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Subject:	Wylfa Newydd DCO Examination Horizon - Deadline 2 Submissions
Date:	04 December 2018 21:54:52
Attachments:	8.25 Statement of Common Ground between Horizon Nuclear Power Wylfa Limited and North Wales Wildlife Trust.pdf 8.25 Statement of Common Ground between Horizon Nuclear Power Wylfa Limited and Betsi Cadwaladr University Health Board.pdf 8.25 Statement of Common Ground between Horizon Nuclear Power Wylfa Limited and Conwy County Council.pdf 8.25 Statement of Common Ground between Horizon Nuclear Power Wylfa Limited and National Trust.pdf 8.25 Statement of Common Ground between Horizon Nuclear Power Wylfa Limited and North Wales Police.pdf

Good Evening

Please find attached Horizon's Deadline 2 submissions relating to :

- Statement of Common Ground Between Horizon Nuclear Power Wylfa Limited and North Wales Wildlife Trust
- Statement of Common Ground Between Horizon Nuclear Power Wylfa Limited and Betsi Cadwaladr University Health Board
- Statement of Common Ground Between Horizon Nuclear Power Wylfa Limited and Conwy County Council
- Statement of Common Ground Between Horizon Nuclear Power Wylfa Limited and National Trust
- Statement of Common Ground Between Horizon Nuclear Power Wylfa Limited and North Wales Police

Kind Regards

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HORIZON NUCLEAR POWER

WYLFA NEWYDD

ENERGY WORKING FOR BRITAIN

Wylfa Newydd Project

Statement of Common Ground between Horizon Nuclear Power Wylfa Limited and North Wales Wildlife Trust

PINS Reference Number: EN010007

Application Reference Number: 8.25

4 December 2018

Revision 1.0
Examination Deadline 2

Regulation Number: 5(2)(q)

Planning Act 2008
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Horizon Internal DCRM Number: WN0902-HZDCO-PAC-REP-00012

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Contents

Appendices

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1 Introduction

1.1 Status of this SoCG

This SoCG is being submitted to the Examining Authority as an agreed draft between both parties. It will be amended as the examination progresses in order to enable a final version to be submitted to the Examining Authority by Deadline 6.

1.2 Purpose of this document

1.2.1 This SoCG is a 'live' document that has been prepared by Horizon and NWWT. It has been prepared in accordance with the guidance published by the Department of Communities and Local Government (hereafter referred to as 'DCLG Guidance')[1] and example SoCG documents provided on the Planning Inspectorate's website[2].

1.2.2 The purpose of this SoCG is to set out agreed factual information about the application for development consent made by Horizon for the construction and operation of a new nuclear power station at the Wylfa Newydd Development Area (hereafter referred to as 'WNDA') together with on and off-site associated development (hereafter referred to as 'the Wylfa Newydd DCO Project').

1.2.3 Paragraph 58 of the DCLG Guidance states:

"A statement of common ground is a written statement prepared jointly by the applicant and another party or parties, setting out any matters on which they agree. As well as identifying matters which are not in real dispute, it is also useful if a statement identifies those areas where agreement has not been reached. The statement should include references to show where those matters are dealt with in the written representations or other documentary evidence"

1.2.4 The aim of this SoCG is to therefore provide a clear position of the state and extent of discussions and agreement between Horizon and North Wales Wildlife Trust on matters relating to the Wylfa Newydd Project as at 4th December 2018.

1.2.5 DCLG Guidance recognises and expects that SoCG's will continue to evolve in the lead up to and during the examination period (if deemed necessary through on-going discussions between the parties). Discussions between Horizon and North Wales Wildlife Trust will therefore continue to seek to extend the areas of common ground.

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[1] Planning Act 2008: Guidance for the examination of applications for development consent (March 2015) paragraphs 58 – 65 https: / / www.gov.uk / government / uploads / system / uploads / attachment_data / file / 418015 / examinations_guidance-__final_for_publication.pdf

[2] https://infrastructure.planninginspectorate.gov.uk/application-process/example-documents/

1.2.6 The first draft of the SoCG was provided to North Wales Wildlife Trust by Horizon on 17th July 2017 for review and comment. This SoCG has evolved through a series of iterative drafts.

1.2.7 The document will be updated as more information becomes available and as a result of on-going discussions between Horizon and North Wales Wildlife Trust.

1.2.8 Once finalised, the SoCG will be submitted to the Examining Authority in relation to the application by Horizon under section 37 of the Planning Act 2008 (the Act) for an order granting development consent for the construction of the Wylfa Newydd DCO Project.

1.3 Description of development

The Wylfa Newydd Project

1.3.1 The Wylfa Newydd Project includes:

The Enabling Works

1.3.2 The Enabling Works comprise the Site Preparation and Clearance Proposals (SPC Proposals) and the A5025 On-line Highway Improvements.

1.3.3 Horizon has submitted applications for planning permission for the Enabling Works under the Town and Country Planning Act 1990 to the Isle of Anglesey County Council (IACC) as local planning authority. The On-line Highway Improvements were granted planning permission on 13th July 2018 (ref: 27C106E/FR/ECON). The planning authority resolved to grant the SPC application subject to the signing of a legal agreement on the 5th September 2018. The position with the SPC application was summarised in the SPC Status Note submitted to the Examining Authority by Horizon at Deadline 1.

1.3.4 In order to maintain flexibility in the consenting process for the Wylfa Newydd DCO Project, the SPC Proposals have also been included in the DCO application. The A5025 On-line Highway Improvements are not part of the DCO application.

The Wylfa Newydd DCO Project

1.3.5 The Wylfa Newydd DCO Project comprises those parts of the Wylfa Newydd Project which are to be consented by a DCO, namely:

The Nationally Significant Infrastructure Project (NSIP)

- **Power Station**: the proposed new nuclear power station, including two UK Advanced Boiling Water Reactors, the Cooling Water System, supporting facilities, buildings, plant and structures, radioactive waste and spent fuel storage buildings and the Grid Connection;

- **Other on-site development**: including landscape works and planting, drainage, surface water management systems, public access works including temporary and permanent closures and diversions of public rights of way, new Power Station Access Road and internal site roads, car parking, construction compounds and temporary parking areas, laydown areas, working areas and temporary works and structures, temporary construction viewing area, diversion of utilities, perimeter and construction fencing, and electricity connections;
- **Marine works comprising**:
  - Permanent Marine Works: the Cooling Water System, the Marine Off-loading Facility, breakwater structures, shore protection works, surface water drainage outfalls, waste water effluent outfall (and associated drainage of surface water and waste water effluent to the sea), fish recovery and return system, fish deterrent system, navigation aids and Dredging;
  - Temporary Marine Works: temporary cofferdams, a temporary access ramp, temporary navigation aids, temporary outfalls and a temporary barge berth;
- **Off-site Power Station Facilities**: comprising the Alternative Emergency Control Centre (AECC), Environmental Survey Laboratory (ESL) and a Mobile Emergency Equipment Garage (MEEG); and

Associated Development

- the Site Campus within the Wylfa Newydd Development Area;
- temporary Park and Ride facility at Dalar Hir for construction workers (Park and Ride);
- temporary Logistics Centre at Parc Cybi (Logistics Centre);
- the A5025 Off-line Highway Improvements;
- wetland habitat creation and enhancement works as compensation for any potential impacts on the Tre'r Gof Site of Special Scientific Interest (SSSI) at the following sites:
  - Tŷ Du;
  - Cors Gwawr;
  - Cae Canol-dydd

1.3.6 The Power Station will be operational for approximately 60 years after which it will be decommissioned. The buildings will be removed from the site and all spent fuel and radioactive waste managed. The end state of the site will be agreed with the regulators.

Licensable Marine Activities

1.3.7 The Licensable Marine Activities comprise the Marine Works and the Deep Disposal (i.e. the disposal of material from dredging at the Disposal Site at Holyhead North). The Licensable Marine Activities will be consented under a Marine Licence, however the Marine Works would also be consented under the DCO.

1.3.8 A more detailed description of development is contained at Chapter 4 of the Planning Statement (APP-406).

2 Overview of Engagement

2.1.1 The preparation of this SoCG has been informed by a programme of discussions between Horizon and North Wales Wildlife Trust. Horizon met with North Wales Wildlife Trust to discuss and document common ground on the following dates:

Table 2-1 SOCG meetings held between Horizon and North Wales Wildlife Trust

Meeting Date	Attendees	Purpose of Meeting
11th July 2017	Horizon North Wales Wildlife Trust	Initial meeting to discuss approach to SoCG
4th October 2017	Horizon North Wales Wildlife Trust	Update meeting to discuss the draft DCO documents and how they relate to the SoCG
16th July 2018	Horizon North Wales Wildlife Trust	Meeting to discuss the areas of concern to be included in the SOCG document.
2nd October 2018	Horizon, National Trust, RSPB, NWWT, IACC, NRW	Meeting to explore any area of common ground relating to the Natura 2000 sites.
10th October 2018	Horizon, National Trust, RSPB, NWWT, IACC, NRW	Meeting to explore any area of common ground relating to Wylfa Head, Tre'r Gof SSSI, and the Site Campus.
11th October 2018	Horizon, National Trust, RSPB, NWWT, IACC, NRW	Meeting to explore any area of common ground relating to marine and terrestrial ecological issues.

2.1.2 In addition to these discussions, Horizon has engaged with North Wales Wildlife Trust since June 2017 through a number of technical meetings to address specific project issues as they have arisen. A list of these meetings is provided below. All of these discussions have informed this SoCG.

Table 2-2 Technical meetings held between Horizon and North Wales Wildlife Trust

Meeting Date	Attendees	Purpose of Meeting
21st June 2017 3rd October 2017	Horizon, IACC, NRW, NWWT, National Trust, RSPB, Gwynedd Archaeology Planning Service, Cadw, Red Squirrels Trust	Wylfa Newydd Natural & Historic Environment Forum (WNNHEF). The forum is intended as a means to obtain stakeholder input into the emerging LHMS.
23rd October 2017	Horizon, RSPB, NWWT	Visit of the ecological receptor sites and discussion of the parameter plans approach to securing the DCO.
5th December 2017	Horizon, NRW, IACC, RSPB, National Trust, NWWT, Seawatch Foundation	Discussion of the issues relating to the marine environment.
12th December 2017	Horizon, NRW, IACC, RSPB, National Trust, NWWT	Discussion of the issues relating to terrestrial and freshwater ecology.
16th January 2018	Horizon, NRW, IACC, National Trust, NWWT	Discussion of the issues relating to Cemlyn Lagoon.
18th February 2018	Horizon, IACC, National Trust, NWWT, RSPB	Discussion of the interim condition should the SPC planning application be approved.
6th March 2018	Horizon, NRW, IACC, National Trust, NWWT, RSPB	Discussion on the draft Landscape and Habitat Management Plan document.
28th June 2018	Horizon, National Trust, NWWT, RSPB	Meeting to update the NGOs on work undertaken to identify possible compensation site for terns should they be required.

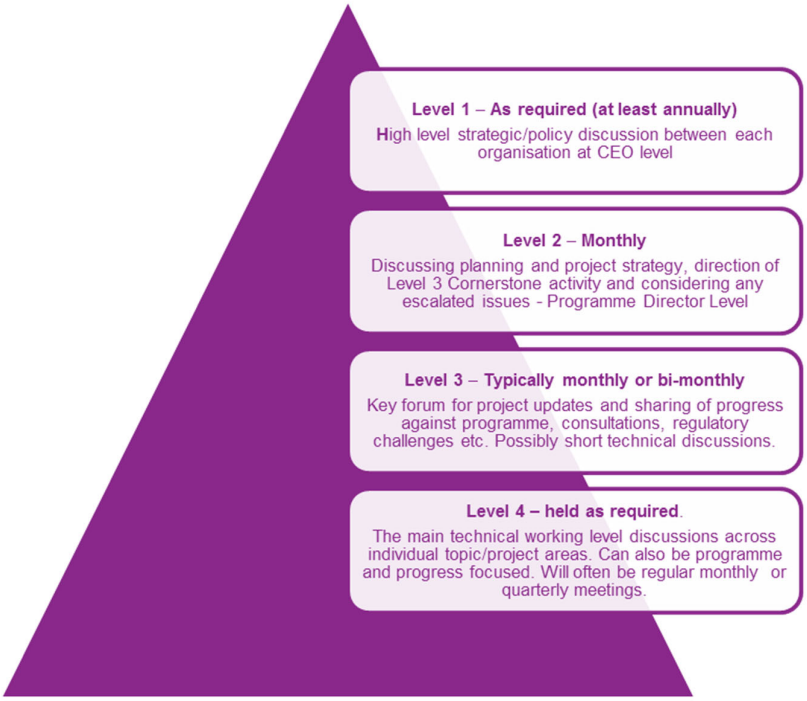
2.2 Consultation with North Wales Wildlife Trust

2.2.1 Horizon has undertaken engagement with the North Wales Wildlife Trust throughout the pre-application period.

2.2.2 Full details are provided in the Consultation Report (APP-037).

2.2.3 Horizon has an overarching engagement framework in place, principally to support engagement with IACC, Welsh Government and NRW. Although this has not been formally agreed with North Wales Wildlife Trust, Officers have attended relevant meetings within this framework, as illustrated in Figure 2-1 below, principally at the Level 4, technical level.

