharia Civil; Lisboa, Portugal (in Portuguese).

LITLINE Coastline Evolution Model

The model LITLINE is part of the software package LITPACK (DHI, 2005) and allows the calculation of the coastline evolution forced by an incident wave regime, in the presence of structures like jetties, groynes, detached breakwaters and revetments, and in the presence of sediment sources and/or sinks.

The model is based on the conceptual 1-line model, i.e., it assumes that the cross-shore beach profile, which geometry can change alongshore, and, within a beach sector, can change in time, remains constant during the erosion or accretion process, i.e., the modification of the beach is based on the parallel displacement of the beach profile. The model application should only be considered for cases in which the hydrodynamic processes vary only in one predominant direction, the cross-shore direction. Coastal zones where the nearshore bathymetry lines are irregular, i.e., not predominantly parallel, should not be considered as domains of application of the model, since in these cases the bidimensional processes are neglected and therefore the physics of the system is not correctly simulated. Areas of study where the diffraction phenomenon is dominant are not legitimate domains of calculation for application of the model. For this reason, the model considers a simplification to introduce the influence of the diffraction process around jetties, groynes and detached breakwaters.

The several models that constitute the software package LITPACK require application conditions in which the assumptions assumed in the derivation of their formulation are verified and thus their application is legitimate. The application of the model is valid under the following conditions:

- The cross-shore beach profile should be normal to the bathymetric lines, which should be parallel to the coastline;
- The extension of the beach profile should be such that the wave induced longshore currents should be insignificant at the first point of the beach profile;
- The cross-shore beach profile can have a varying sediment grading along the profile;
- The cross-shore beach profile can include zones in and out of the surf zone. The surf zone must include at least 10 calculation points.
- The cross-shore beach profile can include longshore bars. In the presence of bars, at least 5 to 10 calculation points should be considered;
- The cross-shore beach profile can include structures like detached breakwaters and/or revetments. In the presence of any of them, the adjacent zones that are submitted to their influence should be described by at least 5 calculations points;

- The incident wave regime can be made to vary in the longshore direction;
- Presence of sources and/or sinks of sediment, concentrated or distributed in the coastal stretch;
- Presence of cross-shore structures, jetties and groynes, in the coastal stretch;
- Seasonal variability of the beach cross-shore profile in different beach sectors.

The model LITLINE is a time domain model, which simulates the medium- and long-term coastline evolution. The sediment transport is calculated through the use of tables generated by the model LITDRIFT, previously described.

In LNEC, the model LITLINE was applied in the following studies:

- Study of the maintenance and improvement of Porto Santo beach (Clímaco *et al.*, 2005);
- Feasibility study on the construction of a white-sand beach at Formosa beach – Funchal (Sancho *et al.*, 2005);
- Intervention alternatives for the improvement of the accessibility to the fishing harbour of Vila Praia de Âncora (Oliveira *et al.*, 2008).

References:

Clímaco, M., Oliveira, F.S.B.F. and Vicente, C., 2005, *Maintenance and improvement of Porto Santo beach. III Congresso sobre Planeamento e Gestão das Zonas Costeiras dos Países de Expressão Portuguesa. Perspectivas de Gestão e Sustentabilidade da Zona Costeira*. Maputo, Moçambique. APRH, CD-ROM, 15 pp, (in Portuguese).

DHI, 2005, *Litpack. Noncohesive Sediment Transport in Currents and Waves. User Guide*. Danish Hydraulic Institute, Denmark.

Oliveira, F.S.B.F., Freire, P.M.S. and Clímaco, M., 2007, *Case study on the sedimentation of a harbor in the north coast of Portugal*. ICCE 2008 (accepted).

Sancho, F., Oliveira, F.S.B.F. and Freire, P., 2005, *Study of the technical feasibility of Formosa beach restoration. 4^{as} Jornadas Portuguesas de Engenharia Costeira e Portuária, Angra do Heroísmo, Portugal, CD-ROM, 17 pp (in Portuguese)*.

LITPROF

Beach Cross-shore Sediment Transport Model

The model LITPROF is part of the software package LITPACK (DHI, 2005) and allows to analyze the evolution of a cross-shore beach profile due to the cross-shore transport of sediments, in the presence of structures like detached breakwater and revetments.

The model LITPROF, based on the physical littoral processes, uses a profile approach (2D-vertical), assuming that the processes that are determinant in the morphodynamics are unidimensional, i.e., neglecting the longshore gradient of the bathymetry and hydrodynamic.

The several models that constitute the software package LITPACK require application conditions in which the assumptions assumed in the derivation of their formulation are verified and thus their application is legitimate. The application of the model is valid under the following conditions:

- The cross-shore beach profile should be normal to the bathymetric lines, which should be parallel to the coastline;
- The extension of the beach profile should be such that the wave induced longshore currents should be insignificant at the first point of the beach profile;
- The cross-shore beach profile should have a constant sediment grading along the profile;
- The cross-shore beach profile can include zones in and out of the surf zone. The surf zone must include at least 10 calculation points.
- The cross-shore beach profile can include longshore bars. In the presence of bars, at least 5 to 10 calculation points should be considered;
- The cross-shore beach profile can include structures like detached breakwaters and/or revetments. In the presence of any of them, the adjacent zones that are submitted to their influence should be described by at least 5 calculations points;
- The calculation of the sediment transport is divided in two components: the bedload transport component and the suspension transport component. The total solid transport in each direction, corresponds to the sum of the solid transport of both components, in that direction;

In LNEC, the model LITPROF was applied in the following studies:

- Study of the integrated solution for environmental rehabilitation of Rodrigo de Freitas lagoon and Leblon, Ipanema and Arpoador beaches (Vicente *et al.*, 2001).
- Study of the rehabilitation of Hac-Sá beach, in Macau (Oliveira *et al.*, 2003).
- Study of the maintenance and improvement of Porto Santo beach (Clímaco *et al.*, 2005).
- Feasibility study on the construction of a white-sand beach at Formosa beach – Funchal (Sancho *et al.*, 2005).
- Beach evolution in zones of restricted fetch: numerical and experimental analysis (Oliveira and Vargas, 2008; Vargas *et al.*, 2008).
- Intervention alternatives for the improvement of the accessibility to the fishing harbour of Vila Praia de Âncora (Oliveira *et al.*, 2008).

References:

Clímaco, M., Oliveira, F.S.B.F. and Vicente, C., 2005, *Maintenance and improvement of Porto Santo beach. III Congresso sobre Planeamento e Gestão das Zonas Costeiras dos Países de Expressão Portuguesa*. Perspectivas de Gestão e Sustentabilidade da Zona Costeira. Maputo, Moçambique. APRH, CD-ROM, 15 pp, (in Portuguese).

DHI, 2005. *Litpack. Noncohesive Sediment Transport in Currents and Waves. User Guide*. Danish Hydraulic Institute, Denmark.

Oliveira, F.S.B.F., 2003, *Impact of anthropological pressure on the coastal area: cross-shore beach analysis. A case study*, CoastGIS'03, Genova, Italy, CD-ROM, 8 pp.

Oliveira, F.S.B.F., Freire, P.M.S. and Clímaco, M., 2007, *Case study on the sedimentation of a harbour in the north coast of Portugal*. ICCE 2008 (accepted).

Oliveira, F.S.B.F. and Vargas, C.I.C., 2008, *Evaluating the geomorphologic stability of an estuarine sandy beach*. Proceedings International Symposium on Integrated Coastal Zone Management, Arendal, Norway, Blackwell Publishing (in press).

Sancho, F., Oliveira, F.S.B.F. and Freire, P., 2005, *Study of the technical feasibility of Formosa beach restoration*. 4^{as} Jornadas Portuguesas de Engenharia Costeira e Portuária, Angra do Heroísmo, Portugal, CD-ROM, 17 pp (in Portuguese).

Vargas, I.C.C., Oliveira, F.S.B.F. e Carvalho, F.L.M., 2008, *Study of the morphodynamics of a low energy beach*. Hidráulica e Recursos Hídricos (in press and in Portuguese).

Vicente, C, Pereira, M.C., Oliveira, F.S.B.F., 2001, *Rodrigo de Freitas lagoon and beaches of Leblon, Ipanema and Arpoador: Integrated solution for environmental*

rehabilitation – Report 7: Detailed study of the selected solution. Book 1: Coastal dynamics., Report 08/01 - NET, Laboratório Nacional de Engenharia Civil; Lisboa, Portugal (in Portuguese).

LITMOD

Coastline Evolution Model

The model LITMOD, developed at LNEC – Laboratório Nacional de Engenharia Civil, IP in 1990 (Vicente, 1991; Vicente e Clímaco, 2003), enables the simulation of coastline changes caused by wave action. It is applicable to situations where beach and rocky coasts coexist, in natural conditions or with coastal structures or artificial nourishment operations. Owing to the high computational speed, it can be applied to extensive coastal areas and it can test long-term evolutions. Its application presents no difficulties, even for coastal sections longer than 10 km and for periods of several decades.

LITMOD is a one-dimensional model that uses a finite difference numerical scheme, where coastal evolution is represented by changes in the position of the shoreline. It is based on the calculation of longshore sediment transport rates and on the application of a continuity equation to the displaced sediment volumes. The variation of the position of the shoreline is calculated, assuming that the cross-shore profile advances and retreats in parallel with itself, without change of shape.

The basic elements to calculate the sediment transport rates are the wave heights, periods and angles at the break point. Since the break point position is affected by the change in the position of the shoreline, the wave characteristics at breaking are subject to an iterative calculation that takes into account the depths that determine the wave breaking. The model considers the bathymetry to be parallel in the calculation of refraction between the depth where the wave data are provided and the break point. When coastal structures or rocky headlands are present it may consider the influence of diffraction on the incident wave.

In the case of natural coasts, without engineering works, the model may contribute to a better understanding of coastal dynamics and configuration, especially in complex situations where sediment sources (sediment loads from rivers, cliff erosion) and rocky features that cause sediment retention and diffraction are present.

It can also be used in the prediction and interpretation of the changes that result from natural fluctuations in sediment supply and sediment transport rates. In the study of coastlines with human intervention it can be used to simulate the evolution of the coast under the effects of artificial nourishment, sand mining and several types of structures: jetties, groynes, revetments and detached breakwaters. It may consider isolated structures or combinations of different structures, associated or not with artificial nourishment.

It has been designed to be of assistance in practical situations, and it can simulate the coastline evolution for a great diversity of geomorphological configurations, sediment budgets and interventions and protection works. Its structure allows for the adjustment to particular aspects of each individual case.

Another advantage of the LITMOD model is that it can use wave data in the form of time series, whenever available, which leads to a greater realism in the representation of the wave conditions and in the simulation of shoreline evolution. It is also possible simulate

the morphological evolutions due to action of severe storms and inter-annual variability of wave regime.

LITMOD has proven useful in several studies of coastal dynamics performed in Portugal and abroad. Among others, the following examples can be cited: protection of the Bugio Fortress (Portugal); Cabo Mondego – Mondego inlet (Portugal) ; beach of Buarcos (Portugal); beach of Porto Santo (Madeira); beach of Lugar de Baixo (Madeira); island of Faro (Portugal); beaches of Leblon, Ipanema and Arpoador (Brazil); beach of Hac-Sá (China).

Bibliography:

Clímaco, M., Vicente, C., 2007, Metodologia de Aplicação de um Modelo de Evolução de Linhas de Costa (Methodology of Exploration of a Numerical Shoreline Change Model). Rel. 283/07-NEC, September, LNEC, Lisbon.

Sancho, F., Clímaco, M., Silva, L. G., Vicente, C., 2007, Projecto “Nautilus Island”. Parecer de Viabilidade Técnica(Nautilus Island Project: Note on the Technical Feasibility). Rel 21/07-NEC/NPE, February, LNEC, Lisboa.

Clímaco, M., Vicente, C., 2006, Dimensionamento Hidráulico e Funcionamento de Esporões (Hydraulic Design and Functioning of Groynes). Rel. 309/06 – NEC, October, LNEC, Lisbon.

Clímaco, M., Oliveira, F. B., Vicente, C, 2005, *Manutenção e Melhoramento da Praia do Porto Santo (Maintenance and Improvement of Porto Santo Beach)*. Paper presented to III Congress on Management of Coastal Zone of Portuguese Language Countries, Maputo, Mozambique.

Clímaco, M., Oliveira, F.S.B.F., Freire, P., 2004, *Manutenção e Melhoramento da Praia do Porto Santo. Relatório 2 Estudo da Dinâmica e Equilíbrio Sedimentar (Maintenance and Improvement of Porto Santo Beach. Report 2: Study of Dynamics and Sedimentary Balance)*. Rel. 170/04, LNEC, Lisbon.