Figure 2-1 Wylfa Newydd Engagement Framework



2.2.4 Following Horizon's Stage Two Pre-Application Consultation, Horizon set up a series of Level 4 technical meetings on specific issues.

2.2.5 DCLG Guidance recognises that the topics on which agreement might be reached in any particular instance (or those areas where agreement might not be reached) will depend on the matters at issue and the circumstances of the case.

2.2.6 Horizon shared with North Wales Wildlife Trust, amongst other statutory consultees, the draft application documents to support the DCO application that they requested in September and October 2017. This followed detailed comments made by the North Wales Wildlife Trust in March 2016 on the Environmental Impact Assessment Progress Report in advance of PAC2. Specifically, North Wales Wildlife Trust were provided with copies of the following documents:

- Environmental Statement chapters:
  - A1 – Introduction to the project and approach to EIA
  - A2 – Project overview and introduction to the development
  - B8 – Introduction to the assessments – surface water and groundwater
  - B9 – Introduction to the assessments – terrestrial and freshwater ecology
  - B12 – Introduction to the assessments – coastal processes and geomorphology
  - B13 – Introduction to the assessments – Marine environment
  - C4 – Project wide effects – air quality effects of traffic
  - C7 – Combined topic effects of traffic
  - D1 – Power Station Main Site – Proposed Development
  - D5 – Power Station Main Site – air quality
  - D6 – Power Station Main Site – noise and vibration
  - D7 – Power Station Main Site – soils and geology
  - D8 – Power Station Main Site – surface water and groundwater
  - D9 – Power Station Main Site – terrestrial and freshwater ecology
  - D12 – Power Station Main Site – coastal processes and geomorphology
  - D13 – Power Station Main Site – marine environment
  - D16 – Power Station Main Site – combined topic effects
  - E1 – Offsite Power Station Facilities – Proposed Development
  - F1 – Park and Ride – Proposed Development
  - G1 – A5025 Offline Highways Improvements – Proposed Development
  - H1 – Logistics Centre – Proposed Development
- Relevant Environmental Statement Appendices
- Shadow Habitats Regulations Assessment
- Construction Method Statement
- Code of Construction Practice
- Code of Operational Practice
- Power Station Main Site sub-CoCP
- Marine Works sub-CoCP
- Site Selection Report Volume 2 main site layout
- Site Selection Report Volume 4 temporary workers accommodation
- Landscape and Habitat Management Strategy

2.2.7 North Wales Wildlife Trust were invited to provide comments on the draft documents. Due to time constraints of the North Wales Wildlife Trust staff and volunteers and the changing nature of some of the on-going studies, North Wales Wildlife Trust were only able to provide summary comments on new elements of the proposal which varied from the detailed response provided in the Environmental Impact Assessment Progress Report Review in March 2016. These documents also served to develop, and inform on-going discussions associated with this SoCG.

3 Current Position

3.1.1 The following schedule sets out the position of North Wales Wildlife Trust alongside Horizon's position following issue and review of the DCO application.

3.1.2 It sets out matters by topic area and provides an indication of whether the issue is agreed (green), not agreed (red) or ongoing (amber).

3.1.3 For ongoing issues, the intention is to provide a final position in subsequent versions of this SoCG.

3.1.4 North Wales Wildlife Trust do not wish to raise objections in relation to any other areas of the Project.

Table 3-1 Statement of Common Ground between the North Wales Wildlife Trust and Horizon

Topic	Issue	SoCG ID	Document Reference/Signpost/ Route map	North Wales Wildlife Trust Position	Horizon Position	RAGs	Further actions required to progress discussion on the issue
Cemlyn Nature Reserve – Anglesey Terns SPA, tern breeding colony and SSSI	Disturbance to terns	NWWT1	APP-050 / App-051 5.2 Shadow Habitats Regulations Assessment Report APP-132 6.4.13 ES Volume D – WNDA Development D13 – The Marine Environment APP-225 6.4.89 ES Volume D – WNDA Development App D13.07 – Seabird Baseline Review APP-414 8.6 Wylfa Newydd Code of Construction Practice APP-415 8.7 Main Power Station Site sub-CoCP APP-416 8.8 Marine Works sub-CoCP APP-421 8.13 Wylfa Newydd Code of Operational Practice APP-422 8.14 Mitigation Route Map APP-424 / APP-425 8.16 Landscape and Habitat Management Strategy	The assessment of the potential effects to the tern colony during construction do not prove 'beyond reasonable scientific doubt that there will be no adverse effect on integrity which is a key test of the Habitats Regulation Assessment. Combined effect of noise, visual stimuli, disturbance from workers / visitors and modification to predator population dynamics from the WNDA could significantly impact the integrity of the site leading to a decline in its current condition and the population stats of the terns (common, Arctic & Sandwich) within and beyond the SPA. North Wales Wildlife Trust consider that on-site measures (within the SPA) to reduce the potential impacts on the tern colony are not clearly defined in the DCO and their delivery is uncertain. North Wales Wildlife Trust are concerned that mitigation measures alone will not be sufficient to conclude no adverse effect on integrity (AEOI) of the Anglesey Terns SPA from the combined impacts during construction and operation. Therefore, the case for no alternative solutions and reasons of overriding public interest, should be considered along with a proposed package of compensation measures that should be presented to the Examining Authority.	The Environmental Statement and Shadow HRA have considered in detail the effects of the various construction and operational activities associated with the three tern species that nest on the islands in Cemlyn Lagoon. A range of mitigation measures have been proposed to ensure that the integrity of the Anglesey terns SPA is maintained and these are secured in the in the Wylfa Newydd CoCP (APP-414), Main Power Station Site sub-CoCP (APP-415) and Marine Works sub-CoCP (APP-416) or are an integral part of the proposals. The Shadow HRA concludes that disturbance from noise and visual stimuli (including workers / visitors and predators in combination) will not result in the abandonment or a reduction in breeding success of the Cemlyn Lagoon nesting site beyond reasonable scientific doubt and based on the best evidence available. Mitigation is proposed to provide confidence that noise will not impact the nesting terns. In August 2018, the IACC considered the risk of increased predation within its assessment of the SPC works under The Conservation of Habitats and Species Regulations 2017 (the Habitats Regulations). IACC concluded that any changes to predation risk associated with the SPC works are likely to be imperceptible and that significant effects, as a result of the SPC works, would not occur. Although this conclusion is specific to the SPC works - which do not involve soil stripping - IACC's justifications for this conclusion are equally relevant to the Project as a whole. Regarding increased footfall from construction workers, those residing within the Site Campus will receive information on the sensitivity and legal protection afforded to Cemlyn Bay and the species it supports. Access to the area from the Site Campus will be a walk of over 6km (a round trip of more than 12km), and entertainment facilities will be provided on-site to reduce the need to seek off-site entertainment. These provisions are secured as part of the Workforce Management Strategy (Section 2.3, APP-413). The Landscape and Habitat Management Strategy (APP-424 and APP-425) sets out the principles for managing public access during construction. The principle which addresses the management of visitors is as follows: *Suitable arrangements to enable viewing of the construction activity should be made. Initially, this may comprise a temporary viewing platform available around 6 months after the start of construction, dependent on availability of safe access and parking capacity. This facility may evolve through the construction period dependant on the positioning of activities while moving through the different phases.* Horizon does not agree that mitigation measure for impacts to terns are not clearly defined. Mitigation measures considered necessary by Horizon are identified in the Mitigation Route Map (APP-422) which sets out which document in the DCO the mitigation measure has been identified as needed, and which control document the mitigation measure will be secured by. For construction impacts, mitigation measures are set out in the Wylfa Newydd CoCP (APP-414), Main Power Station Site sub-CoCP (APP-415) and Marine Works sub-CoCP (APP-416). During operation, mitigation measures are secured in the Landscape and Habitat Management Strategy (APP-424 and APP-425) and the Wylfa Newydd Code of Operational Practice (APP-421). Horizon propose to include a contribution in the draft s.106 agreement for part funding of a tern warden during breeding seasons for the duration of the construction period. The Shadow HRA concludes that there will not be an adverse effect on integrity to the Anglesey Terns SPA. Consequently Stages 3 and 4 of the HRA process do not need to be progressed, nor compensation provided.	Not agreed	No further actions identified at this time.

Topic	Issue	SoCG ID	Document Reference/Signpost/ Route map	North Wales Wildlife Trust Position	Horizon Position	RAGs	Further actions required to progress discussion on the issue
Cemlyn Nature Reserve – Cemlyn Bay SAC, saline lagoon and shingle ridge, and SSSI	Long term viability of the shingle ridge.	NWWT2	APP-131 6.4.12 ES Volume D – WNDA, D12 – Power Station Site – Coastal Processes and Coastal Geomorphology, APP-216 6.4.80 ES Volume D WNDA Development App, D12.01 – Coastal Geomorphology Baseline for the Wylfa Newydd Project – 2014, APP- 218 6.4.82 ES Volume WNDA Development App D12.03 – Wylfa Newydd Main Site - Final Wave Modelling Report	The North Wales Wildlife Trust do not agree that sufficient information has been provided to conclude that there will be no adverse effects to the long term viability of the Esgair Gemlyn shingle ridge and consequently it cannot be concluded beyond reasonable scientific doubt there will be no adverse effect on integrity (AEOI) of Cemlyn Bay SAC. The North Wales Wildlife Trust considers that mitigation measures alone will not be sufficient to conclude no AEOI of the Anglesey Terns SPA as a result of potential changes to coastal processes (in addition to other identified impacts during construction and operation) and therefore the case of no alternative solutions and reasons of overriding public interest together with a proposed package of compensation measures should be presented to the Examining Authority. North Wales Wildlife Trust will defer to the evidence of the National Trust's specialist witness	Since the submission of the DCO application, Horizon has undertaken further modelling assessments which couple the model for the worst case 99%ile NE wave scenario with the coastal processes model to identify any impacts to Esgair Gemlyn. The additional modelling information was sent to the North Wales Wildlife Trust on 5th October 2018 and was discussed at a meeting on the 11th October 2018. The additional modelling information has been submitted to the Examining Authority at Deadline 2. The results show that the bed sheer stresses predicted to arise due to the Marine Works would not change sufficiently to cause an increase in sediment mobilisation that could have an adverse impact on Esgair Gemlyn. Moreover, there is not predicted to be a significant change in the energetics of the water body within / adjacent to Cemlyn lagoon. Consequently, the functioning of the lagoon and islands that terns use for breeding would not be adversely affected. No mitigation measures are proposed for this issue.	Not agreed	North Wales Wildlife Trust to review the additional information submitted at Deadline 2.
	Changes to the chemical conditions within Cemlyn Lagoon.	NWWT3	APP-127 6.4.8 ES Volume D – WNDA Development D8 – Surface water and groundwater APP-415 8.7 Main Power Station Site sub-CoCP	The North Wales Wildlife Trust do not consider that adequate consideration has been given to changes in chemical conditions within the Cemlyn Lagoon's freshwater 'water budget'. Insufficient information has been provided to conclude that runoff from Mound E will not reach the Nant Cemlyn and subsequently the Cemlyn Lagoon with corresponding impacts to the lagoon's water quality. The proposals to pump drainage water overland to be discharged into the Afon Cafnan are welcomed, but concerns remain over the effectiveness of the strategy as no information has been provided on the specification of plant to be used and its adequacy to cope with extreme storm events. The North Wales Wildlife Trust remains opposed to any reworking of Mound E and the flexibility sought by Horizon.	The drainage design for Mound E will ensure that surface water drainage from Mound E will be captured and treated through the use of swales, attenuation ponds, and silt busters. The treated surface water will then be pumped overland and discharged to the Afon Cafnan under a discharge permit issued by NRW during the earthworks phase before vegetation is established on Mound E. The specification for the pumping equipment has not yet been determined but it will be adequately specified to prevent discharges of silted water to the Nant Cemlyn watercourse. The DCO application states that the overland pumping will be switched off when the slopes of Mound E are adequately vegetated to prevent elevated siltation of the discharged runoff (paragraph 10.2.10, APP-415). Discussions with NRW on this issue have resulted in a change in strategy so that additional baseline monitoring of the Nant Cemlyn will be undertaken to understand the seasonal fluctuations of the water course. Monitoring of the pumped discharge to Afon Cafnan will also be monitored and the pumping will only be switched off and runoff allowed to discharge to the Nant Cemlyn when the water quality threshold agreed with NRW is achieved. The Main Power Station Site sub-CoCP (APP-415) will be updated at Deadline 2 to secure this amendment. By diverting runoff from Mound E to the Afon Cafnan there will be a small reduction in the amount of freshwater input to Nant Cemlyn and subsequently Cemlyn Lagoon. There will also be a small reduction in the amount of groundwater input to the lagoon. The reduction in freshwater inputs is small and the assessment has determined no significant effect (paragraphs 8.5.24 to 8.5.27 inclusive, APP-127) to the chemistry or water budget of Cemlyn Lagoon.	Ongoing	North Wales Wildlife Trust to review the additional information submitted at Deadline 2.

Topic	Issue	SoCG ID	Document Reference/Signpost/ Route map	North Wales Wildlife Trust Position	Horizon Position	RAGs	Further actions required to progress discussion on the issue
Water Framework Directive	Impacts to The Skerries Coastal Waterbody (marine)	NWWT4	APP-444 8.26 Water Framework Directive Compliance Assessment APP-445 8.27 Water Framework Directive Information to Support Article 4(7) Derogation	North Wales Wildlife Trust are concerned that the late acknowledgement of the deterioration of the Skerries Coastal Waterbody has not allowed for the consideration of alternatives or use of Best Available Technology. North Wales Wildlife Trust are concerned about impacts from hydromorphology, geomorphology and wave dynamics, the extent and loss of subtidal and intertidal habitats, and the hydrological consequences of the cooling water system.	The WFD compliance assessment concludes that there is a risk of deterioration in The Skerries Coastal water body due to the loss of marine habitat and changes to coastal morphology due to the construction of the MOLF and breakwater. The predicted loss is small, indeed it is below the generic threshold of effect under which deterioration from high morphological status to good morphological status would typically occur. However, in liaison with NRW and with reference to the normative definitions for coastal water bodies, the WFD compliance assessment concludes that there is a risk of deterioration. Horizon notes that NRW and the Secretary of State, as the competent authorities in respect of applications relating to the Wylfa Newydd Project, are ultimately responsible for assessing WFD compliance, including in respect of any Article 4(7) derogation. In order to assist this process, Horizon has prepared the Water Framework Directive Compliance Assessment (APP-444) and Information to Support Article 4(7) Derogation (APP-445).Horizon continues to liaise with NRW to ensure that materials can be made available to inform the assessment to inform this work.	Ongoing	North Wales Wildlife Trust to review additional information to support Article 4(7) derogation.
	Impacts to the Ynys Môn Secondary Groundwater Body (freshwater)	NWWT5	APP-444 8.26 Water Framework Directive Compliance Assessment APP-445 8.27 Water Framework Directive Information to Support Article 4(7) Derogation APP-128 6.4.9 ES Volume D – WNDA Development D9 – Terrestrial and Freshwater Ecology	North Wales Wildlife Trust are concerned that the late acknowledgement of the deterioration of the Ynys Môn Secondary Groundwater Body has not allowed for the consideration of alternatives or application of Best Available Technology which would avoid the deterioration in quality. Specifically, North Wales Wildlife Trust are concerned about impacts to hydrologically dependent fen habitat at Tre'r Gof SSSI the inappropriate siting of the Associated Development of the Site Campus and the drainage system in this catchment.	The WFD compliance assessment concludes that there is a risk of deterioration to the Ynys Môn Secondary groundwater body. This is driven by saline intrusion and impacts on Tre'r Gof SSSI (which is termed a groundwater dependent terrestrial ecosystem or GWDTE under the WFD). Tre'r Gof SSSI sits within a 'non-reportable' surface water body (identified as Tre'r Gof Drains in the WFD compliance assessment). It's status as a non-reportable water body means that effects are assessed with reference to the next downstream water body, which in this case is the Anglesey North coastal water body. Effects associated with the Site Campus are assessed for Tre'r Gof Drains (concluding compliance for Anglesey North) and for Ynys Môn Secondary groundwater body (concluding compliance). Under the WFD, there is no specific requirement to compensate for deterioration of the Ynys Môn Secondary groundwater body. WFD mitigation measures must be within the affected water body and, consequently, the sites at Cae Canol-dydd and Cors Gwawr do not qualify.	Not agreed	No further actions identified at this time.
Impacts from the temporary Site Campus	Impacts to chough, fungi and Tre'r Gof SSSI from the Site Campus.	NWWT6	APP-128 6.4.9 ES Volume D – WNDA Development D9 – Terrestrial and Freshwater Ecology APP-168 6.4.34 ES Volume D – WNDA Development pp D9-1 – Fungi Technical Summary Report APP-413 8.7 Workforce Management Strategy APP-424 8.16 Landscape and Habitat Management Strategy APP-029 3.1 Draft Development Consent Order	North Wales Wildlife Trust do not accept that the temporary Site Campus, as an Associated Development, needs to be located in the proposed position. Specific concerns relate to impacts from scale, site infrastructure and foul sewer diversion on grassland fungi and chough foraging, uncontrolled recreational usage and Tre'r Gof SSSI. North Wales Wildlife Trust question whether there are techniques available to achieve and / or sufficient information to demonstrate that the site can be restored to its current condition in relation to 'old' soil structures, interrupted shallow groundwater flows or soil	Horizon have undertaken fungi surveys in the fields where the Site Campus will be located. The surveys have identified hotspots in the field but these are along the coastal strip, outside of the perimeter fence, and will not be disturbed by the construction, operation, or decommissioning of the Site Campus. Horizon acknowledges that there is a potential impact to chough from the loss of foraging and are currently implementing a management regime on Wylfa Head and the adjoining coastal strip which is sympathetic to chough foraging as mitigation. The management regime has been informed by advice provided by the RSPB. Horizon has shared with the North Wales Wildlife Trust the draft Landscape and Habitat Management Scheme, which is being developed under the LHMS to implement the Principles set out in Section 4 of APP-424, and sets out the proposed management measures. Horizon welcome the organisation's comments on this document. Chough surveys have been undertaken over the 2018 breeding season and the initial results have been presented to the North Wales Wildlife Trust at a meeting on the 10th October 2018 and the report subsequently shared with the North Wales Wildlife Trust. The results showed that the nesting pair is different to previous years but has foraged primarily (71% of foraging time) on Wylfa Head, 4% in the adjoining fields where the Site Campus would be located and the remainder of the time to the west of the Magnox buildings, presumed to be at Trwyn Pencarreg where there is suitable habitat. The results indicate	Not agreed	No further actions identified at this time.

Topic	Issue	SoCG ID	Document Reference/Signpost/ Route map	North Wales Wildlife Trust Position	Horizon Position	RAGs	Further actions required to progress discussion on the issue
				invertebrates. The Workforce Management Strategy does not provide adequate provisions to prevent impacts to ecological receptors in the vicinity of the Site Campus. North Wales Wildlife Trust question the effectiveness and achievability of the proposed off-site SSSI compensation based on the DCO submission.	that the loss of foraging from the construction and operation of the Site Campus will not adversely affect chough through a loss of foraging habitat, provided that Wylfa Head is adequately maintained. The appropriate management of Wylfa Head will be secured through the LHMS and the corresponding Landscape and Habitat Management Scheme which Horizon will continue to consult with the North Wales Wildlife Trust on. Horizon have discussed the issue of disturbance from the workforce with the North Wales Wildlife Trust and other stakeholders at a meeting on the 10th October 2018. Horizon can confirm that gates marked on the submitted plans are for emergency use only and that workers wishing to access Wylfa Head for recreational purposes will have to walk 4.7km in each direction to gain access. Horizon believe that this will deter casual visitors of Wylfa Head but there will still be some workers who wish to visit. Measures to manage increased visitors to Wylfa Head have been discussed and will be included in the Wylfa Head Landscape and Habitat Management Scheme which will require approval by IACC, as secured by Requirement WN11 of the draft DCO (APP-029). The measures that have been discussed with the North Wales Wildlife Trust and other stakeholders include fencing off the chough nesting site with an adequate buffer during the critical establishment period, way marking of routes across Wylfa Head away from the most sensitive areas, and installation of signs and interpretation boards informing visitors of sensitive areas to avoid. Workers residing in the Site Campus will be informed of the sensitive nature of Wylfa Head and the species it supports (including their legal protection where relevant). The Site Campus will also be designed to provide entertainment facilities on-site, reducing the potential need for workers to leave site for recreation. The Environmental Statement has considered the impact of the Site Campus and other construction activities, including major changes to landform within the Tre'r Gof catchment due to the construction of Mound A, and has concluded that there will be a significant adverse effect. The impacts have been mitigated as far as possible but there remains uncertainty over the effectiveness of this mitigation and therefore a worst case scenario has been assessed, resulting in predicted significant residual effects. As such Horizon are proposing to compensate the potential loss of Tre'r Gof SSSI through the creation of new fenland habitat and enhancement of existing fenland habitat on Anglesey. North Wales Wildlife Trust's concern on the management of topsoil is acknowledged by Horizon and the feasibility of different topsoil management options is under consideration for viability. This will be shared with the North Wales Wildlife Trust once the work is complete. The compensation site selection process, which is detailed in Appendix D9-23 (APP-190) has identified a compensation package with high potential to meet the compensation objectives through the provision of more than 10ha of rich-fen habitat creation and a further 20ha of enhancement of existing fen/mire habitats, as well as improving habitat connectivity between units of the Anglesey Fens SAC.		

Topic	Issue	SoCG ID	Document Reference/Signpost/ Route map	North Wales Wildlife Trust Position	Horizon Position	RAGs	Further actions required to progress discussion on the issue
Biodiversity net gain	European protected species, Section 7 species and Red Data Book species. Habitat connectivity within the restored landscape.	NWWT7	APP-424 / 425 8.16 Landscape and Habitat Management Strategy	The North Wales Wildlife Trust do not consider that the biodiversity principle of no net loss or net gain has been applied to habitats and those that support of protected species including European Protected Species, species listed under Section 7 of the Environment (Wales) Act 2016, red species listed in the Red Data Book or loss of marine habitats. The DCO application does not consider habitat connectivity within or relating to the wider landscape for recolonisation by protected or biodiversity species.	The principle of net biodiversity gain is secured through the Landscape and Habitat Management Strategy (LHMS, APP-424 and 425). Section 4 of the LHMS sets out the principles which secure net biodiversity gain. The principles are a controlled part of the document and therefore a commitment under the DCO which requires (Requirement WN11) their implementation through a series of Landscape and Habitat Management Schemes. The principles include a net increase in habitat for protected species including reptiles, chough, and bats, the enhancement of freshwater habitats for water vole and otter; and, an increase in the carrying capacity of a range of other notable and protected species listed in Annex A of the LHMS, across the WNDA once operational. Since the submission of the DCO application, Horizon have committed to offset the loss of ponds during construction through the creation of nine new ponds which will be designed and managed throughout operation for the benefit of wildlife. This is part of an updated LHMS (APP-424 and APP-425) that will be submitted at Deadline 2 (December 4th 2018). Section 4 of the LHMS contains a principal which requires the final landscape design to distribute the specified habitats in such a way as to facilitate the movement of species across the restored site and into the surrounding landscape. The principle specifically references connectivity with the Notable Wildlife Enhancement site. The indicative landscape design is one way in which this principle can be implemented and the final design is likely to closely resemble the indicative design. The final design will need to be approved by the IACC and the Council's officers will need to satisfy themselves that all of the habitat principles have been implemented in the design before approval can be issued.	Ongoing	North Wales Wildlife Trust to review amended LHMS submitted at Deadline 2.
	Loss of marine habitats.	NWWT8	APP-132 6.4.13 ES Volume D – WNDA Development D13 – The Marine Environment WN0902-JAC-PAC-TEC-00011 Marine ecological enhancement mitigation memorandum APP-444 8.26 Water Framework Directive Compliance Assessment APP-416 8.8 Marine Works sub-CoCP	The marine works will result in the direct loss of approximately 30ha of marine benthic habitat. The proposals for the mitigation for the loss of these marine habitats in both the DCO application and the issued memorandum is insufficient in both quality and quantity.	The direct losses of intertidal and subtidal habitats are assessed in DCO ES chapter D13 (APP-132) and in the WFD compliance assessment (APP-444). There would be a total loss of approximately 30.5ha of marine habitat, of which, 20ha have been classified as subtidal and intertidal habitats of conservation importance. The loss of habitats results from the footprint of the permanent and temporary marine works. This loss of habitat of conservation importance is assessed as being a moderate adverse effect within chapter D13 (APP-132) of the DCO ES. Additional mitigation through ecological enhancement will be provided to increase the diversity and biomass of ecological communities on the new marine structures resulting in a reduction of the effect on subtidal and intertidal habitats of conservation importance to minor adverse. Further details of the proposals for marine ecological enhancement of the breakwater have been provided to NRW in the form of a memorandum and have been added to the Marine Works sub-CoCP (APP-416) to be submitted at Deadline 2 (December 4th 2018). The memorandum provides an appraisal of the available measures and the feasibility and constraints of implementing for the Wylfa Newydd Project to satisfy the requirements of Test (a) of Article 4(7) of the WFD; to ensure that all practicable mitigation measures have been included in the project.	Ongoing	No further actions identified at this time.