Clímaco, M., Oliveira, F.S.B.F., 2004, *Manutenção e Melhoramento da Praia do Porto Santo. Relatório 3: Alternativas de Intervenção (Maintenance and Improvement of Porto Santo Beach. Report 3: Alternative Solutions)*. Rel. 320/04, LNEC, Lisbon.

Vicente, C., Clímaco, M., 2003, *Evolução de Linhas de Costa. Desenvolvimento e Aplicação de um Modelo Numérico (Shoreline Evolution Development and Application of a Numerical Model)*. ICT-ITH 42, LNEC, Lisbon.

Oliveira, F. B., Clímaco, M., Freire, P. S., 2002, *Rehabilitation of Hac-Sá Beach (Macau). Phase 1- Volume 2: Characterization of the Sediment Dynamics and the Erosion Causes*. LNEC report 286/02. Portugal. Lisbon.

Vicente, C., Clímaco, M., 2002, *Marina do Lugar de Baixo (Ilha da Madeira). Estudo de Viabilidade da Nova Praia (Lugar de Baixo Marina - Madeira Island. New Beach Feasibility Study)*. Rel. 116/02 - NET, LNEC, Lisbon.

Oliveira, F. B., Clímaco, M., 2002, *Rehabilitation of Hac-Sá Beach (Macau). Phase 2: Alternative Solutions for Beach Restoration*. LNEC report 331/02. Portugal. Lisbon.

Vicente, C., Clímaco, M., Oliveira, F., 2001, *Lagoa Rodrigo de Freitas e Praias de Leblon, Ipanema e Arpoador. Solução Integrada de Reabilitação Ambiental. Relatório 7: Estudo de Pormenor da Solução Seleccionada. Volume 1: Dinâmica Costeira (Rodrigo de Freitas Lagoon and Beaches of Leblon, Ipanema and Arpoador. Integrated Solution for Environmental Rehabilitation. Report 7: Detailed Study of the Selected Solution Book 1: Coastal Dynamics)*. Rel. 08/01 - NET, LNEC, Lisbon.

Vicente, C., Clímaco, M., Oliveira, F. B., 2001, *Estabilização da Marginal de Buarcos. Análise das Intervenções Complementares de Protecção (Stabilization of Buarcos Seafront Avenue. Analysis of Additional Protection Measures)*. Rel. 64/01 - NET, LNEC, Lisbon.

Vicente, C., Clímaco, M., Oliveira, F. B., 2000, *Lagoa Rodrigo de Freitas e Praias de Leblon, Ipanema e Arpoador: Solução Integrada de Reabilitação Ambiental. Relatório 3: Caracterização da Situação Actual. Volume 1: Dinâmica Costeira (Rodrigo de Freitas Lagoon and Beaches of Leblon, Ipanema and Arpoador: Integrated Solution for Environmental Rehabilitation. Report 3: Characterization of Present conditions. Book 1: Coastal Dynamics)*. Rel.158/00 NET, LNEC, Lisbon.

Vicente, C., Clímaco, M., 1998, *Análise da Dinâmica Costeira do Trecho Cabo Mondego - Estuário do Mondego. Erosões em Buarcos (Coastal Dynamics Analysis of Stretch Mondego Cap - Mondego Estuary)*. Rel. 88/98 NET, LNEC. Lisbon.

Vicente, C., Clímaco, M., 1997, *Protecção do Forte do Bugio. Estudos de hidrodinâmica e Sedimentologia. Estabilidade do Enchimento Artificial de Protecção (Protection of the Bugio Fortress. Hydrodynamics and Sedimentation Studies. Stability of the Beach Protection Fill)*. Rel. 70/97 NET, LNEC. Lisbon.

Vicente, C., 1991, *Aperfeiçoamento de Métodos de Modelação Matemática e Física Aplicáveis a Problemas de Dinâmica Costeira (Improvement of Physical and Mathematical Modelling Applied to Coastal Dynamics Problems)*. LNEC, Lisbon.

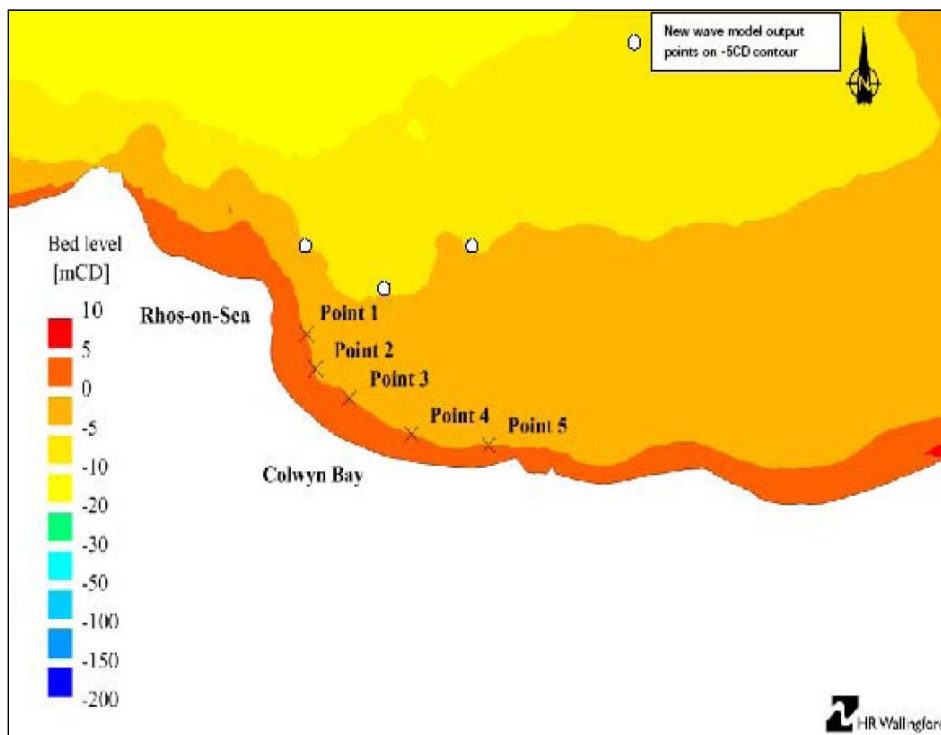
APPENDIX B – MODEL DATA

Wave Data

Time series of hindcast wave data (including wave height, period and direction) at a 3 hour interval were provided by HR Wallingford^[1] at 3 inshore points at -5m CD (FigureB1) for a period 19 years (01/1/1987 – 31/12/2005). However, the time series data was not complete. About 11-13% of the data were either invalid or missing. In this study, those data gaps were filled by the following method depending on the length of each gap:

- gap \leq 24hrs: linear interpolation
- gap $>$ 24hrs: daily average of that day, from records in other years

Figure B1: Locations of the input wave points



Tidal Data

The time series of the water level data recorded at Llandudno were provided by British Oceanographic Data Centre (BODC) for a period between 1994 and 2008. To match the 19 year period (1987 – 2005) of the wave data, astronomic tidal levels were used to fill the missing period of 1987 – 1994 (inclusive) and other small gaps where the water level data was either missing or invalid. Recognizing the importance of surges, the residuals between measured and astronomic tidal levels in other years was added on top of the astronomic tidal levels to “restore” the “real” water level conditions (see Table B1).

The “repaired” 19 year time series water level data was transferred from Llandudno to Colwyn Bay using linear interpolation of the level differences between two places at HAT, MHWS, MHWN, MTL, MLWN, MLWS and LAT published by the Admiralty Tide Tables.

Table B1: Replacing years for the surges

Years that measured tidal level data was not available at Llandudno	1987	1988	1989	1990	1991	1992	1993	1994
Replacing years	1995	1996	1997	1998	1999	2000	2006	2008

Storm Data

The storm event occurring between 26th February and 1st March 1990 (referred as to the “Feb1990” event) was the most severe maritime storm observed in the Colwyn Bay since 1987, and was estimated, at its worst, to be approximately a 1 in 100-500 year event. Therefore, this event was chosen to test the stability of the proposed recharge beach profiles (see Section 4). To reproduce the “true” water levels at the time of the event, the residuals (difference between astronomic and measured water levels) data recorded at Holyhead (provided by BODC) were transferred to Llandudno, and subsequently the combined water levels were transferred from Llandudno to Colwyn Bay using the method described above.

It is worth noting that there were no recorded water level data at Holyhead between 1991 and 1994. This was the reason that the 19 year period (1987 – 2005) could not be “repaired” with the Holyhead data alone, and the simple surge replacing approach (Table B2) was adopted.

Beach Data

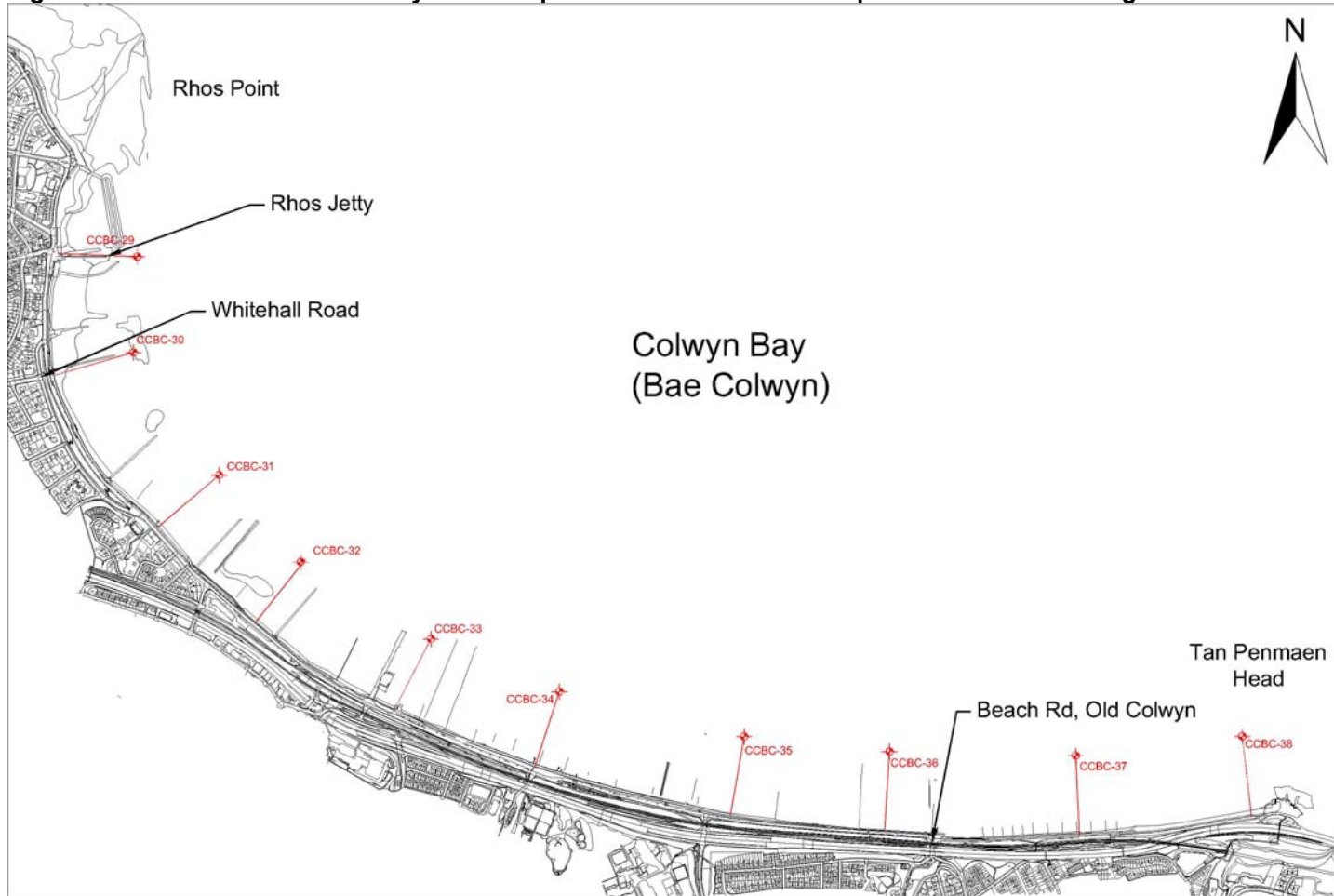
Two sets of beach profile survey data were provided by CCBC, which are summarized in Table, and the locations of the beach profiles are illustrated in Figure B2.

Table B2: Summary of beach survey data

Dataset	Survey Time	Beach Profiles*
Beach Profile Survey (1956 – 1990)	1956, 1968, 1969, 1970, 1980, 1984, 1986, 1988, 1989, 1990	CS-10 – CS-26
Full topographic Survey (1997 – 2009)	Nov97, May98, Nov98, May99, Nov99, Jun00, Oct01, Jul02, Oct02, Jul03, Nov03, May04, Nov04, Feb05, Jul05, Nov05, Jul06, Oct06, Apr07, Dec07, Jun08, Dec08, May09	CCBC-29 – CCBC-35

Note: *the beach profiles that are within the area for potential beach recharge

Figure B2: Illustration of the surveyed beach profiles within the area for potential beach recharge



Sediment Data

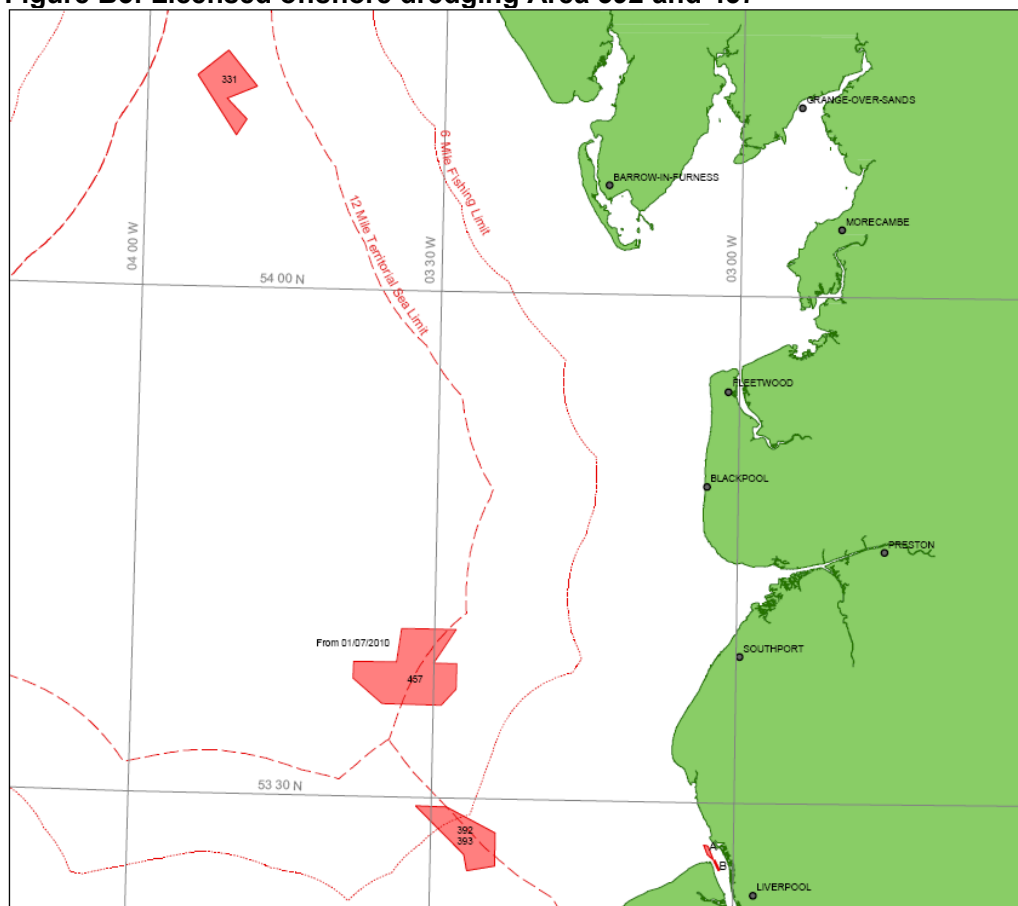
There were three sets of sediment datasets available to this study, which include:

- 2 bed samples were taken at upper and lower beach by LNEC on 7th August 2009 and subsequently analysed for sediment density and particle size grading;
- Local sediment data collected from Colwyn Bay foreshore beach (trial holes); and
- Source sediment data collected from the licensed offshore dredging areas (Area 392 and 457 in Liverpool Bay) where recharge material may be sourced.

Trial holes were performed along Colwyn Bay foreshore beach on 26 February and 1 March 2007. Test pits were located along nine transect lines (identified as CCBC-30 to CCBC-38) ^[2]. Three pits were excavated per transect line (at levels +1.5 m, 0.0 m and -2.6 m OD), giving a total of 27 samples. For each location description of the strata was made available, as well as the sediment particle size grading of the cohesionless material.

The particle size grading data for two licensed offshore dredging areas, i.e. Area 392 and 457, were provided as well as sediment density data collected in Area 392 (Figure B3).

Figure B3: Licensed offshore dredging Area 392 and 457



Reference:

- [1] HR Wallingford, Colwyn Bay Wave Modelling: Time series wave hindcasts for 3 points on the -5mCd contour, Technical Note DDM6371-01, September 2009.
- [2] Celtest (2007), Colwyn Bay Coastal Strategy: Site Investigation, March.

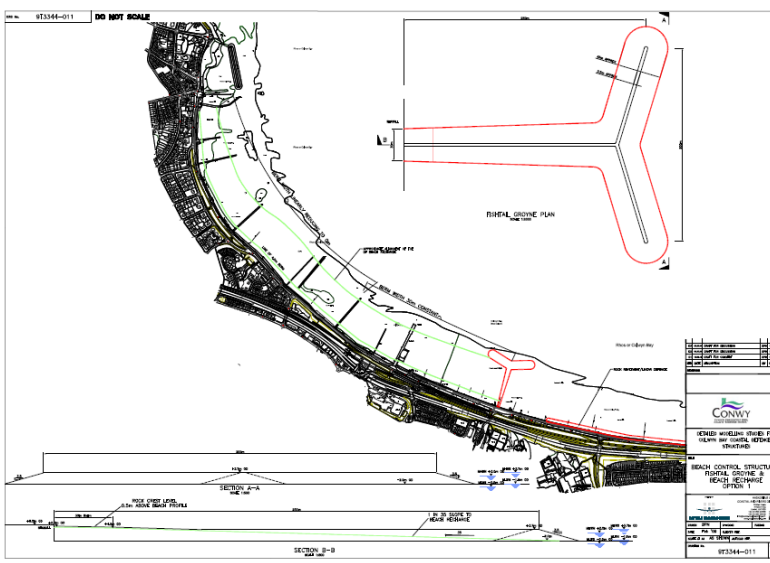
APPENDIX C – BEACH EVOLUTION MODELLING RESULTS

The following provides a summary adopted for each of the model runs

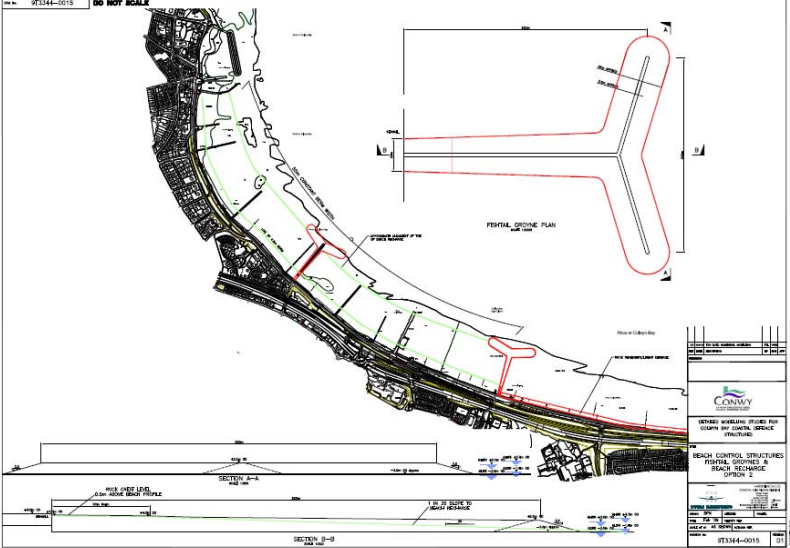
1. Beach Recharge without Control Structures (Options A1 and A2)

Covered area	between CCBC-29 and CCBC-35
Estimated Recharge volume	3,300,000 m ³ (Option A1) and 2,225,000 m ³ (Option A2)
Recharge material	d ₅₀ =0.25mm and σ=1.72 for Option A1 d ₅₀ =0.45mm and σ=2.1 for Option A2
Recharge time	5 months
Models	both LITLINE and LITMOD
Test data	19 year wave and tide conditions (1987-2005)
Results	See Figures C1-C4

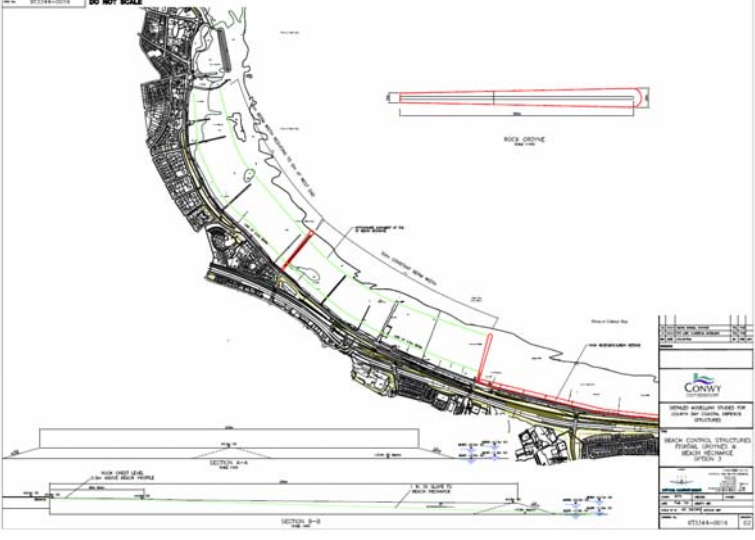
2. Beach Recharge with a Single Fishtail Groyne (Option 1)

Layout	 <p>See Drawing D-1 (Appendix D)</p>
Covered area	between CCBC-29 and CCBC-34
Estimated Recharge volume	2,500,000 m ³
Recharge material	d ₅₀ =0.25mm and σ=1.72
Recharge time	5 months
Control structures	single fishtail groyne (250m long and fishtail 200 wide) sited on the existing outfall near CCBC-34
Models	LITMOD
Test data	19 year wave and tide conditions (1987-2005)
Results	See Figure C5, C5A

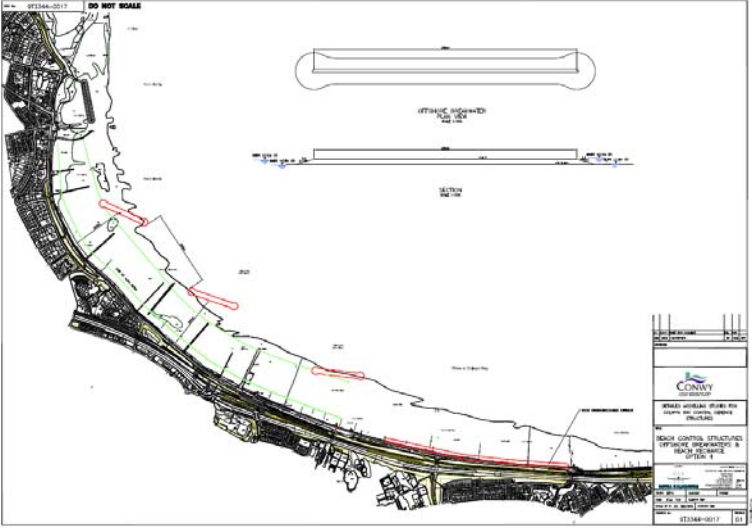
3. Beach Recharge with Two Fishtail Groynes (Option 2)

Layout	 <p>See Drawing D-2 (Appendix D)</p>
Covered area	between CCBC-29 and CCBC-34
Estimated Recharge volume	2,500,000 m ³
Recharge material	d ₅₀ =0.25mm and σ=1.72
Recharge time	5 months
Control structures	two fishtail groynes (250m long and 200 wide at head) sitting on two existing outfalls which are approximately 1.1km apart
Models	LITMOD
Test data	19 year wave and tide conditions (1987-2005)
Results	See Figure C6, C6A

4. Beach Recharge with Two Groynes (Option 3)

Layout	 <p>See Drawing D-3 (Appendix D)</p>
Covered area	between CCBC-29 and CCBC-34
Estimated Recharge volume	2,500,000 m ³
Recharge material	d ₅₀ =0.25mm and σ=1.72
Recharge time	5 months
Control structures	two groynes sitting on two existing outfalls which is approximately 1.1km apart
Models	both LITLINE and LITMOD
Test data	19 year wave and tide conditions (1987-2005)
Results	See Figures C8, 9, 9A