Topic	Issue	SoCG ID	Document Reference/Signpost/ Route map	North Wales Wildlife Trust Position	Horizon Position	RAGs	Further actions required to progress discussion on the issue
	Long term maintenance and sustainability of recreated biodiversity habitats.	NWWT9	APP-424 / 425 8.16 Landscape and Habitat Management Strategy	The North Wales Wildlife Trust are concerned that the maintenance of habitats created as part of the site restoration will not be maintained for the operational & decommissioning lifetime of the project when land is returned / management transferred to other landowners. No mechanism has been identified to ensure compliance on transfer of title / tenancy	The LHMS (APP-424 and APP-425) sets out the information that will need to be included in the Habitat Management Schemes which are secured as a Requirement of the DCO. The Habitat Management Schemes will need to be approved by the IACC whose officers will need to be satisfied that they deliver the principles set out in the LHMS before approving the schemes. Horizon will have to ensure that the Habitat Management Schemes are implemented appropriately. There are a number of ways in which this could be achieved, including tenancy agreements with local farmers, licence agreements with local farmers, and the use of specialist contractors to undertake specific management activities. While it is acknowledged that the nature of the management delivery mechanism will have a bearing on management success, such detail is not considered necessary at this stage and the absence of such detail is not considered to detract from the adequacy or ambition of the habitat creation and management proposals contained within the LHMS (APP-424 and APP-425).	Not agreed	No further actions identified at this time.
Air quality	Air quality impacts on ecological receptors	NWWT10	APP-124 6.4.5 ES Volume D – WNDA Development D5 – Air Quality APP-140 6.4.21 ES Volume D – WNDA Development App D5-2 – Main Site Construction Phase Air Dispersion EIA – Final Modelling Report APP-128 6.4.9 ES Volume D – WNDA Development D9 – Terrestrial and Freshwater Ecology APP-415 8.7 Main Power Station Site sub-CoCP	The North Wales Wildlife trust have concerns on the air quality mitigation given the conclusion of adverse impacts on Tre'r Gof SSSI. There remain questions on evaluation parameters for other receptors sensitive to air quality. North Wales Wildlife Trust are concerned that there has been insufficient investigation of amelioration of impacts and whether the monitoring strategy will be effective.	The Environmental Statement chapters D5 Air Quality (APP-124) and Terrestrial and freshwater ecology (APP-128) predict a negligible adverse effect to Tre'r Gof SSSI from air quality impacts. With regards to Cae Gwyn SSSI, Horizon has committed to additional mitigation regarding reducing the emissions of NOx from construction plant in the DCO submission (tot be part of the updated Main Power Station Site sub-CoCP (APP-415) that will be submitted at Deadline 2) which will act to reduce adverse air quality effects at all ecological receptors. A revised air quality assessment screens out Cae Gwyn SSSI from requiring further ecological assessment in all aspects except nitrogen deposition, which is only above critical load value during construction year 2 (peak earthworks and marine works), and only by 2%. This revised assessment will be submitted to the Examining Authority for examination at Deadline 3.	Ongoing	North Wales Wildife Trust to review additional information in the amended sub-CoCPs submitted at Deadline 2.
Dredged materials	Beneficial reuse of dredged materials	NWWT11	APP-132 6.4.13 ES Volume D – WNDA Development D13 – The Marine Environment	The North Wales Wildlife do not agree with the proposal to dispose of dredged material at the Holyhead Deep disposal site. Beneficial reuse of the dredged material should be investigated and only once all other options have been ruled out should disposal be considered.	Excavated material from the inner harbour will be reused on site (e.g. for core material in the cooling water intake breakwaters). Dredged rock and soft sediments from the outer harbour will be disposed at the Holyhead Deep disposal site. There is insufficient space within the WNDA to stock pile excavated materials from the outer harbour area. The Environmental Statement Chapter D13 The marine environment (APP-132) assumes a worst case scenario which would be the disposal of the dredged material. Beneficial use of dredged material will be progressed if possible at detailed design.	Not agreed	No further actions identified at this time.

Appendix A – Memorandum WN0902-JAC-PAC-TEC-00011: Marine ecological enhancement mitigation

JACOBS

Memorandum

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Subject	**Marine ecological enhancement mitigation**	**Project Name**	Wylfa Newydd Project
Attention	Horizon Nuclear Power Ltd.	**Project No.**	60PO80AG
From	Jacobs UK Ltd.	**Document No.**	WN0902-JAC-PAC-TEC-00011 (Horizon)
Date	3 September 2018		60PO80AG/AQE/TM/002 (Jacobs)
Copies to	Tei Ho and Alex Herbert		

1. Introduction

On the 4th December 2017, Horizon UK Ltd. (Horizon) began engagement with Natural Resources Wales (NRW) regarding the proposal to include marine ecological enhancement measures as part of the Wylfa Newydd Project (referred to as 'the Project' hereon in). The purpose of these measures are to mitigate the significant moderate adverse effects to marine habitats and species of conservation importance from construction of the Marine Works[1], as identified within the marine environment chapter (chapter D13, Application Reference Number: 6.4.13) of the Environmental Statement.

During this initial meeting, Jacobs UK Ltd. presented the work done to date including ecological and design considerations, engineering constraints and the ecological enhancement measures under consideration. One of the actions taken away from this meeting was to provide NRW with further information regarding:

- the detailed literature review which was undertaken in April 2017 in relation to ecological enhancement measures; and
- the results of the feasibility study which was carried out in June 2017 to evaluate a number of ecological enhancement options.

The purpose of this memorandum is to provide NRW with the information requested; this is presented in Section 2 (literature review) and Section 3 (feasibility study) of this technical memo. To facilitate further engagement, any new information which has come to light since April 2017 and subsequently reviewed and assessed in relation to the Project has also been presented for completeness.

During the Statement of Common Ground (SoCG) meeting held on the 1st August, NRW made the comment that they considered there was "*insufficient detail on the proposed enhancement for marine elements to mitigate/offset damage to benthic habitats*". In response to this comment additional detail surrounding the ecological enhancement measures proposed as part of the DCO application has been included within Section 4 of this technical memo.

[1] The Marine Works includes: the permanent structures such as the breakwaters, Marine Off-Loading Facility (MOLF), cooling water intake and outfall, shore protection, and navigation aids; temporary structures such as the access ramp, barge berth, cofferdams and southern causeway; and the area that would be dredged and excavated.

Horizon is seeking ongoing consultation regarding marine ecological enhancement in order to reach an agreement with NRW that the level of mitigation proposed and the assessment presented within chapter D13 (Application Reference Number: 6.4.13) of the Environmental Statement with respect to the loss of benthic habitats and species due to construction of the Marine Works is appropriate.

2. Overview of the ecological enhancement literature review

This section provides an overview of the ecological enhancement literature review which was carried out in April 2017. The purpose of this literature review was to develop a detailed understanding of the science underpinning the concept of marine ecological enhancement and the potential measures which could be incorporated into the design of the permanent marine structures to mitigate for adverse effects to benthic habitats and species. This literature review culminated in a detailed report which aimed to achieve the following objectives:

1) to identify the key ecological and design considerations which should be borne in mind when developing ecological enhancement mitigation; and
2) to identify ecological enhancement measures that could be implemented at the design stage of the Project to achieve the ecological objectives of the mitigation.

The following sub-sections 2.1 to 2.4 summarise the contents of this detailed literature review and builds upon the information presented to NRW in December 2017.

2.1 Ecological design considerations

There has been an increasing amount of research into how the design of marine structures can be manipulated to enhance their ecological value (Moschella *et al.*, 2005; Chapman and Blockley, 2009; Martins *et al.*, 2010) and consequently, ecological enhancement measures are being considered increasingly during engineering design. In response to this, regulatory and non-governmental bodies have published limited guidance outlining recommendations for the inclusion of ecological enhancement measures in the planning and design of rock and concrete structures.

Key guidance includes the report published in 2011 by the Environment Agency's Evidence Directorate (Naylor *et al.*, 2011). The Manual on the Use of Rock in Hydraulic Engineering (CIRIA, 2009) also gives some broad considerations, as well as specific recommendations, but the most substantial piece of work on ecological enhancement of structures in Europe to date is the 'Environmental Design of Low-crested Coastal Defence Structures' (DELOS) project (www.delos.unibo.it), which ran as an international collaboration between 1998 and 2002. This study examined existing coastal defence structures in Europe and has produced the most comprehensive guidance for ecological consideration in engineering design to date (Burcharth *et al.*, 2007). This guidance (Burcharth *et al.*, 2007) along with that provided by Naylor *et al.* (2011) has been incorporated into a set of key design considerations outlined below.

Research into rocky shore ecology is also of key importance as this environment is considered to be the nearest natural equivalent to artificial structures and can therefore help identify those features of structures which could be manipulated for ecological gain (Thompson *et al.*, 2002; Chapman, 2003; Chapman and Bulleri, 2003; Moschella *et al.*, 2005). There is also an extensive literature base comparing the ecological benefits provided by artificial and natural rocky reefs. Reference is made to this research where it is believed to offer an insight into the potential capacity of the breakwater structures to operate as artificial rocky reefs.

Table 1 summarises the literature review undertaken to examine the design features which should be borne in mind when considering ecological enhancement of marine structures. Briefly, this considered:

- the position of the marine structure in the tidal frame;
- its gradient;
- its orientation and exposure to prevailing wind and wave conditions; and
- its surface and structural heterogeneity.

Table 1: A summary of the design features and associated evidence in literature which should be borne in mind when considering ecological enhancement of marine structures.

Feature	Evidence from literature	Key references
Position in the tidal frame (i.e. the area exposed/immersed)	Sessile, intertidal fauna and flora are able to withstand different degrees of stress (emersion, immersion) and therefore will only occupy a certain position along environmental gradients (e.g. high to low water mark, wave exposed to sheltered, etc.) within the tidal zone. This phenomenon is known as zonation. The position of artificial structures in the tidal frame influences the zonation of intertidal and subtidal species. If a larger proportion of the structure is located below mean tidal level then biological communities colonising the structure would be dominated by taxa such as kelps, which occur lower down in the tidal frame because of their limited tolerance to desiccation and thermal stress. Structures which sit higher within the tidal frame and therefore have a larger proportion above mean tidal level, would be colonised by biological communities dominated by taxa such as barnacles which are outcompeted at lower shore heights but are able to tolerate prolonged emersion on the high shore. Any area which sits above the mean high water spring mark is unlikely to be available for colonisation by marine organisms. The diversity of flora and fauna communities is also known to differ greatly between biotic zones, with lower regions of the shore generally exhibiting greater diversity and biomass.	Connell (1961) Lewis (1964) Dring and Brown (1982) Barnes and Hughes (1988) Evans (2015)
Gradient	Most naturally occurring rocky shores have a gentler gradient than artificial structures like breakwaters and steep sea walls. Vertical substrates support fewer mobile marine organisms due to the smaller extent of intertidal habitat available for colonisation. In addition, species resident on gentle gradients may not be able to survive on vertical surfaces, especially when the effects of wave action are significant. Whorff *et al.* (1995) for example, showed that the invertebrates and algal epiphytes associated with intertidal algal turfs were strongly influenced by the gradient of the substratum, possibly because of the amount of sediment trapped in the algal fronds. Steeper intertidal surfaces may, therefore, reduce habitat quality in addition to available area, resulting in differences in the composition of the associated communities.	Whorff *et al.* (1995) Glasby (2000) Chapman and Bulleri (2003)
Orientation and Exposure	Orientation and exposure can influence the wave and water flow dynamics around artificial structures. Orientation can also influence the degree of shading on epibenthic (surface) communities.	Underwood and Chapman (1998)

Feature	Evidence from literature	Key references
	The physical conditions experienced by organisms can differ greatly with location on the artificial structure owing to variations in orientation and exposure; this enables different species to colonise particular areas while others may be excluded. For example, reduced water movements on the leeward side of a breakwater could promote the growth of certain seaweeds (e.g. *A. nodosum* and *Fucus* spp.). Conversely increased water movement could suppress seaweed growth whilst promoting the presence of filter feeders such as mussels and barnacles. There are often significant interactions between the effects of orientation and exposure, with greater numbers of taxa and functional groups associated with rock pools positioned lower down in the tidal frame and those located in more exposed areas.	Chapman and Bulleri (2003) Moschella *et al.* (2005) Blockley and Chapman (2006) Blockley (2007) Jackson (2015) Firth *et al.* (2016b)
Structural heterogeneity	Microhabitats such as small pits and crevices are important for rocky shore biota, providing shade and refuge from desiccation, predation and disturbance. Structural heterogeneity not only increases the amount of surface area available for colonisation but also presents an increased edge effect, which facilitates the attachment and growth of benthic taxa and the development of communities on the substrate. Rock pools have been found to support more than twice the number of species than emergent areas. Similarly, more than three times the number of species (belonging to a greater number of taxonomic classes) has been found within crevices compared to adjacent rock surface.	Fairweather (1988) Gray and Hodgson (1998) Spieler *et al.* (2001) Jackson (2015) Ostalé-Valriberas *et al*., (2018)
Surface heterogeneity	The geology of the substrate (i.e. rock type and surface texture) has been shown to influence intertidal and subtidal assemblages at finer scales (millimetres). Rock type (e.g. granite and limestone) and texture can influence water drainage and ponding, which can generate microclimates as well as provide refuge for animals and plants from waves, predation, heat and desiccation stress. Moreover, a complex surface texture can increase the boundary layer near the surface thus increasing the likelihood of larval settlement compared to smooth surfaces. Substratum roughness is widely known to influence the initial settlement of marine invertebrate larvae and the subsequent development of epibenthic communities. Colonisation by barnacles, for example, is known to be strongly influenced by substratum texture with settlement and recruitment of barnacles and algal spores typically greater on rougher surfaces. The grazing efficiency of molluscs is also affected by surface roughness.	Crisp (1974) Raimoni (1988) McGuiness (1989) Fletcher and Callow (1992) Anderson and Underwood (1994) Johnson (1994) Jacobi and Langevin (1996) Hills and Thompson (1998) Lapointe and Bourget (1999) Berntsson *et al.* (2000) Wahl and Hoppe (2002) Moschella *et al.* (2005) Koehl (2007) Coombes (2011)

The key ecological and design conclusions/recommendations drawn from this review of literature were:

- to ensure a large proportion of the marine structures sit within the lower proportion of the tidal frame to maximise ecological diversity and biomass opportunities;
- to minimise the gradient of the marine structures with the purpose of increasing the surface area available within the three intertidal zones (lower, mid and high);
- to ensure a range of orientation and exposure conditions are available;
- to maximise structural heterogeneity across the surface of the marine structures, particularly within the intertidal and subtidal zone through the generation of cracks, crevices, overhangs and rock pools; and,
- to maximise surface heterogeneity to promote increased rates of colonisation and development towards communities of greater ecological value (e.g. larger biomass, diversity, the presence of rare or vulnerable species, etc.).

2.2 Invasive non-native species (INNS)

Through the ecological enhancement literature review it was identified that artificial structures often support a greater number of INNS than natural habitats as their surfaces are generally characterized by an absence of competition and predation (Glasby *et al.*, 2006; Airoldi *et al.*, 2015). They are also frequently constructed in highly disturbed environments that further favour the establishment of opportunistic species (Firth *et al.*, 2012). When multiple artificial structures are built relatively close to one another along stretches of coast comprising predominantly soft sediments, these structures can sometimes function as pathways or stepping stones, facilitating the spread and connectivity of both native and non-native marine species (Airoldi and Bulleri, 2011).

On the basis of the diversity resistance hypothesis, it is widely acknowledged that more complex or diverse communities can reduce the establishment of INNS (Stachowicz *et al.*, 2002; Arenas *et al.*, 2006; Naylor *et al.*, 2011; Firth *et al.*, 2016a). This, therefore, provides further argument for implementing ecological enhancement measures as part of the Project as these can improve the resistance of artificial structures to the establishment of INNS.

Understanding how the design of artificial structures can facilitate the introduction and establishment of key INNS of concern, and how ecological enhancement mitigation measures can be used to interrupt or obstruct interactions, could help reduce the impact of INNS on marine benthic habitats and species arising from the Project. For example, the green alga, *Codium fragile* (sub sp. *tomentosoides*) has been recorded within the Wylfa Newydd Development Area since 2015 and is known to rapidly colonise artificial structures such as breakwaters, preferring the more sheltered leeward side (Bulleri and Airoldi, 2005; Glasby *et al.*, 2006). Many other INNS considered to be key species of concern for the Project, also proliferate in sheltered harbour environments including, the leathery sea squirt, *Styela clava*, the wireweed *Sargassum muticum*, and the carpet sea squirt, *Didemnum vexillum* (Horizon, 2018). With this in mind, it may be wise to consider ecological enhancement measures which could be implemented at appropriate locations on the leeward side of the breakwater structures with the dual purpose of enhancing the ecology (i.e. habitat complexity) and minimising the risk of INNS becoming established within this region of the structures.

This illustrates the importance of considering in detail the interaction between the design of artificial structures (including ecological enhancement measures) and both the current and future ecology of the marine environment. The biosecurity risk assessment strategy for the Project outlines all the invasive non-native species of concern in north Wales (Horizon, 2018). For a vast majority of these species, their life history strategies and habitat requirements are well known and therefore it would be

possible to make assumptions about what ecological enhancement and other management measures could be implemented to minimise the risks presented by these particular INNS. It is also considered that this information should be used to help inform the type, location and extent of ecological enhancement proposed as part of the Project as well as the ecological objectives defined for these additional mitigation measures.

2.3 Timescales associated with marine ecological enhancement mitigation

In order to appropriately assess the effectiveness of ecological enhancement mitigation, it is important to understand the phasing of the Project and to be aware of the key milestones which might have a bearing on the decision as to whether the proposed mitigation is appropriate.

The construction phase would represent a period of net ecological loss under the footprint of the Marine Works, the magnitude of which can be measured by the time taken for construction to be completed which is estimated to be approximately two years. Furthermore, there would be a time lag between the effects of construction and the marine ecological enhancement measures achieving their ecological objectives. To estimate the potential duration of this time lag, it is necessary to understand rates of colonisation and community succession; these are discussed in Sections 2.3.1 and 2.3.2 below.

2.3.1 One to five years

Encrusting species such as *Corallina officinalis* and crustose brown algae of the family Ralfsiaceae, are believed to exhibit good recruitment and settlement rates on artificial surfaces (Loke *et al*., 2016). Studies have shown that new bases have appeared on sterilised plots within six months and 10% cover was reached within 12 months (Littler and Kauker, 1984). A number of studies have shown similar recovery rates, although it is unclear whether the more resistant crustose bases were thoroughly removed from the rock (Bamber and Irving, 1993). Evans *et al.* (2016) found coralline algae were notably absent following a 30-month monitoring period of artificial rock pools with only a small amount of *Lithothamnia* crust present in one artificial pool during the final survey, 30 months after construction. It is likely to take up to five years for encrusting species to become fully established on marine structures.

Ulva spp. are ephemeral seaweeds that are believed to be among the first to colonise newly available substrate, usually within weeks, depending upon availability of spores (Budd, 2007). It is, therefore, likely that species of *Ulva* and *Cladophora* would have a considerable capacity for recovery, as both genera are widespread and release motile gametes and spores making dispersal and attachment to the breakwater structures highly likely within a few years. Jackson (2015) observed a dominance of *Ulva* spp. within a year.

Fucoids (e.g. *Fucus serratus* and *Fucus vesiculosus*) recruit readily to barren areas, especially in the absence of grazers (Holt *et al.*, 1995). Jackson (2015) found fucoids replaced *Ulva* spp. on concrete armour units within one year. Although, whilst it is thought recruitment is likely to be reasonably rapid, recovery to a mature community structure is likely to take some years (Holt *et al.*, 1997). This is likely to be especially true for *Ascophyllum nodosum* which is a slow-growing species that generally exhibits poor recruitment. The reason for such poor recruitment is unclear; this species invests the same high level of energy in reproduction as other fucoids and is extremely fertile every year (Printz, 1959). However, the reproductive period only lasts for about two months which is much shorter than for other fucoids.

Within the subtidal zone, red algae have been found to colonise cleared concrete blocks within 26 weeks in the shallow subtidal (0.8 m) and 33 weeks at a depth of 4.4 m (Kain, 1975). Red algae persist throughout the early colonisation phase and have been found to increase in biomass from

0.04% to 1.5% within the first four years (Kain, 1975). Red algae produce non-motile spores and most recruitment is thought to occur within 10 m of the parent plants (Norton, 1992). This would likely delay colonisation of red algae on the marine structures, particularly for the more remote areas (e.g. western breakwater), although it is reasonable to assume red algae would be able to colonise the breakwaters within five years.

Kelp is a common subtidal species present within the footprint of the Marine Works and dominates a number of biotopes which cumulatively represent 20.0% of the total area. Kain (1975) examined recolonisation of cleared concrete blocks in a subtidal kelp forest and found a standing crop of *Laminaria hypoborea* similar to that of a virgin forest, present within 2.5 years of the blocks being cleared. Kelp species colonise at different rates which can vary temporally. Within the same study, blocks cleared in August 1969 were initially colonised primarily by *Laminaria saccharina* but subsequently colonised by *L. hypoborea*. Kain (1975) also observed temporal variations in the dominant colonists of cleared concrete blocks with brown algae dominant in the spring, green algae in the summer and red most important in the autumn and winter. The timing of construction could, therefore, have important implications for early settlers and the trajectory of community development.

Recruitment to rock pools is likely to be sporadic and variable (Metaxas and Scheibling, 1993). Initial colonisers of these environments are likely to be present within a year, whilst the development of recognisable rock pool biotopes may take up to five years. Evans *et al.* (2016) found total species richness on emergent rock reached carrying capacity (an asymptote population) after six months (24 species) but species accumulation curves for the artificial rock pools did not reach an asymptote even after 30 months of monitoring. This suggested that whilst artificial rock pools supported resident communities, they were also being used at different times of the year by transient and ephemeral taxa. It is thought that kelps could potentially colonise low shore rock pools within three to four years, depending on grazing and competition for space (Kain, 1975). Recovery of species such as *Chondrus crispus*, which is generally found on the middle to lower rocky shore and in rock pools, is likely to be relatively slow as holdfasts need to generate before thalli can grow (Holt *et al.*, 1995). However, Minchinton *et al.* (1997) documented the recovery of *C. crispus* after a rocky shore in Nova Scotia, Canada, was totally denuded by ice scouring and found that this species had re-established approximately 50% cover on the lower shore within two years.

In terms of fauna, gastropods and other mobile grazers (e.g. amphipods, isopods) are likely to be attracted by developing microalgae and macroalgae and could return quickly by either migration or larval recruitment. Epifaunal species vary in their recruitment rates; Sebens (1985; 1986) reported that rapid colonisers such as encrusting bryozoans, amphipods and tubeworms recolonised cleared rock surfaces within one to four months. Ascidians such as *Aplidium* spp. achieved significant cover in less than a year, and, together with *Halichondria panicea*, had reached pre-clearance levels of cover after two years. Anemones are thought to be able to colonise within four years (Sebens, 1986) but may take longer to reach mature abundances. The anemone *Urticina felina* exhibits poor recoverability due to limited dispersal and slow growth (Chia and Spaulding, 1972), though populations may recover within five years. *Mytilus edulis* populations are also considered to have a strong ability to recover from environmental disturbance (Seed and Suchanek, 1992; Holt *et al.*, 1998).