5. Beach Recharge with Three Detached Breakwaters (Option 4)

Layout	 <p>See Drawing D-4 (Appendix D)</p>
Covered area	between CCBC-29 and CCBC-34
Estimated Recharge volume	2,500,000 m ³
Recharge material	d ₅₀ =0.25mm and σ=1.72
Recharge time	5 months
Control structures	three detached breakwater each 280m long
Models	LITMOD
Test data	19 year wave and tide conditions (1987-2005)
Results	See Figures C11

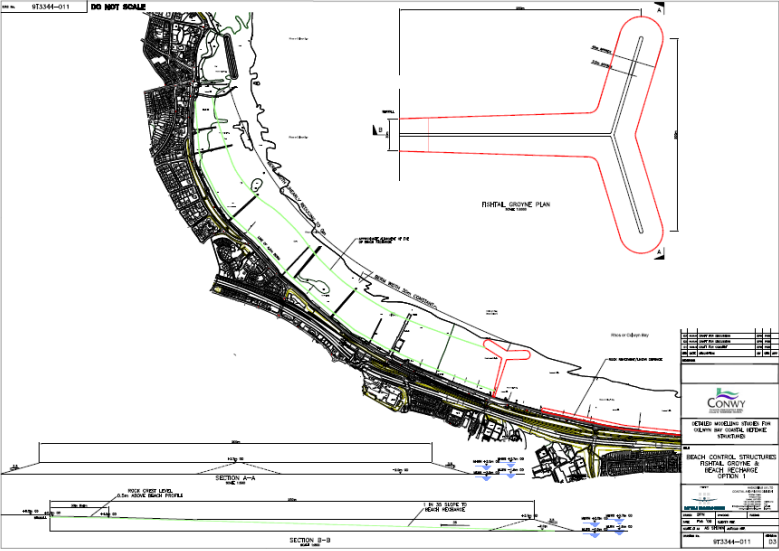
6. Beach Recharge with Two Fishtail Groynes (Options 5a and 5b)

Covered area	between CCBC-29 and CCBC-34
Estimated Recharge volume	2,500,000 m ³
Recharge material	d ₅₀ =0.25mm and $\sigma=1.72$
Recharge time	5 months
Control structures	two fishtail groynes are 1.35km apart (Option 5a) two fishtail groynes are 1.6km apart (Option 5b)
Models	LITMOD
Test data	19 year wave and tide conditions (1987-2005)
Results	See Figures C7, 7A

7. Beach Recharge with a Single Groyne (Option 6)

Covered area	between CCBC-29 and CCBC-34
Estimated Recharge volume	2,500,000 m ³
Recharge material	d ₅₀ =0.25mm and $\sigma=1.72$
Recharge time	5 months
Control structures	A single groyne built on the existing west outfall (CCBC34)
Models	LITMOD
Test data	19 year wave and tide conditions (1987-2005)
Results	See Figures C10

8. Single Fishtail Groyne with No Recharge (Option 7)

Layout	 <p>See Drawing D-1 (Appendix D)</p>
Covered area	between CCBC-29 and CCBC-34
Estimated Recharge volume	no recharge
Recharge material	$d_{50}=0.25\text{mm}$ and $\sigma=1.72$
Recharge time	n/a
Control structures	A single fishtail groyne built on the existing west outfall (CCBC34)
Models	LITMOD
Test data	4 year wave and tide condition (2001 - 2005); 19 year wave and tide conditions (1987-2005)
Results	See Figures C12, C13

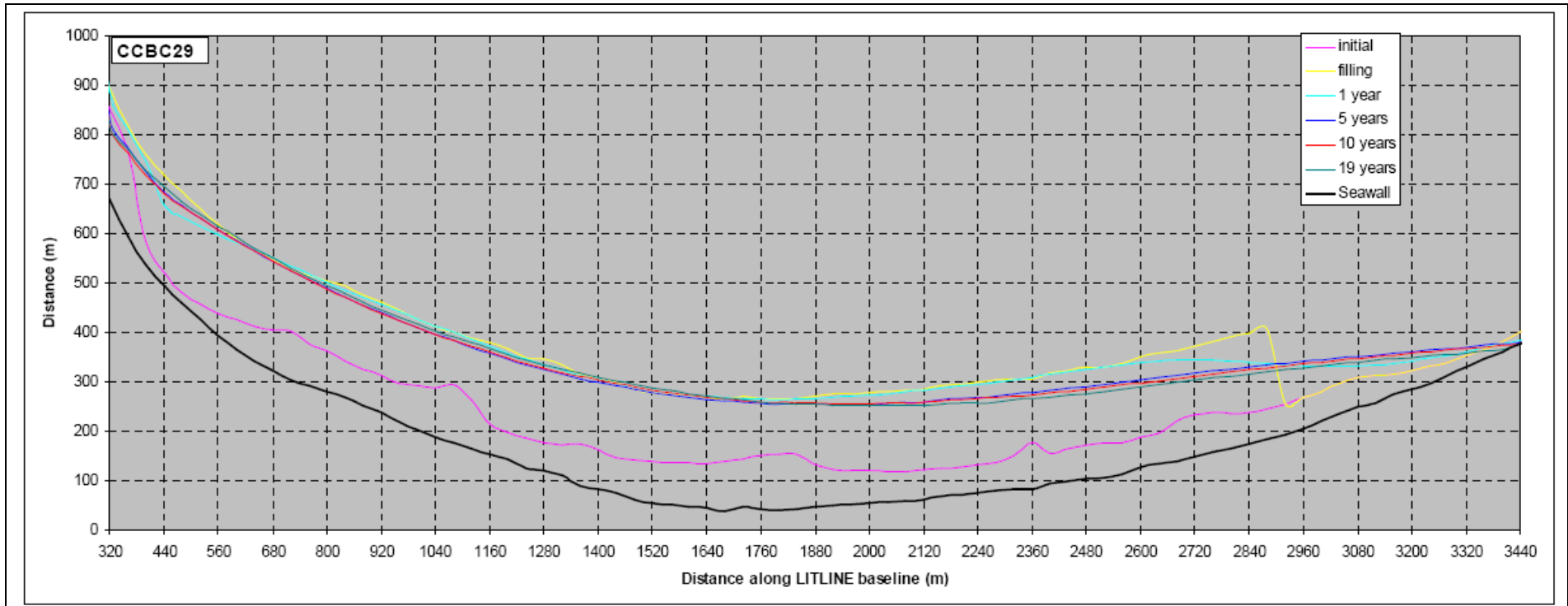


Figure C1: LITLINE Results of Test A1 ($d_{50}=0.25\text{mm}$)

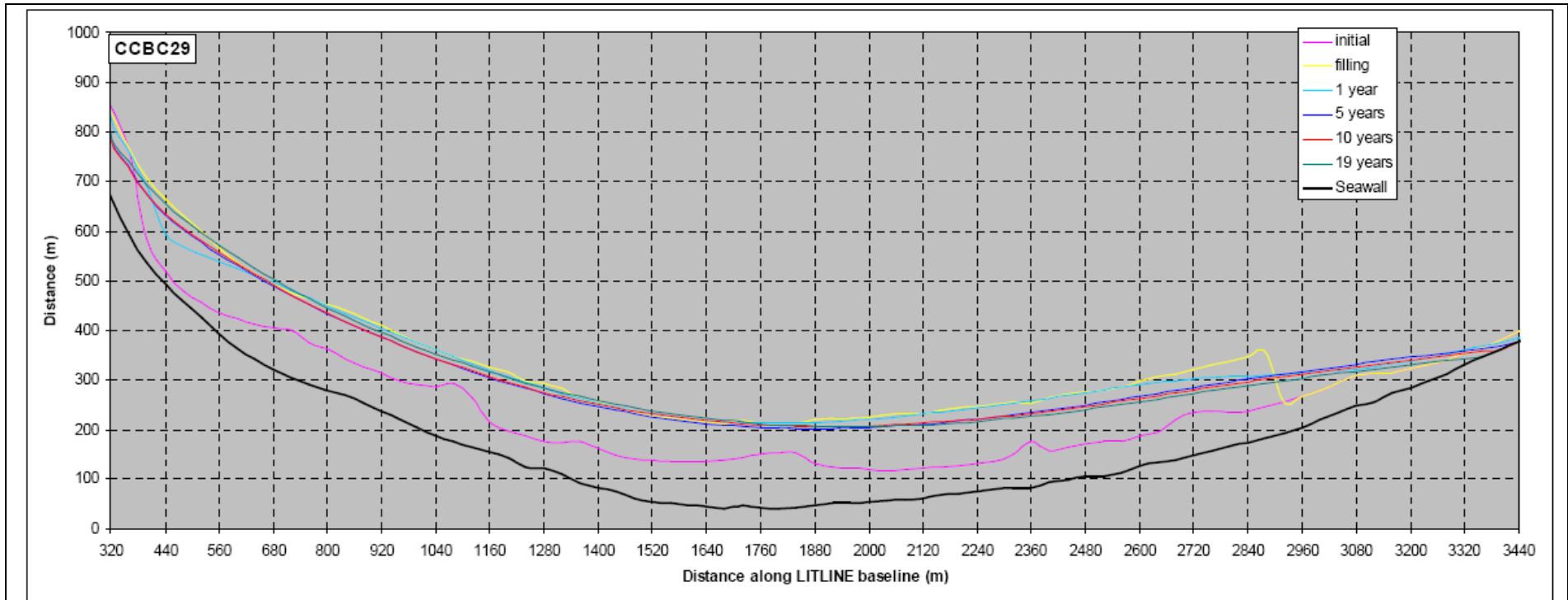


Figure C2: LITLINE Results of Test A2 ($d_{50}=0.45\text{mm}$)

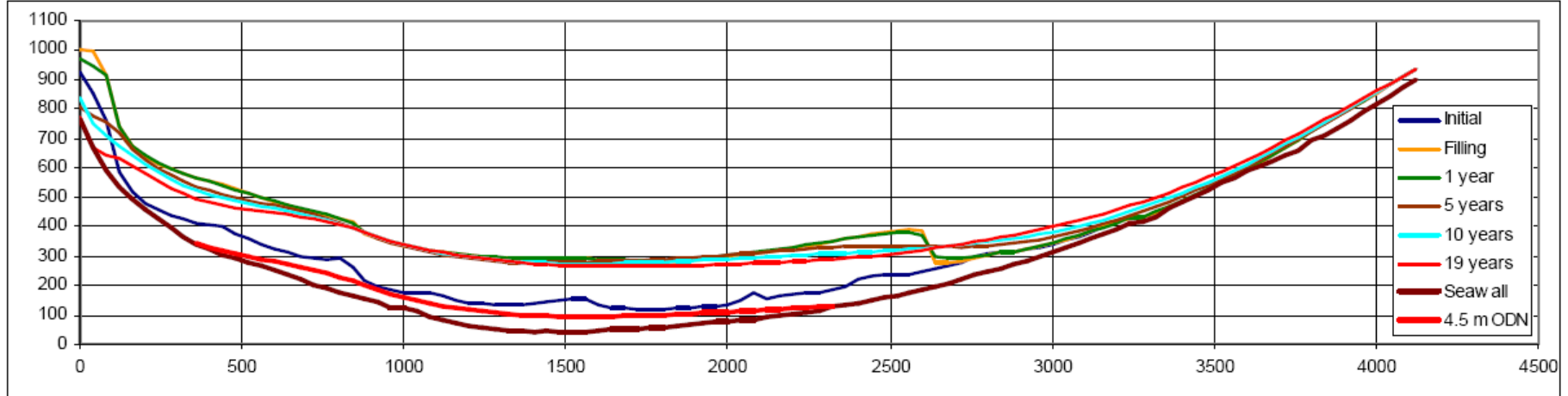


Figure C3: LITMOD Results of Test A1 ($d_{50}=0.25$) (+4.5m ODN line is after 10 years)