The DELOS project (Burcharth *et al.*, 2007) found the most commonly recorded fauna on low crested structures within two years of construction included barnacles (predominately *Semibalanus balanoides* and *Elminius modestus*), limpets (*Patella vulgata* and *P. depressa*) and littorinids (*Littorina littorea* and *L. saxatilis*). On the northern coast of northern Denmark, structures located within the lower tidal frame were found to be dominated by mussel *M. edulis*, particularly juveniles (<2 cm standard length) and the locally abundant bryozoan, *Electra pilosa*. Jackson (2015) reported similar findings and also observed an increase in the biomass of limpets over five years; although from four to five years, the numbers declined while the biomass still increased indicating inter-size competition (Boaventura *et al.*, 2003).

2.3.2 Five to 15 years

A number of taxa currently present within the footprint of the Marine Works are likely to take considerably longer to colonise the marine structures. For example, although the sexual spores and asexual propagules of lichens are probably widely dispersed by the wind and mobile invertebrates making colonisation of the breakwater structures likely, crustose lichen species exhibit low growth rates (0.5 - 1 mm/year) while foliose species may grow up to 2 - 5 mm/year. Fletcher (1980) suggests that newly exposed substratum needs to be modified by weathering and that initiation of new thalli is thought to take several years. Whilst increased surface heterogeneity may increase the colonisation rate of lichens to the breakwater structures, it is believed that it would take in excess of five years (Holt *et al.*, 1995).

For benthic fauna within the dredged/excavated area, the rate of recovery is dependent on a number of factors including the original faunal composition, sediment characteristics, proximity to 'healthy' populations, the size of dredge area, hydrodynamic regime and the programme of maintenance dredging (Hill *et al.*, 2011). The shortest recoveries occur in areas of highly mobile sands under conditions of strong tidal stress. These environments are characterised by opportunistic 'colonisation communities' which can recover very quickly (within six months in some instances (Newell *et al.*, 1998)). The longest recoveries occur in habitats that are less dynamic, particularly coarse sediments in areas of weak or moderate tidal stress. These environments are characterised by mature communities that include long-lived species such as bryozoans and large bivalves e.g. *Pecten* spp., *Chlamys* spp. (Hill *et al.*, 2011). The dominance of muddy sands and sandy muds within the footprint of the Marine Works coupled with the decrease in tidal stress (<1 knot) due to the presence of the breakwaters suggests that recovery is likely to take in excess of five years.

2.4 Ecological enhancement options

Ecological enhancement is a relatively new science which continues to receive considerable academic attention, with a growing number of experimental trials currently underway which are aimed at advancing knowledge of ecological enhancement measures. An increasing number of commercial trials and installations are also in existence in the UK and worldwide, but at present these remain relatively few with only four known ecologically enhanced hard coastal structures operational in the UK.

The first of these was the Shaldon and Ringmore Tidal Defence Scheme in Devon (Naylor *et al.*, 2012); however, the largest to date remains the coastal protection scheme at Hartlepool which included the creation of an 800 m granite rock revetment which was completed in 2016. This project is particularly significant as it was the first commercial example where ecological enhancement measures were included to mitigate indirect effects (from a loss of food resource) to internationally important waterbirds under the European Union Habitats Directive (European Commission., 1992). Other commercial projects which include ecological enhancement can be found on the Isle of Wight and at Bournemouth on the south coast of the UK (Arc Consulting, 2016). Worldwide, there have been a number of large scale commercial trials in Europe (Netherlands, Portugal), Middle East (Israel), North America (Seattle, New York and Vancouver) and Australia (Sydney) (see Naylor *et al.* (2011) for a detailed review).

Table 2 provides an overview of the most well-known ecological enhancement case studies to date including experimental and commercial trials. This body of evidence provides a business case for ecological enhancement, demonstrating 'proof of concept' and has been used to identify ecological enhancement options that may be relevant to the Project.

Table 2: Ecological enhancement options, including example installations, engineering performance and ecological benefits.

Option	Description	Ecological purpose	Example installations	Engineering performance	Ecological benefits
1. **To select ecologically favourable construction materials (e.g. limestone over granite or smooth pre-cast concrete) to stimulate colonisation**	Can be implemented across the whole structure or at specific locations depending on engineering constraints.	To increase surface heterogeneity at the millimetre to centimetre scale with the purpose of encouraging colonisation.	**Seawall at Hartlepool, UK** (commercial trial)	Granite was selected over more ecologically preferable (but expensive) local limestone. This construction material met the engineering performance requirements for its intended use.	Monitoring 12-18 months post-installation showed that the enhanced rock revetment supported quicker succession and had the same biotope and supported similar species densities as the baseline natural shore platform (Naylor *et al.*, 2017).
2. **To use textured armour or pre-cast units to stimulate colonisation**	Textured armour units such as specially selected natural textured rocks or pre-cast units such as ECOPODE™ manufactured by Concrete Layer Innovations (CLI) and Eco-Xbloc-I manufactured by Delta Marine Consultants (DMC).	To increase surface heterogeneity at the millimetre to centimetre scale with the purpose of encouraging colonisation. Pre-cast units available in a range of sizes (e.g. ECOPODE™) can also add structural heterogeneity at the centimetre to metre scale.	**ECOPODE™ units have been added to breakwaters in the Ospdaletti marina, Italy and coastal protection at Garachico, Tenerife** (commercial trials)	ECOPODE™ units have been subject to extensive testing to ensure their structural integrity is comparable to any other unit. Tests have included hydraulic stability, robustness and concrete strength, the results of which are available on their website (http://www.concretelayer.com/).	ECOPODE™ has been found to be naturally effective for marine life, with fish and other species rapidly recruiting to these structures due to the variety of difference sized shelters (CLI, pers. comm.).
			Eco-Xbloc-I have been trialled on a breakwater in Ijmuiden, the Netherlands (experimental trial)	The use of Eco-Xbloc-I is not considered to have a significant impact on the structural stability or the overtopping performance of the armour units.	The study in the Netherlands showed this measure to be effective in low and highly dynamic environments (Paalvast, 2011).
3. **To use pre-cast panel walls or units with tiles fitted to provide surface and structural heterogeneity**	This is the addition of textured marine or cement-based concrete tiles. Often installed on smooth plain cast concrete structures. DMC produce pre-cast Xbloc units with the embedded concrete tiles (e.g. Eco-Xbloc-II).	To increase surface heterogeneity at the millimetre to centimetre scale with the purpose of encouraging colonisation.	**Seawall at Hartlepool, UK** (commercial trial) **Seawall at Saltcoats harbour, Scotland** (experimental trial)	Commercial and experimental installations at Hartlepool and Saltcoasts were not considered to compromise the engineering performance of the structures as they were affixed onto the existing surface using natural cement and/or marine epoxy.	Ecologically enhanced tiles have been found to support greater habitat complexity, abundance and species richness compared to standard smooth plain-cast concrete (Naylor *et al.*, 2017).
			Eco-Xbloc-II have been trialled on a breakwater in Ijmuiden, the Netherlands (experimental trial)	Pre-cast units with integrated tiles (e.g. Eco-Xbloc-II) have a lower mass than conventional units. DMC has proposed increasing the thickness of the main body of the block proportionally to the number of tiles fitted; and increasing the	Establishment and growth of algae occurred almost immediately after placement and were found to be effective in low and highly dynamic environments (Paalvast, 2011).

Option	Description	Ecological purpose	Example installations	Engineering performance	Ecological benefits
				mass density of the concrete itself to improve engineering performance. Small alterations to the size of the Eco-Xblocs are not considered to affect their ability to interlock with one another and with conventional Xblocs.	
			Seawall, Seattle, USA (commercial installation)	Installation of the ecologically enhanced tiles were not considered to affect the engineering performance of the structure.	Different organisms showed different responses to surface texture (e.g. mussels preferred cobbled textures over smooth surfaces) (Goff, 2010).
			Rock rubble breakwater, Elmer, East Sussex, UK (experimental trial)	Installation of the ecologically enhanced tiles were not considered to affect the engineering performance of the structure.	Holes increased diversity of species two-fold compared to smooth concrete panels (Moschella *et al.*, 2005).
4. To retro-fit pits, cracks, crevices and grooves into armour rock	This can be achieved by drilling or scoring the armour rock.	To increase surface heterogeneity at the millimetre to centimetre scale with the purpose of encouraging colonisation.	**Coastal defence structures at Runswick Bay, North Yorkshire, Plymouth Sound, Boscombe, Poole Bay, Dorset** (experimental trials)	The size and density of the features was such that it was not considered to adversely affect the engineering performance of the armour rock.	A significant increase in species richness and species diversity was found on the ecologically enhanced rock amour compared to unenhanced controls (Jackson, 2015; Hall *et al.*, 2018).
			Shaldon and Ringmore Tidal Defence Scheme (commercial installation)	Monitoring has shown no negative effects on material integrity due to the presence of niche habitats.	Eighteen months following installation, nine invertebrate species were found associated with the enhancements. Overall, the enhancements increased abundance and diversity (Naylor *et al.*, 2012).
5. To retro-fit rock pools to armour rock	Water retaining features can be created by coring rock pools into armour rock.	To increase structural heterogeneity at the centimetre to metre scale.	**Armoured breakwater at Tywyn, Wales** (experimental trial)	The size and density of the features was such that it was not considered to adversely affect the engineering performance of the armour rock.	The pools supported higher biodiversity than surrounding surfaces without water retaining features. When comparing to natural rock pools, the artificial rock pools supported a similar number of species; however, community structure differed (Evans, 2015).

Option	Description	Ecological purpose	Example installations	Engineering performance	Ecological benefits
			Causeway, Galway Bay (experimental trial)	The City Council Engineer approved the modification of the Shepard Hill Energy Dissipation Units. The modifications also survived the winter storms of 2014.	Twelve months after installation, lower and exposed pools supported greater diversity than upper pools (Firth *et al.*, 2016a).
6. To install prefabricated rock pools or rock pool features during design	Installation of prefabricated units such as those offered by ECOncrete® and Vertipools by Artecology. These are fixed (cemented) into existing rock structures.	To increase structural heterogeneity from the centimetre to metre scale.	**ECOncrete®'s rock pools installed at the Brooklyn Bridge Park, USA** (experimental trial)	Rock pools have also developed in line with the performance requirements of specific projects. For example, in New York, rock pools were specifically designed to have up to 5 - 8% of air (freeze and thaw) resistance, 40 MPa and anti-crack structural fibres.	Found to create well-defined local ecosystems that mimic natural rock pools typical to rocky coasts, and increase local biodiversity and biological productivity (Perkol-Finkel, pers. comm.).
			Vertipools on seawall, Isle of Wight (commercial installation)	The size and density of the features was such that it was not considered to adversely affect the engineering performance of the armour rock.	Field testing has demonstrated that these features provide refuge for key species and support higher species richness than natural shore pools (Hall *et al.*, 2018).
			Artificial pools in a vertical sand stone wall, Sydney Harbour, Australia (commercial trial)	The size and density of the features was such that it was not considered to adversely affect the engineering performance of the armour rock.	Invertebrate species richness was increased after one year, with pool biodiversity greater than adjacent walls (Chapman and Blockley, 2009).
7. To install prefabricated ecologically enhanced units	Pre-cast concrete units (e.g. BIOBLOCKS™ and ECOncrete®'s armouring units) are designed to incorporate multiple habitat types on the different faces of the block. These units can be placed between existing rocks on the structures.	To increase surface and structural heterogeneity from the millimetre to metre scale.	**BIOBLOCKs at Colwyn Bay, West Wales** (academic trial)	Although constructed from marine grade concrete, no formal assessment of the structural integrity of BIOBLOCKS™ has been conducted to date. BIOBLOCKS™ were positioned on the opposite side of a groyne to the prevailing current to ensure their presence did not compromise the functioning of the breakwater as a coastal defence structure.	The BIOBLOCK™ was found to support a greater biodiversity than the surrounding rock revetment (Firth *et al.*, 2014).