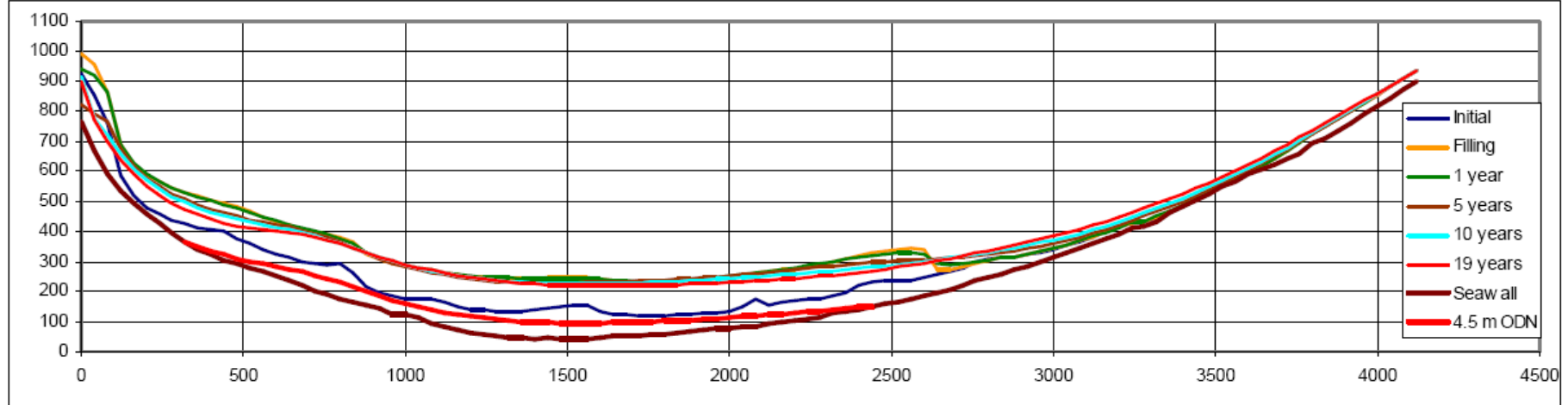


Figure C4: LITMOD Results of Test A2 ($d_{50}=0.45$ mm) (+4.5m ODN line is after 10 years)

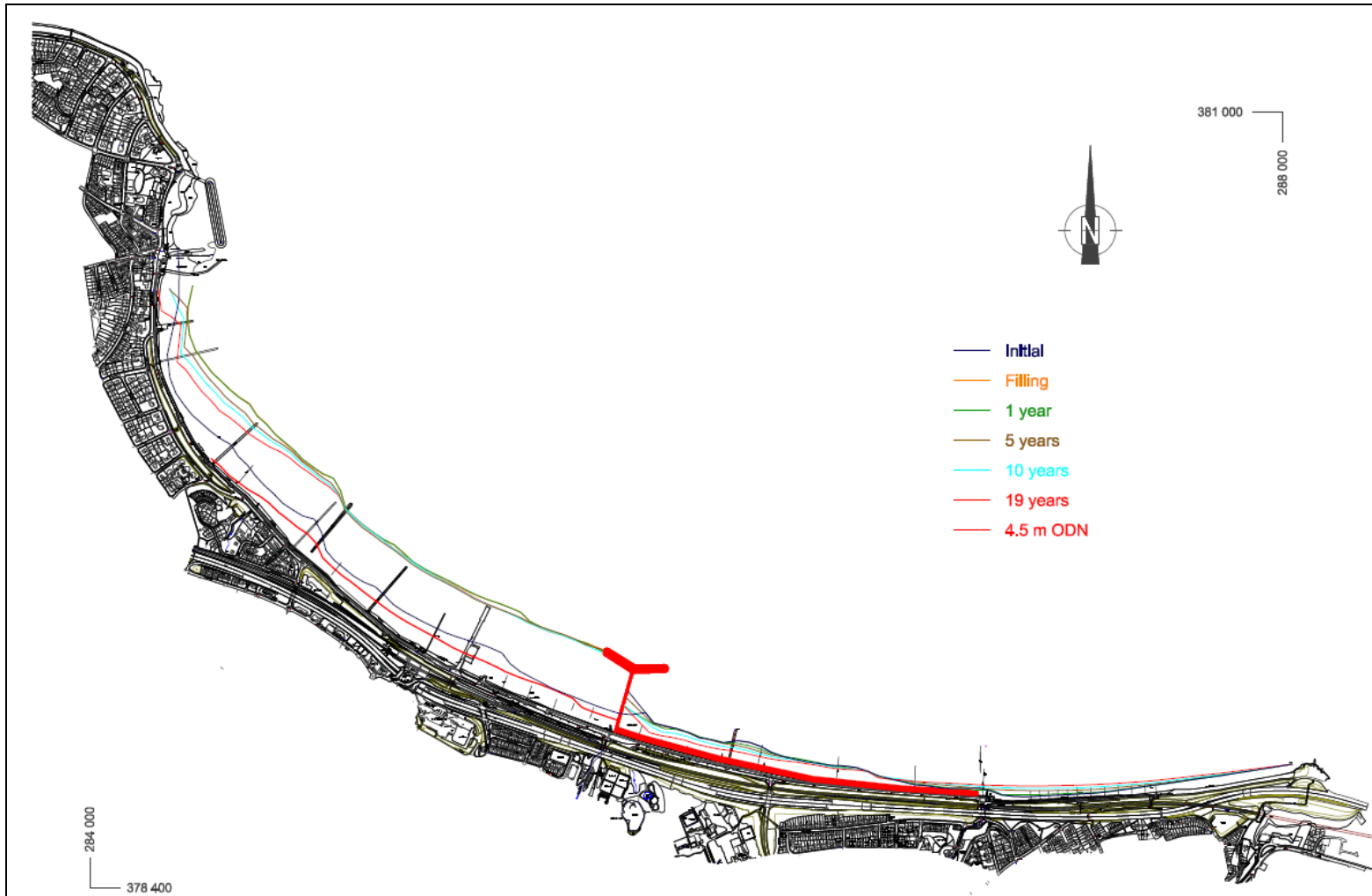


Figure C5: LITMOD Results of Option 1 (+4.5m ODN line is after 10 years) – Groyne length 250m

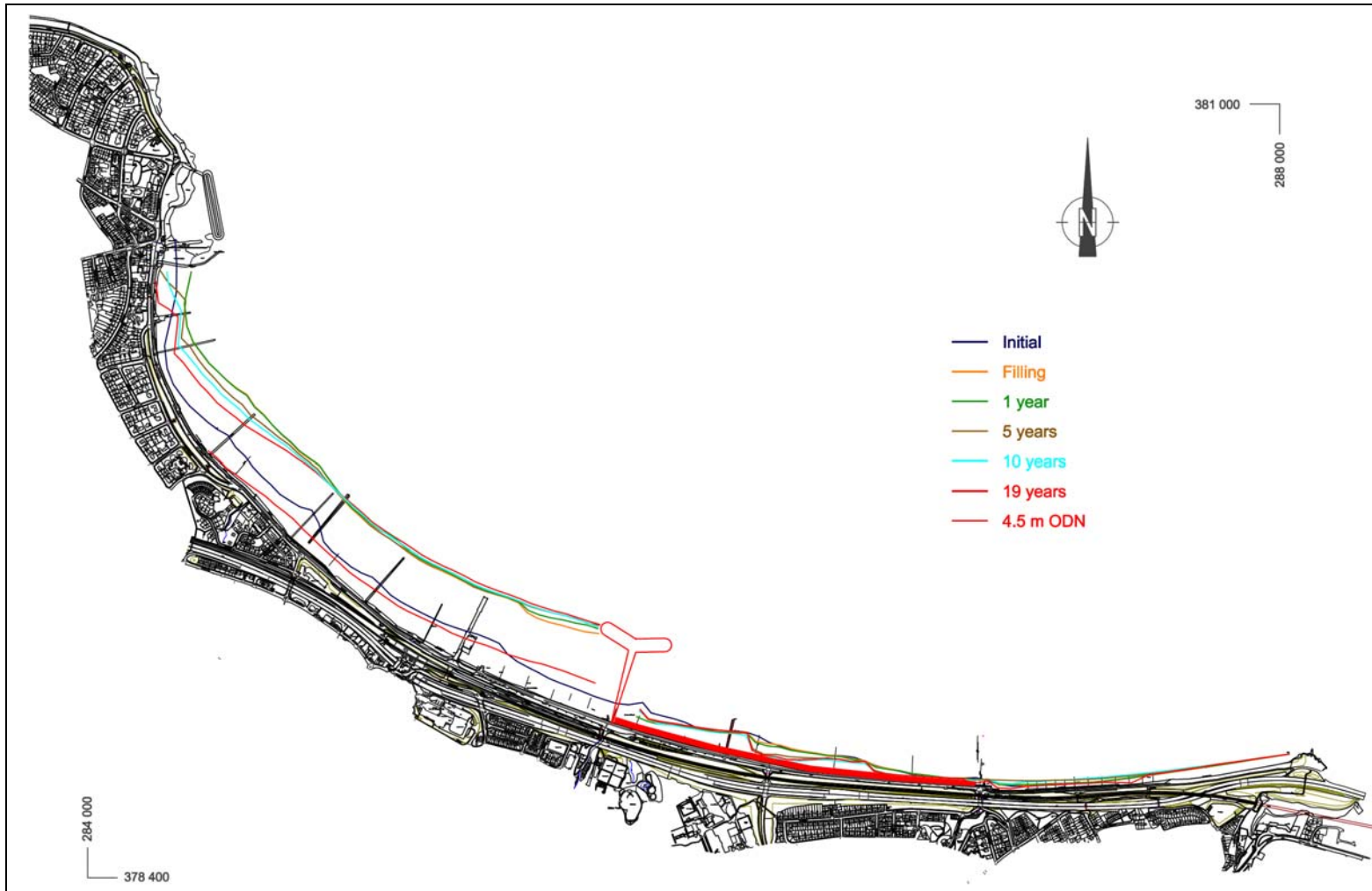


Figure C5A: LITMOD Results of Option 1 (+4.5m ODN line is after 10 years) – Groyne length 300m

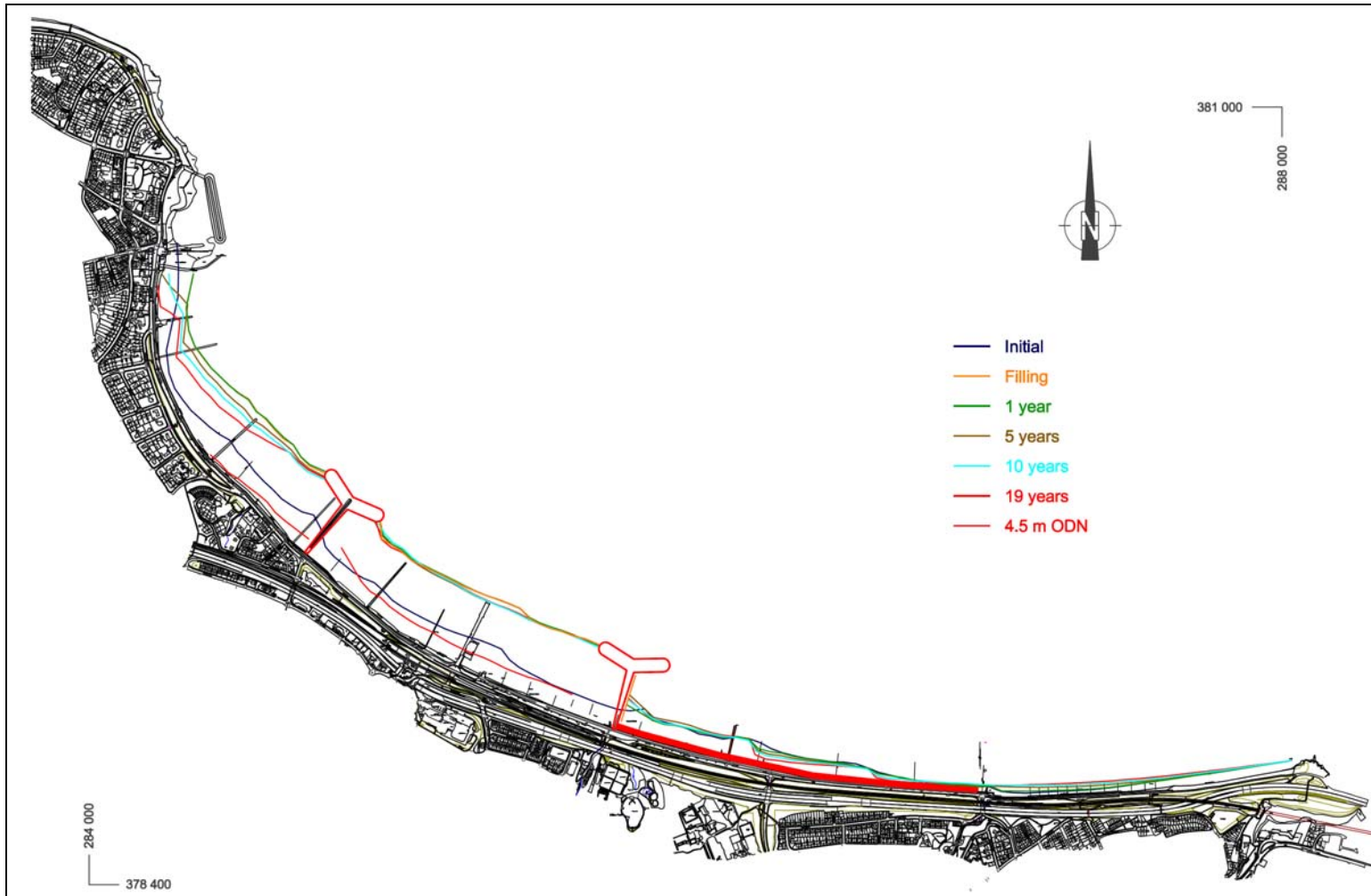


Figure C6: LITMOD Results of Option 2 (+4.5m ODN line is after 10 years) – Groyne length 250m

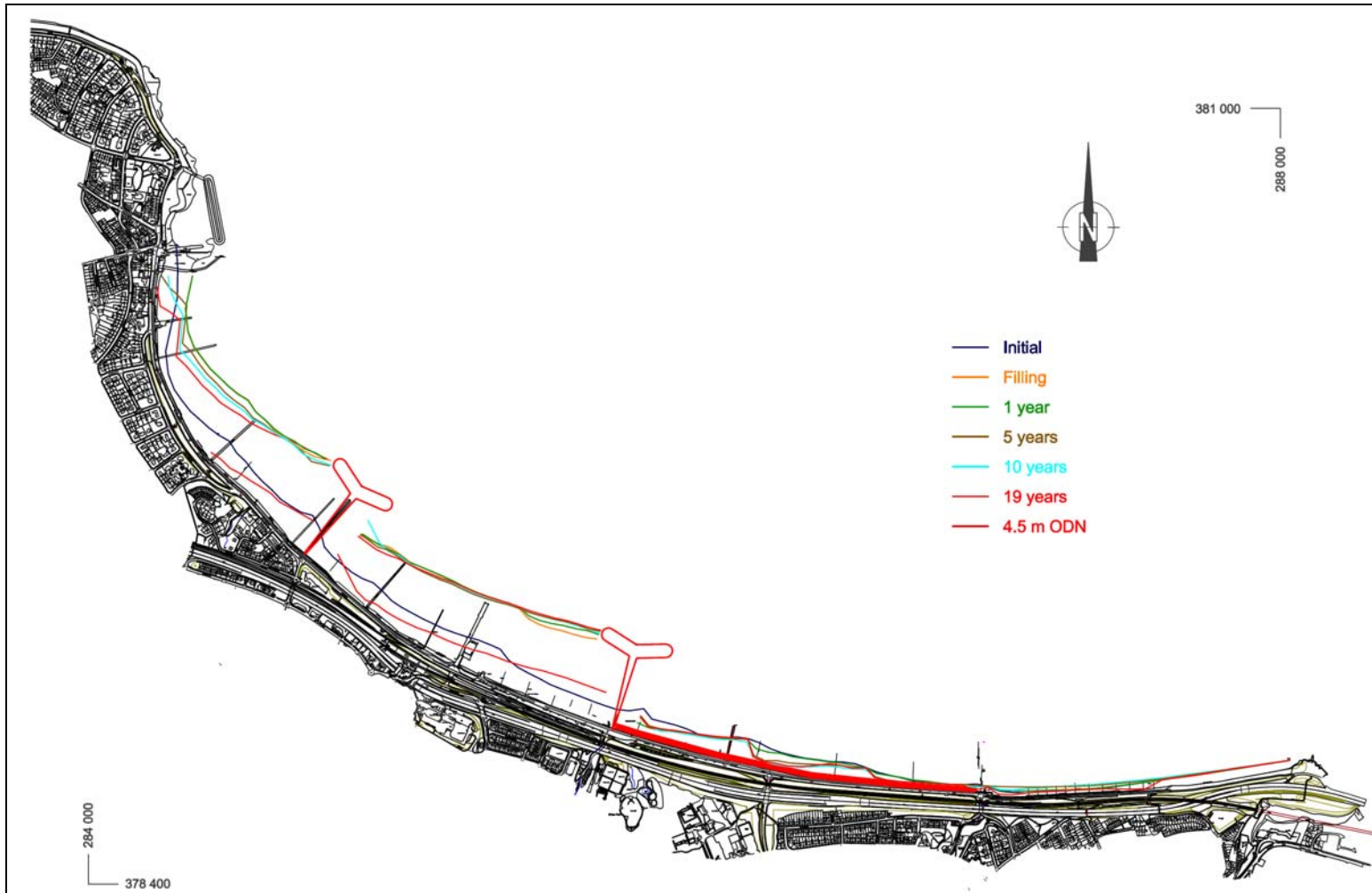
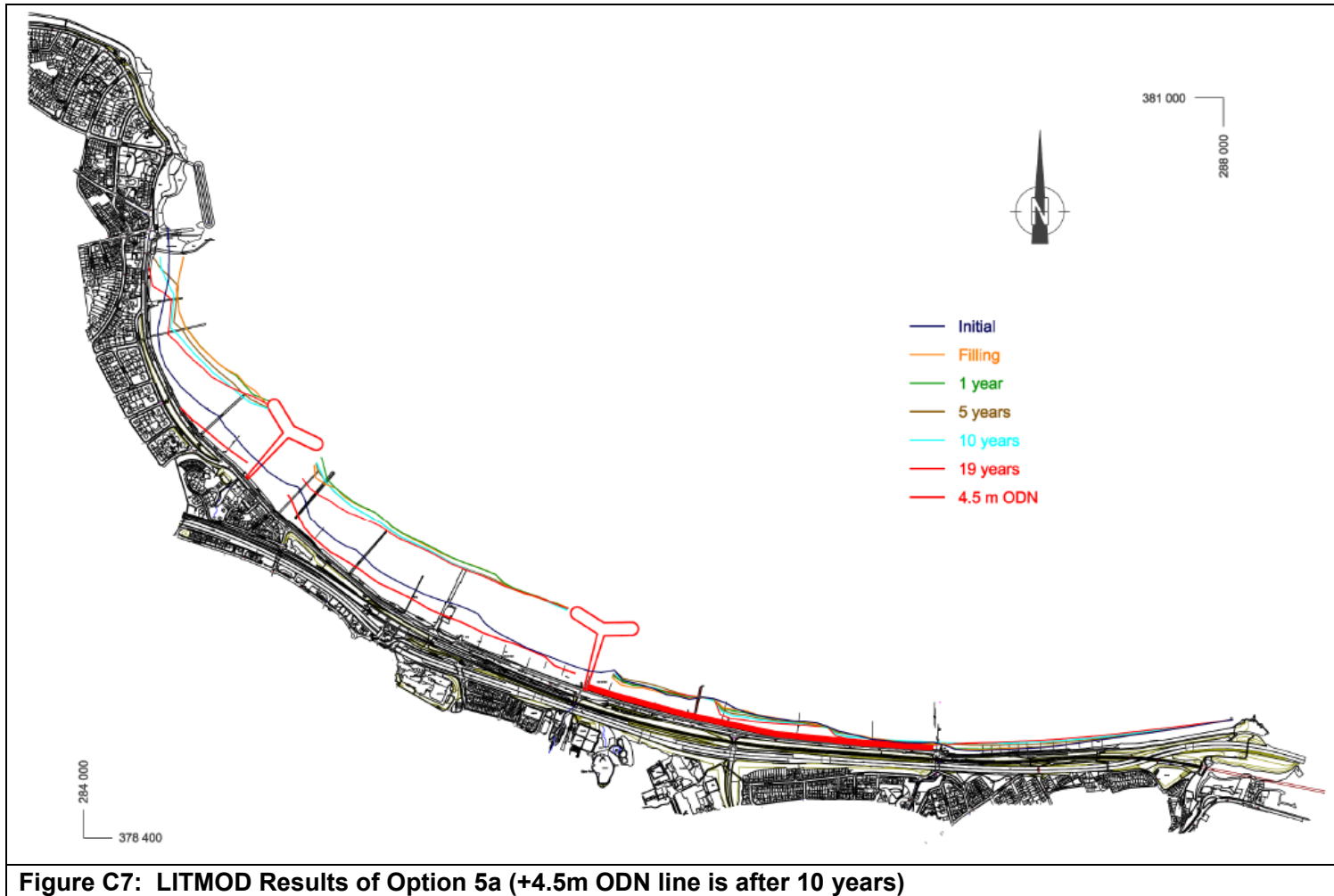


Figure C6A: LITMOD Results of Option 2 (+4.5m ODN line is after 10 years) – Groyne length 300m



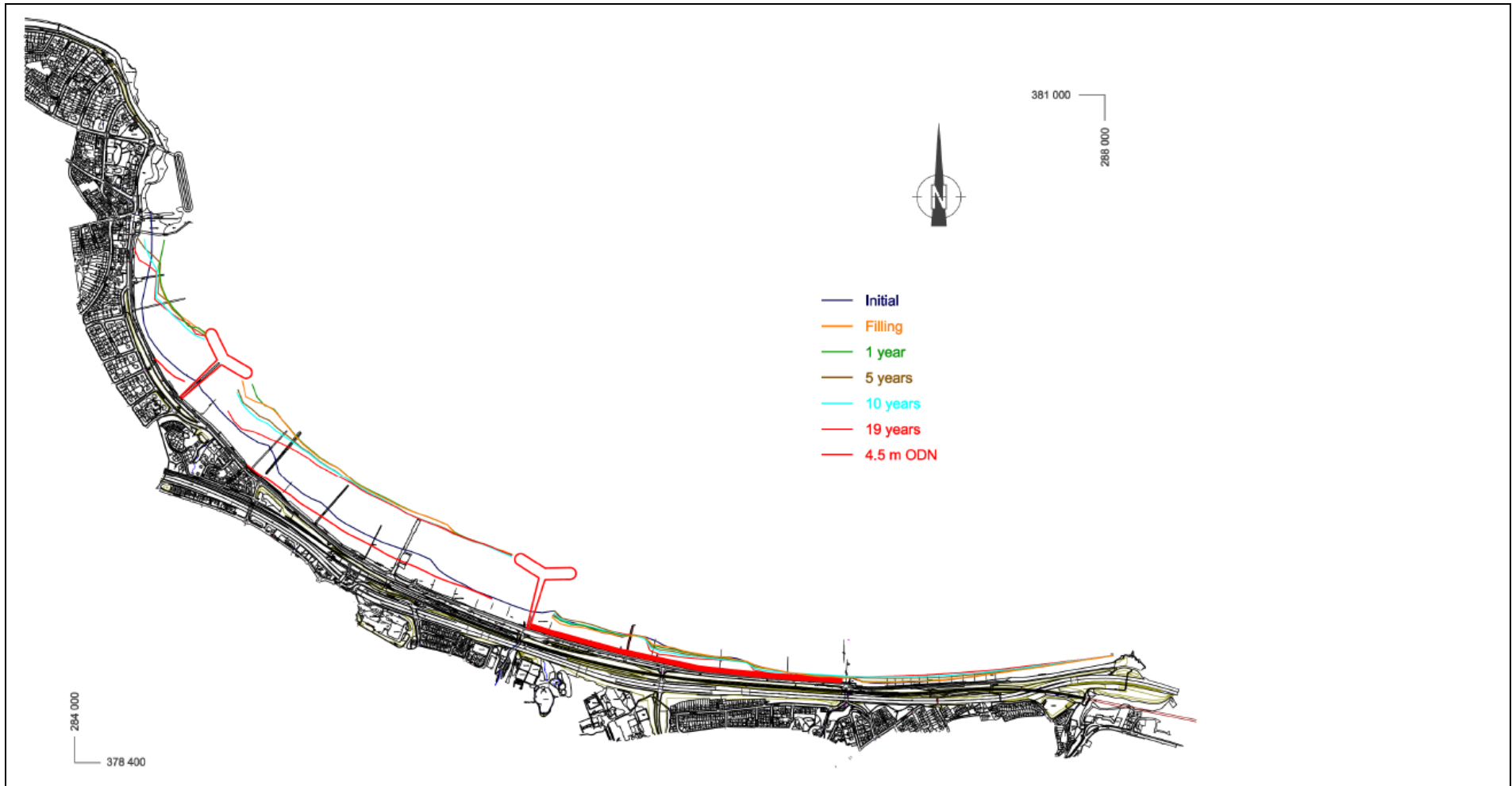


Figure C7A: LITMOD Results of Option 5B (+4.5m ODN line is after 10 years)