Option	Description	Ecological purpose	Example installations	Engineering performance	Ecological benefits
			ECOncrete®'s armouring units, Haifa, Israel (academic trial)	ECOncrete® has undertaken structural testing of its ecological enhancement units to ensure compliance with ASTM/EN standards including, but not limited to, compressive strength (ASTM C 39 (AASHTO T 22)), water pressure penetration resistance (EN 12390-8), and chloride ion penetration resistance (ASTM C1202-12).	The abundance, richness and diversity of invertebrates and fish were higher on and around the ECOncrete®'s armouring units compared to standard units, whilst the ratio of invasive to local species was considerably lower (Sella and Perkol-Finkel, 2015).

3. Ecological enhancement feasibility study

This section provides details of the ecological enhancement feasibility study which was carried out in June 2017. This feasibility study examined the ecological enhancement measures identified in Section 2.4 and considered project specific design information (see Section 3.1) and engineering and Project constraints (see Section 3.2) in order to evaluate potentially feasible ecological enhancement measures for the Project. The outcome of this feasibility study is summarised in Table 3 (Section 3.3) below.

3.1 Design of the Marine Works

The Marine Works include two breakwater structures which would be rubble mound, overlaid with pre-cast concrete armoured Xblocs. The western breakwater would be 400 m long, comprising a 300 m southern element unconnected to the coast and a 100 m northern element. The eastern breakwater would be approximately 150 m long at the crest and connected to the shoreline by shore protection made of armour rock; the slope of armour rock and the breakwaters would be 1 in 4/3 (1 in 1.5 along the 300 m leeward face of the western breakwater). The eastern and western breakwaters would have a combined surface area of approximately 58,899 m^2. A small region on the leeward side of the western breakwater (approximately 4,755 m^2) would also be comprised of armour rock.

The MOLF would be comprised of two quays (bulk quay and Roll on Roll off (Ro-Ro) quay) and a layby berth. The bulk quay would be comprised of two berthing platforms, each with four mooring dolphins (i.e. eight in total). The area between the two platforms would represent shore protection comprising either rock revetment with a 1 in 1.5 slope and a total area of 1,171 m^2 or a continuous vertical quay wall. The Ro-Ro quay represents a 100 m long quay wall whereas the layby berth would consist of a series of berthing and mooring dolphin structures.

It is anticipated that the walls of the bulk berthing platforms and Ro-Ro quay would be constructed of pre-cast mass concrete blockwork structures. The mooring dolphins would either be similarly constructed in pre-cast mass concrete blocks or using large diameter steel mono-piles socketed into the seabed or multi-pile dolphins similarly socketed into the seabed.

3.2 Engineering and project constraints

Preliminary discussions with Horizon and their engineering partners identified that it would not be possible to influence the orientation, gradient and position of the marine structures, notably the breakwaters, owing to engineering constraints with regards to the primary aim of the breakwater structures which is to create acceptable wave conditions for the operation of the cooling water intake. An additional constraint is the requirement to ensure an even flow field and low approach velocities (<0.3 m/s) at the cooling water intake to mitigate fish entrapment.

As Xblocs are interlocking units which conform to a specific design (i.e. packing density, unit size, placement distance, etc.) defined by the project specification and the hydrodynamic conditions, it is not possible to ‘open up’ this design at the risk of compromising the integrity and primary function of the breakwater structures.

A project constraint stipulated by Horizon in accordance with the Marine Licence Application was that any marine ecological enhancement mitigation must be carried out within the Order Limits. In the event that the marine ecological enhancement measures proposed by Horizon were considered insufficient, or that the mitigation measures failed to meet their objectives, therefore triggering a requirement for further mitigation, Horizon would look to explore opportunities which did not have a physical presence within the marine environment (e.g. funding for research projects examining ecological enhancement).

3.3 Ecological enhancement options

Table 3 summarises the findings of the feasibility study which examined each ecological enhancement measure identified during the detailed literature review and assessed whether there were any engineering or project constraints which would prohibit application to the Project.

Table 3: Feasibility study of ecological enhancement measures in relation to the Project.

Option	Engineering design and constraint	Feasibility of option
1. To select ecologically favourable construction materials (e.g. limestone over granite or smooth pre-cast concrete) to stimulate colonisation	It involves considerable challenge to procure armour rock, particularly units measuring 9 m^3 and 16 m^3 including quarry production, transportation, logistics as well as placement on the breakwaters themselves. Furthermore, natural rock does not possess the same interlocking properties as engineering concrete armour units and therefore generally, armour rock units are required to be larger in order to achieve the same engineering performance. This and the aforementioned challenges were the primary reasons for the decision to use concrete armour units for the breakwater design. There are a range of types/brands of concrete armour units. Xbloc was chosen due to its previous performance record in the UK/European environment/context.	Owing to the requirement to use concrete armour units (specifically Xbloc) for the design of the breakwaters, it is not possible to alter the construction material of these structures. However, there is potential to modify the construction materials within the regions of armour rock on the inner face of the western breakwater and along the eastern margin of the eastern breakwater.
2. To use textured armoured or pre-cast units to stimulate colonisation (e.g. Eco-Xbloc-I and ECOPODE™)	No engineering constraints have been identified in relation to the use of textured pre-cast Xbloc units such as Eco-Xbloc-I as these could simply be inserted in place of standard units. However, it has been identified that this option would present a small impact to the construction schedule owing to the additional time required for casting and the requirement to produce bespoke moulds with form-liners which would require replacement on a regular basis. Given the requirement to use Xblocs over much of the surface area of the breakwaters and given the reasons described above for option 1, it would only be possible to use other textured pre-cast units (e.g. ECOPODE™) in the areas of armour rock. However, to allow the pre-cast units to be inserted in place of armour rock units, they would need to possess the same mass density (e.g. 3-6 tonnes). Pre-cast units possessing a smaller mass density than the armour	Whilst in principle, the use of Eco-Xbloc-I is feasible, there are schedule impacts associated with this option and therefore it is undesirable from a Project perspective. There are engineering and logistical constraints associated with the use of textured pre-cast units within the regions of armour rock and therefore although feasible in principle, this option is undesirable from a Project perspective.

Option	Engineering design and constraint	Feasibility of option
	rock units could be added on top of the structure but it is considered a high risk that these would be washed away during storm conditions.	
3. To use pre-cast panel walls or units with tiles fitted to provide surface and structural heterogeneity	The addition of textured tiles recessed into pre-cast units (e.g. Eco-Xbloc-II) decreases the overall mass of the units and could have implications for their hydraulic stability. Whilst manufacturers of such products suggest marginally increasing the thickness of the main units to address this issue, there is additional concern that the tiles could de-bond over time forming a weakness plane which could cause individual units to become unstable. There is currently no evidence to suggest that the addition of tiles has no effect on the structural integrity units and therefore there is concern regarding their application to commercial projects.	This option is not considered feasible on the grounds that the structural integrity of such measures remains untested.
4. To retro-fit pits, cracks, crevices and grooves into armour rock.	This option would decrease the mass density of armour rock units and could have implications to their hydraulic stability. There is currently no evidence which suggests that modifications to armour rock has no effect on their structural integrity and therefore there is concern regarding the application of this option to commercial projects.	This option is not considered feasible as its implications to the structural integrity of armour rock remains untested.
5. To retro-fit rock pools to armour rock.	This option would decrease the mass density of armour rock units and could have implications to their hydraulic stability. There is currently no evidence which suggests that modifications to armour rock has no effect on their structural integrity and therefore there is concern regarding the application of this option to commercial projects.	This option is not considered feasible as its implications to the structural integrity of armour rock remains untested. However, this option is considered feasible if implemented under the footprint of the temporary causeway once removed.
6. To install prefabricated rock pools or rock pool features during design.	No engineering constraints have been identified in relation to the installation of prefabricated rock pools on the Permanent Marine Works.	This option is considered feasible.
7. To install prefabricated ecologically enhanced units.	Given the requirement to use Xblocs over much of the surface area of the breakwaters and given the reasons described above for option 1, it would only be possible to use other textured pre-cast units (e.g. ECOPODE™) in the areas of armour rock. However, to allow the pre-cast units to be inserted in place of armour rock units, they would need to possess the same mass density (e.g. 3-6 tonnes). Pre-cast units possessing a smaller mass density than the armour rock units could be added on top of the structure but it is considered a high risk that these would be washed away during storm conditions	There are engineering and logistical constraints associated with the use of textured pre-cast units within the regions of armour rock and therefore although feasible in principle, this option is undesirable from a Project perspective.

4. Further detail on the ecological enhancement mitigation presented in the DCO application

Within the DCO application ecological enhancement is presented as an additional mitigation measure intended to address the moderate adverse effect to subtidal and intertidal habitats and species of conservation importance arising from the direct loss of habitat under the footprint of the Marine Works (see chapter D13, Application Reference Number: 6.4.13) of the Environmental Statement.

This additional mitigation forms part of the ecology and landscape management strategy secured in the Marine Works sub-Code of Construction Practice (sub-CoCP) (Application Reference Number: 8.8) and states that:

"*Marine ecological habitat enhancements measures will be provided in suitable locations unconstrained by engineering design and functionality, to include pre-cast ecological units (e.g. rock pools or features similar to bio-blocks) and modification of the permanent artificial structures (e.g. construction material, surface roughness or the addition of surface features). The purpose of marine ecological enhancement measures would be to increase surface and structural heterogeneity, encouraging the colonisation of native marine species and the establishment of diverse and productive intertidal and subtidal habitats within the footprint of the Marine Works*" [paragraph 11.2.1].

Furthermore, as part of this strategy it is proposed that a method statement would be developed to include "*measures for the protection of existing rocky shoreline beneath the temporary causeway*" which would include "*making good of the intertidal zone on removal of the temporary causeway, to restore a natural appearance, similar to the adjacent shore, where practicable*" [paragraph 11.4.1].

During the recent SoCG meeting held on the 1st August, NRW requested additional detail regarding the ecological enhancement measures proposed within the DCO application. To expand upon paragraph 11.2.1 of the Marine Works sub-CoCP (Application Reference Number: 8.8), Horizon has provided detail about a number of specific ecological enhancement measures which would be implemented to mitigate effects to benthic habitats and species. These measures, listed here, are described in detail within the subsequent sections:

1. the addition of up to 10 pre-cast vertical rock pools on the MOLF wall;
2. seeding of the breakwaters and adjacent areas with natural rock where practicable;
3. actively maintaining surface roughness of intertidal and subtidal areas subject to dredging as part of the Marine Works;
4. monitoring of the permanent marine structures and ecological enhancement measures following construction; and
5. provision of relevant monitoring data to academic institutes to facilitate research into sustainable marine infrastructure.

In addition, Horizon has taken the opportunity to expand upon paragraph 11.4.1 of the Marine Works sub-CoCP (Application Reference Number: 8.8) and provide further detail about the shoreline protection and restoration method statement.

4.1 Pre-cast vertical rock pools

As detailed in Table 1, studies have shown that vertical substrates support fewer marine organisms, particularly mobile species, compared with substrates with a gentler gradient (Glasby, 2000;

Chapman and Bulleri, 2003). This is primarily because of the lack of physical complexity, particularly horizontal surfaces and features which provide shelter from the effects of emersion.

Intertidal rock pools are known to be important features of natural rocky shores, providing habitat for specialist fauna and flora, but also refuge during times of stress for many other species that also use the surrounding rock platform. If artificial structures can be engineered to include habitats that function as rock pools, local diversity may be enhanced and species that are generally confined to the low shore levels may be able to expand their distribution over a greater tidal range (Chapman and Blockley, 2009; Firth *et al.*, 2013; Evans *et al.*, 2016; Ostalé-Valriberas *et al*., 2018). The presence of rock pools on otherwise smooth uniform structures can also increase the edge effect facilitating the attachment of algae.

The MOLF wall is approximately 380 m long (see the detailed plans for the Marine Works, Application Reference Number: 2.6.3) and presents a surface which could be ecologically enhanced to facilitate the colonisation and establishment of marine organisms and habitats on this structure. Consequently, Horizon proposes to incorporate up to 10 pre-cast vertical rock pools similar to vertipools (Figure 1) on the MOLF wall between the fenders. The purpose of the vertipools would be to create water retaining features at points above mean high water springs to increase the surface area available for intertidal species and habitats.

Providing Horizon can confirm that these pre-cast rock pools would not inhibit the operation of the MOLF and therefore the Project schedule, these would be installed during construction. Otherwise they would be installed retrospectively once the operational phase of the MOLF is complete.