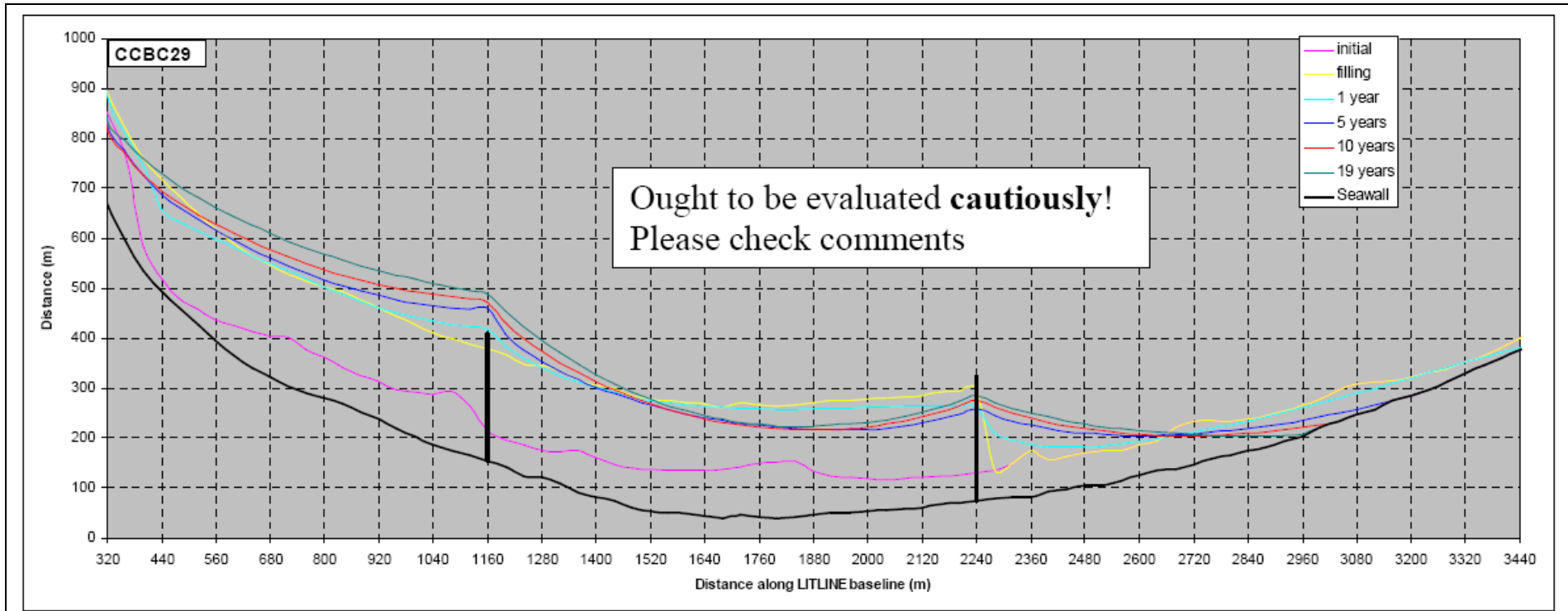


Figure C8: LITLINE Results of Option 3

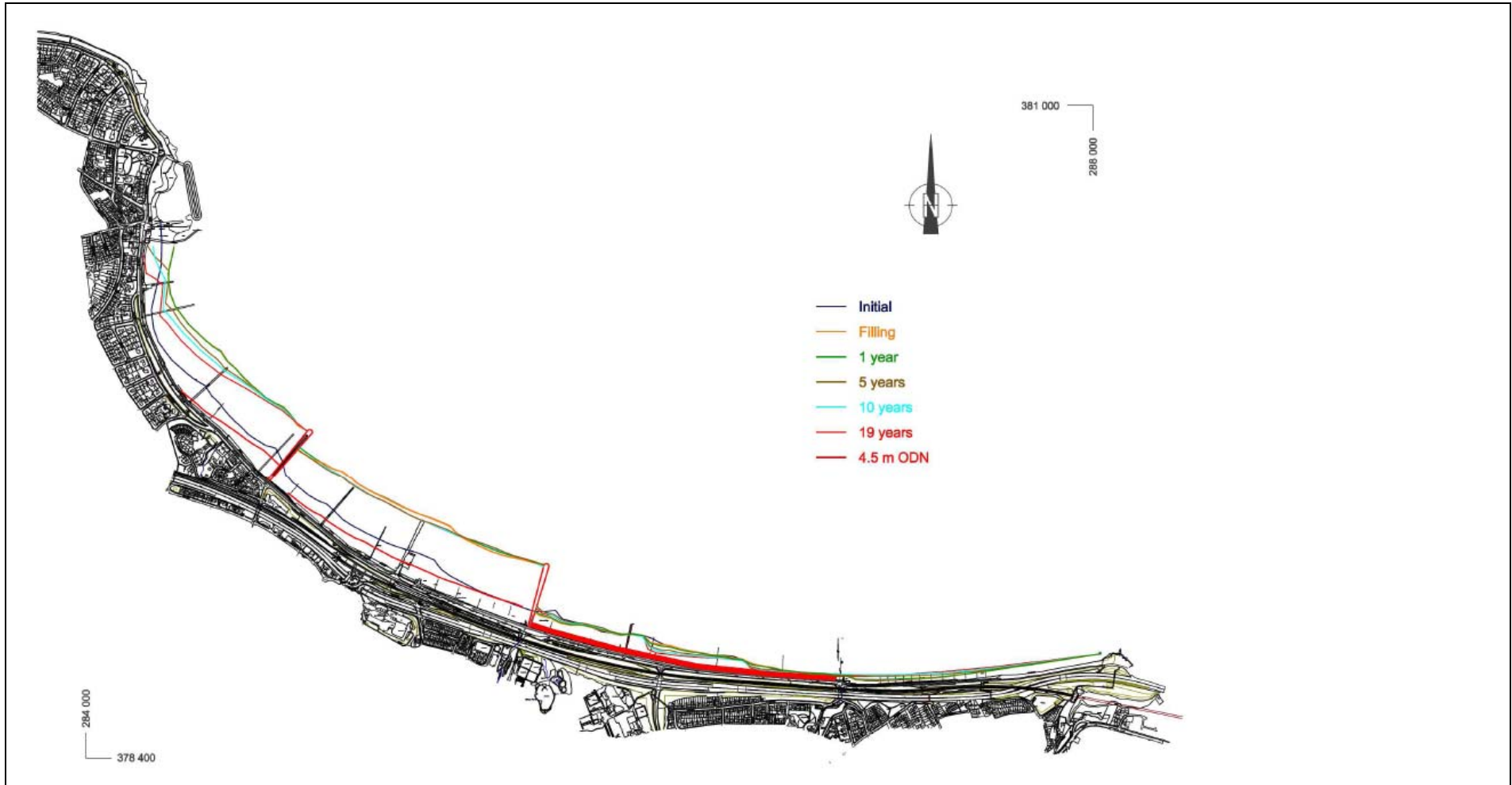


Figure C9: LITMOD Results of Option 3 (+4.5m ODN line is after 10 years) - Groyne length 250m

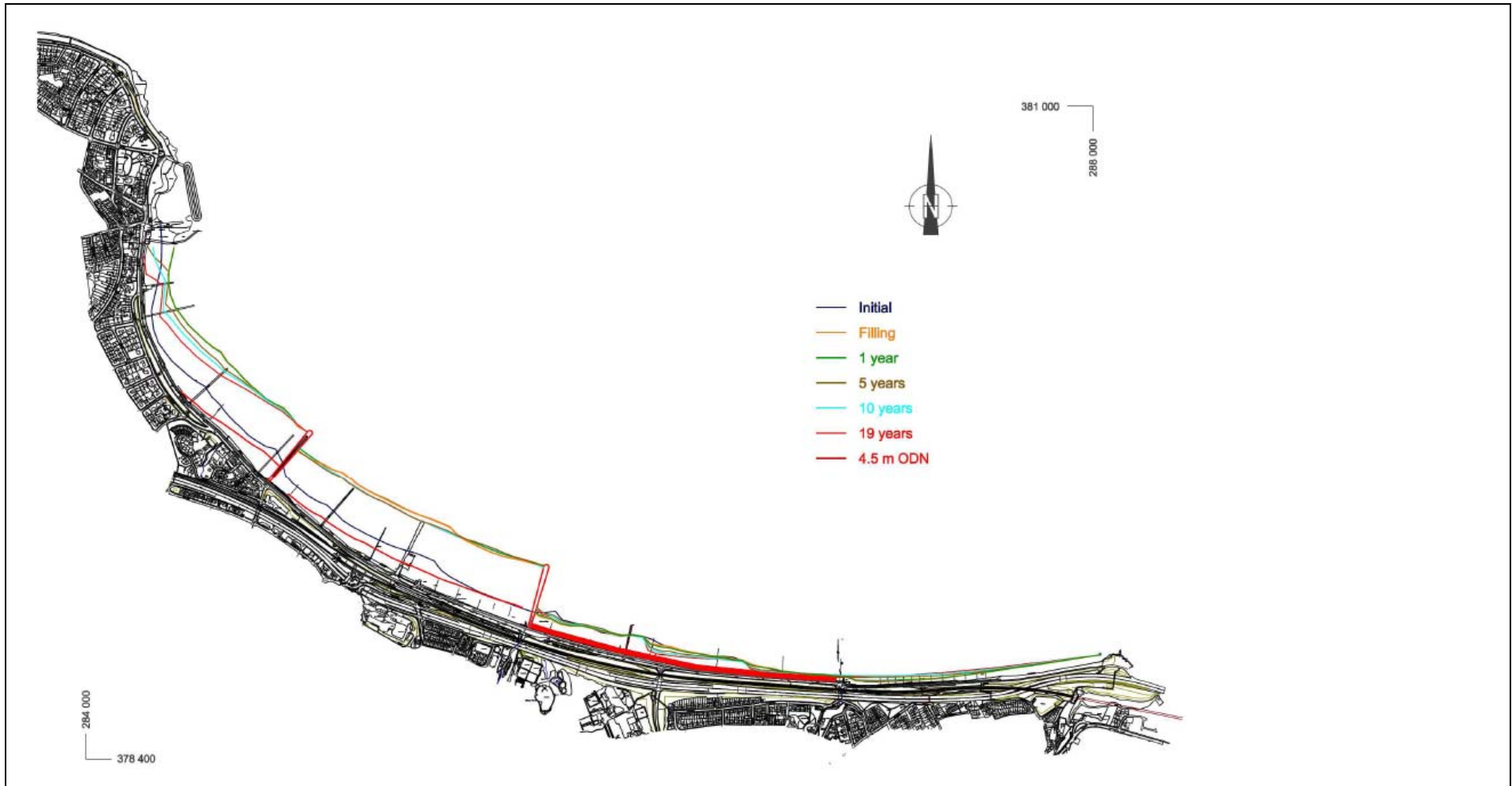


Figure C9A: LITMOD Results of Option 3 (+4.5m ODN line is after 10 years) - Groyne length 300m

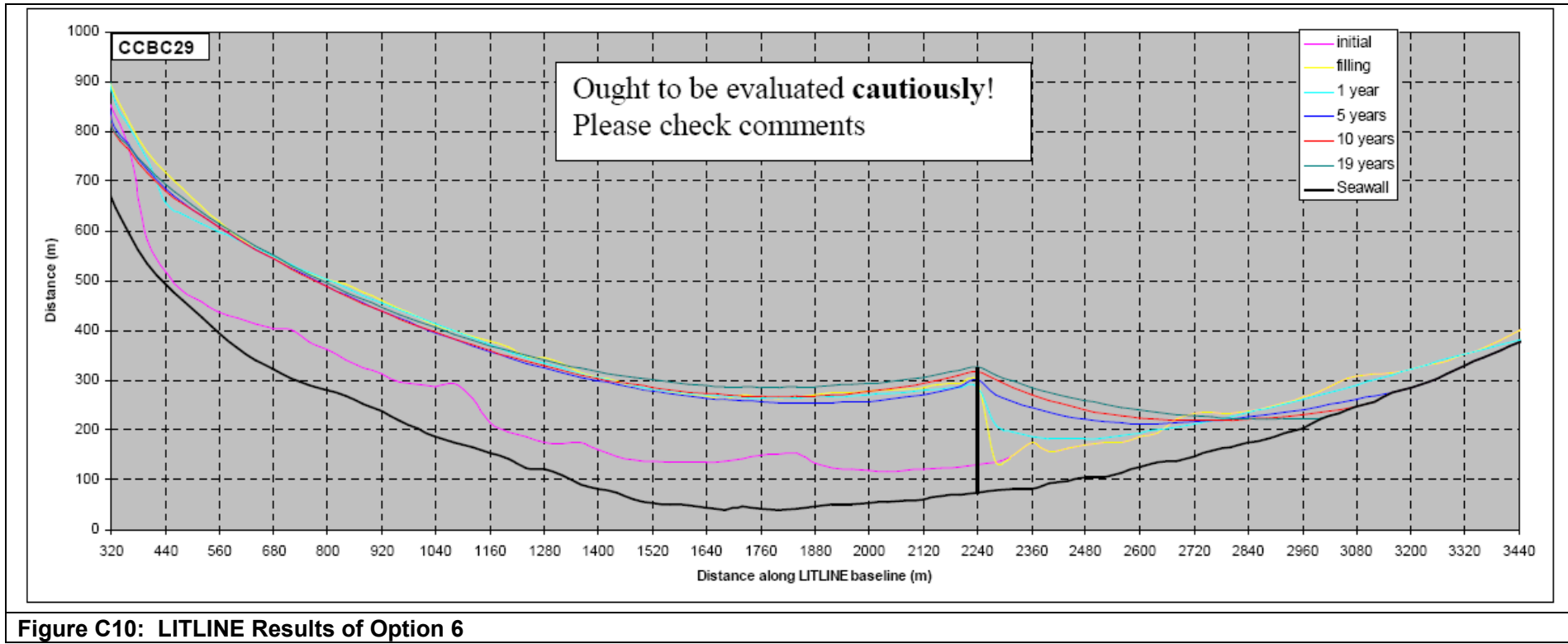


Figure C10: LITLINE Results of Option 6

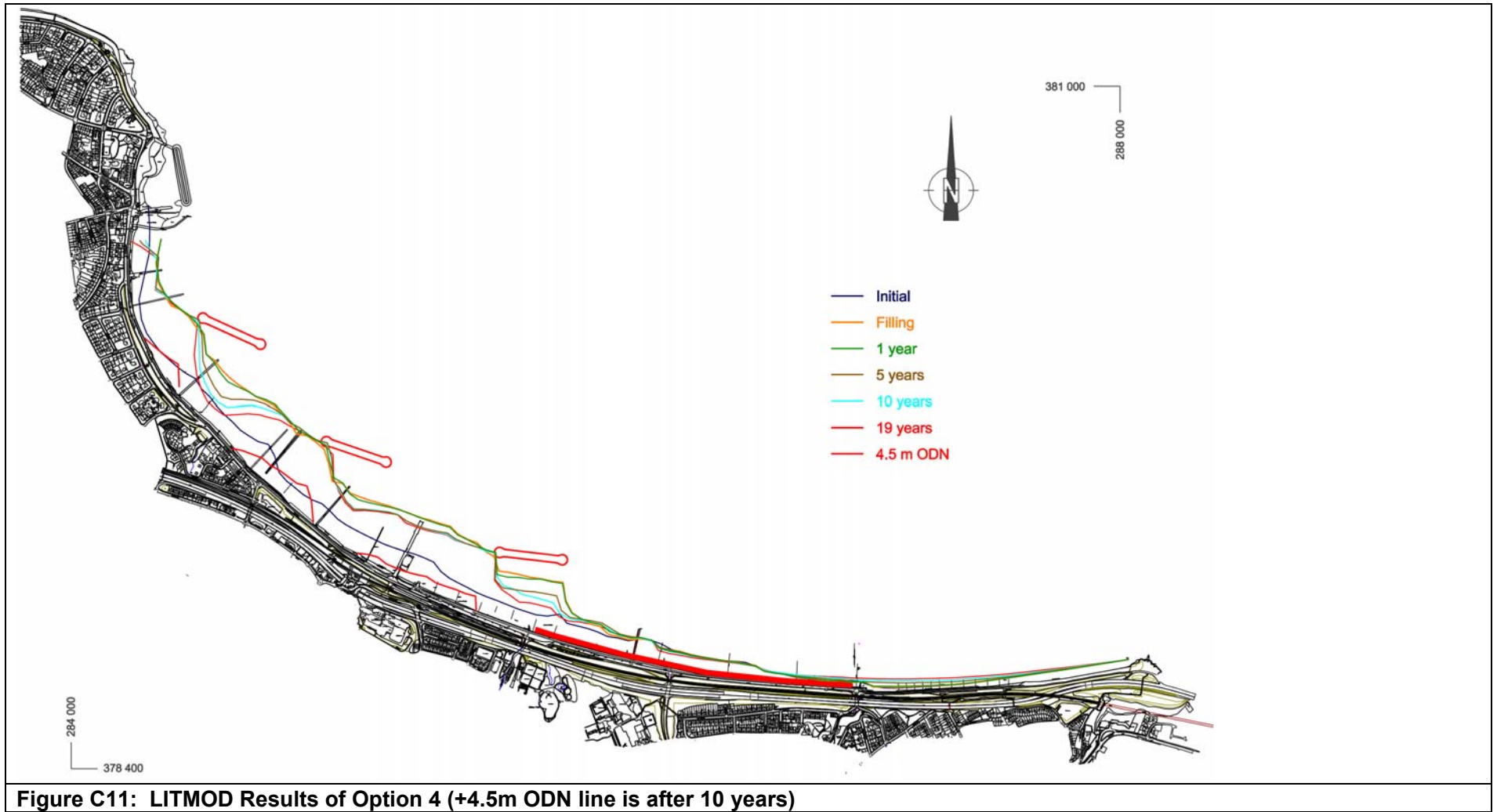


Figure C11: LITMOD Results of Option 4 (+4.5m ODN line is after 10 years)

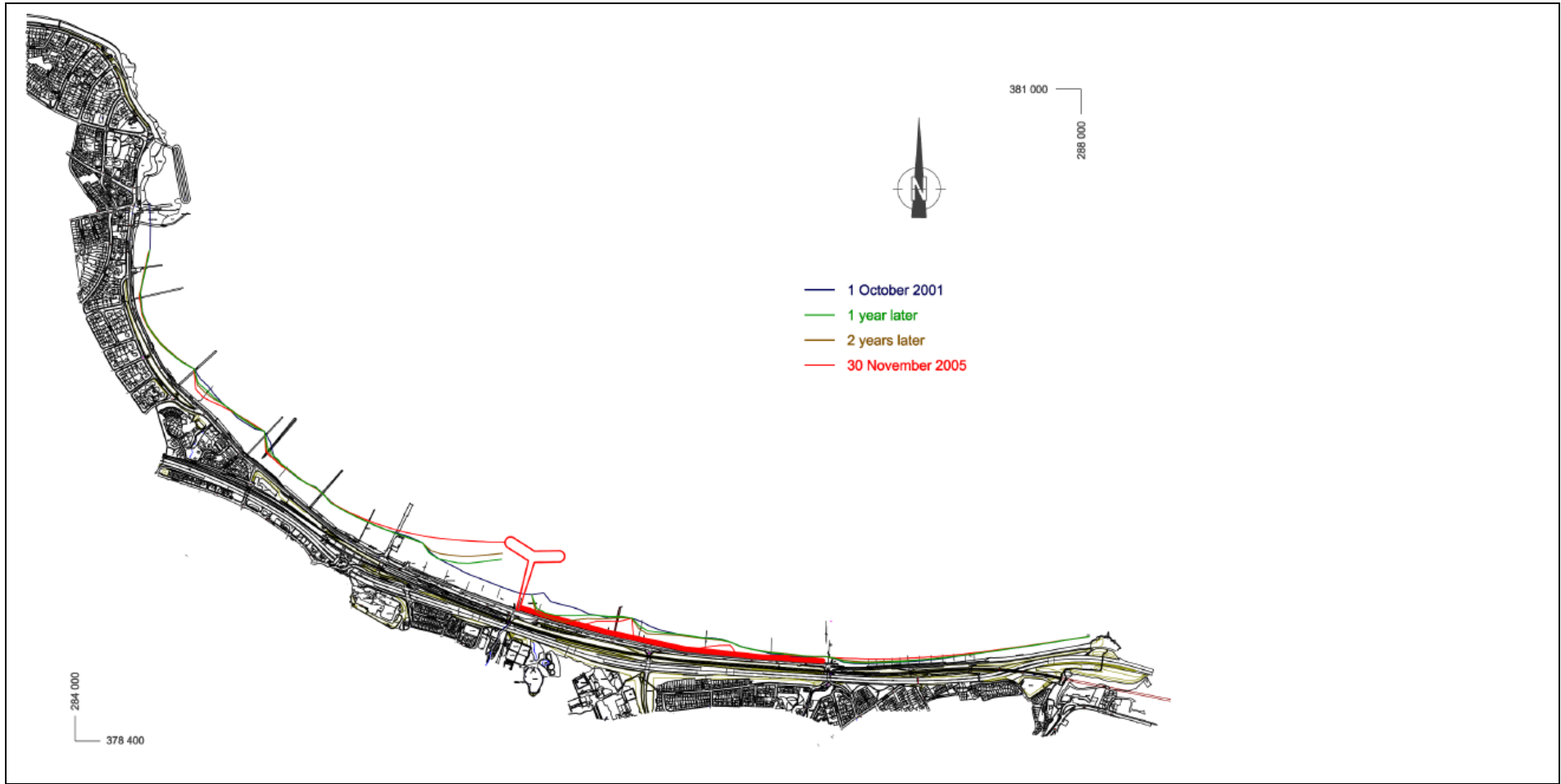


Figure C12: LITMOD Results of Option 7 (for a period of 1 October 2001 to 30 November 2005)

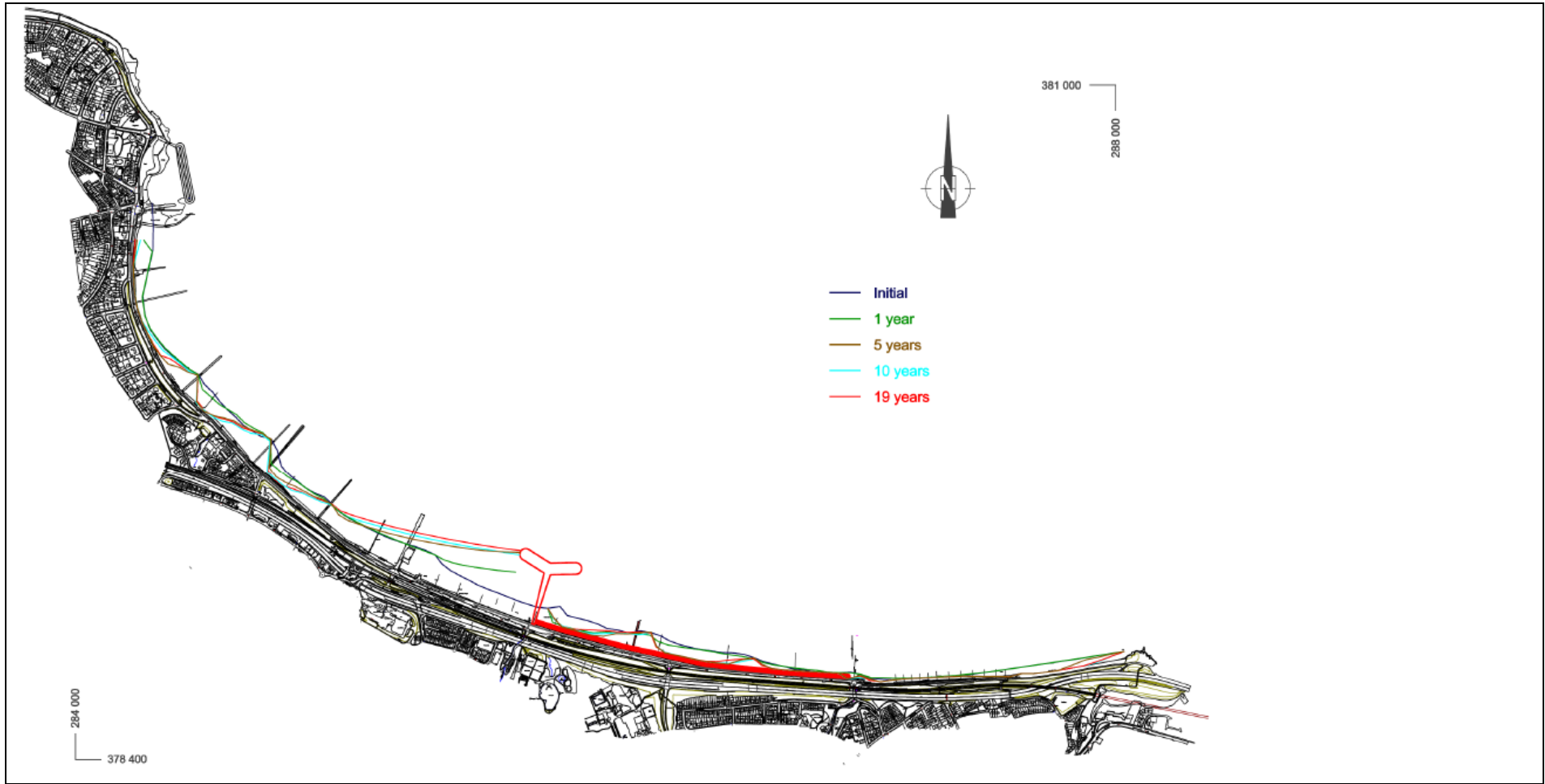


Figure C13: LITMOD Results of Option 7 (for a 19 year period)