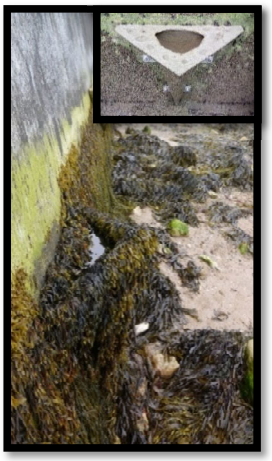

Figure 1: Pre-cast vertipools manufactured by Artecology (http://www.artecology.space/).

4.2 Seeding permanent marine structures with natural rock

Although the majority of the breakwater structures will be comprised of pre-cast concrete armoured Xbloc units, there is an area of armour rock located on the harbour side of the southern element of the western breakwater (Figure 2). This armour rock would cover a total area of 0.3 ha; of this 0.2 ha would occur within the intertidal zone whilst the remaining 0.1 ha would occur subtidally[2].

[2] Note these areas are based on the preliminary engineering design of the breakwaters and may be subject to small changes during development of the detailed design.

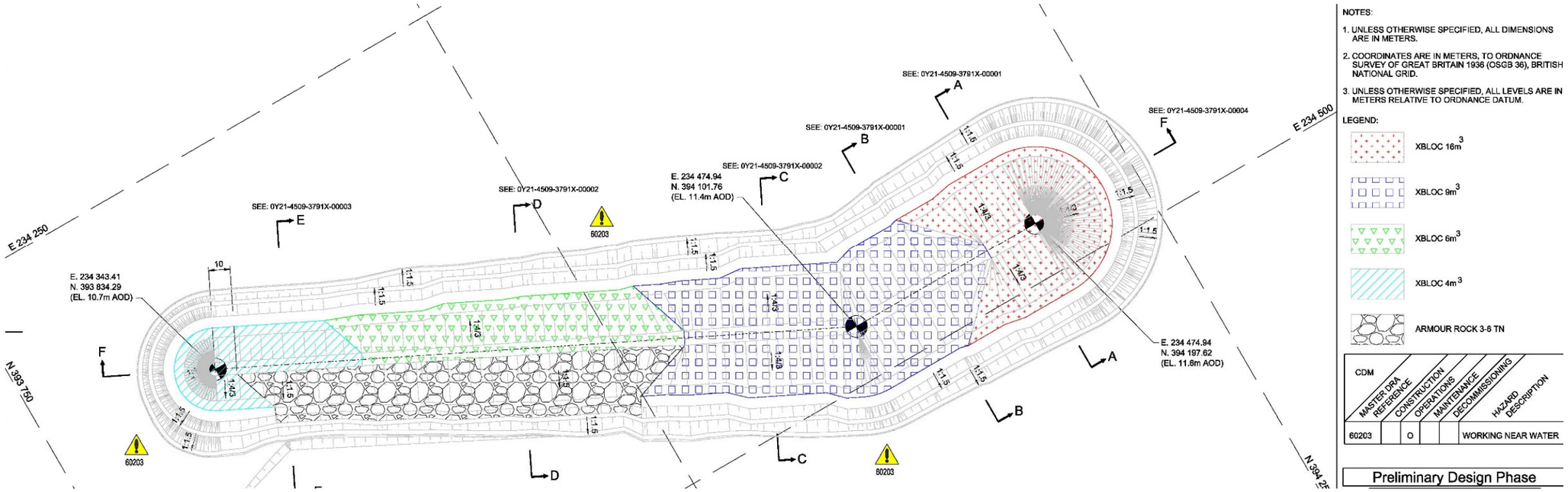

Figure 2: Preliminary engineering design of the western breakwater showing the area of armour rock.

Horizon are proposing to seed this area and any other areas of armour rock with natural rock won from the Marine Works, where practicable. The extent to which this would be feasible depends on the size of the material excavated; each rock would need to weigh 3-6 tonnes to be able to be used within the armour rock.

This excavated material would be non-uniform in shape and therefore possess both surface and structural heterogeneity that would be expected to facilitate colonisation and the establishment of intertidal and subtidal habitats at a greater rate than the adjacent pre-cast armoured Xbloc units. The location of this ecological enhancement measure on the leeward side of the western breakwater would be considered to help minimise the risk of INNS establishment, many of which are known to proliferate in sheltered harbour environments (see Section 2.2 for more information).

There are also aesthetic benefits associated with this ecological enhancement measure, with armour rock won from the site possessing an appearance more akin to the natural rocky shore found along the coast of Anglesey. It is also acknowledged that the use of material won from the site is more sustainable than importing quarried material from elsewhere.

4.3 Actively maintaining surface roughness

An area of approximately 17 ha within the harbour would be dredged and excavated during construction. For the purpose of assessment within the DCO application, this area has been assumed to be permanently lost (see chapter D13, Application Reference Number: 6.4.13, of the Environmental Statement).

On completion of the Marine Works and removal of the temporary cofferdam, this area would be largely unaffected by the remaining construction activities. During operation of the Power Station, there may be a requirement to carry out maintenance dredging within the approaches of the Cooling Water Intake channel; however, it is expected that the frequency of this activity would be low. This assumption has been made based on the hard nature of the substrate and the limited deposition that is predicted to occur within the harbour (see chapter D13, Application Reference Number: 6.4.13) of the Environmental Statement).

Horizon and their engineering partners have confirmed that as part of the dredging and excavation operations, the seabed within the harbour would not be scraped smooth but rather left with a surface roughness of ±250 mm. The purpose of this would be to provide surface heterogeneity to promote recolonisation of the area and the establishment of more complex habitats which would help reduce the risk of INNS becoming established subtidally within the harbour.

4.4 Monitoring

Within the DCO application, Horizon has made a commitment to implement a monitoring programme for INNS (see the Marine Works sub-CoCP (Application Reference Number: 8.8). As shown in Section 2.2 above, ecological enhancement measures which facilitate the development of more complex habitats can help reduce the establishment and spread of the INNS.

Given the relationship between INNS and ecological enhancement, Horizon confirms that the current commitment to monitoring for INNS would include monitoring of the ecological enhancement measures. This would have the dual purpose of assessing the benefits of ecological enhancement in relation to INNS whilst also assessing the effectiveness of the enhancement measures against a suite of clearly defined ecological goals. The monitoring data would be used to permit adaptive management and inform the decision to implement further enhancement if necessary.

4.5 Supporting academic research

Horizon recognizes that ecological enhancement is an expanding area of science which is currently receiving considerable academic attention. Of particular relevance is the European funded Ecostructure Project which represents a collaboration between three Welsh (Aberystwyth, Bangor and Swansea University) and two Irish institutions (University College Dublin and University College York).

Horizon has initiated contact with academic experts and institutes currently undertaking research in ecological enhancement to begin fostering links within the field. It is Horizon's intention to provide relevant monitoring data to academic institutes for the purpose of supporting research into sustainable infrastructure.

4.6 Shoreline protection and restoration method statement

As part of the shoreline protection and restoration method statement, Horizon proposes to restore the intertidal and subtidal area located under the footprint of the temporary causeway once this structure is removed, and the adjacent intertidal area to the east where disturbance of habitats is also likely to occur.

The restoration method statement would aim to restore a total area of 4 ha; 3 ha would be located subtidally whilst the remaining 1 ha would be located intertidally (i.e. on the foreshore). The biotopes known to be present in the area as identified during the 2014 biotope mapping survey (see appendix D13-3 Porth-y-pistyll Biotope Surveys Report, Application Reference Number: 6.4.85, of the Environmental Statement) are shown in Figure 3.

The shoreline protection and restoration method statement would aim to achieve the following:

- to restore the topography of the substrate including gradient and structural heterogeneity;
- to reinstate the 15 rock pools measuring greater than 1 m^2 that are currently known to be present within the area; and
- to develop the same or similar rock pool biotopes to those currently known to be present within the area.

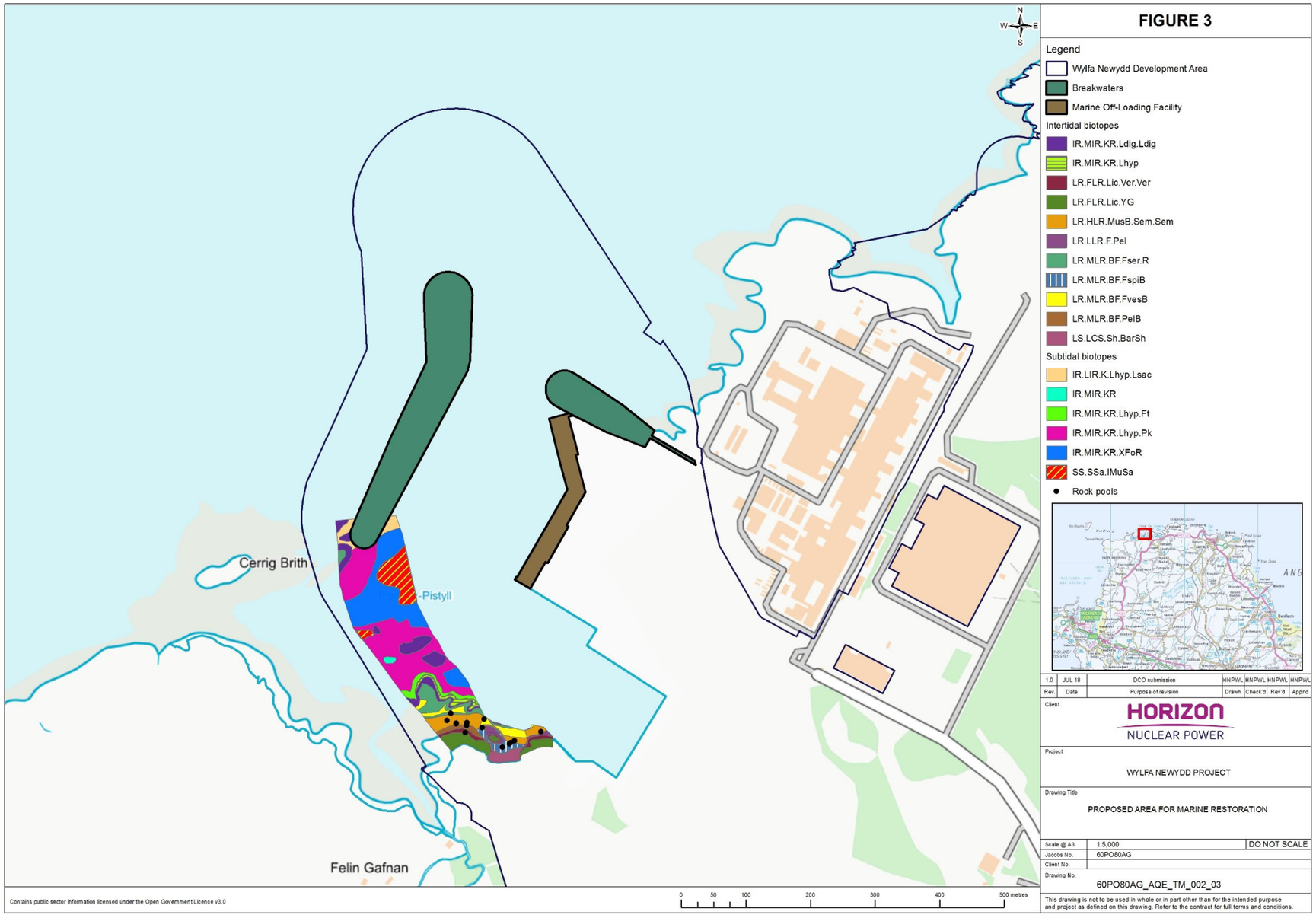

Figure 3: Intertidal and subtidal area which would be restored following removal of the temporary causeway.

The content of the shoreline protection and restoration method statement for the Project would include:

- a clear rationale as to why restoration is needed;
- an ecological description of the areas of historical state and/or trajectory;
- a statement of the goals and objectives of the restoration plan;
- explicit plans for site preparation, installation and post-installation activities;
- well-developed and explicitly stated standards with details of monitoring protocols by which the plan can be evaluated; and
- at least one control site in the vicinity, where feasible, for the purposes of comparison with the restored environment or ecosystem.

It is recognized that owing to changes to the hydrodynamic conditions within the harbour following construction of the Marine Works, it is unlikely that it would be possible to completely restore the area to its previous natural state. Therefore, the goal would be to facilitate recovery along an alternate trajectory towards a climax community which would provide comparable ecosystem processes and services.

In accordance with the guidance provided by The Society for Ecological Restoration Science & Policy Working Group (SERSPWG, 2002), the shoreline protection and restoration method statement would broadly seek to achieve habitats which:

- contain species assemblage's characteristic of the wider rocky coastline of Anglesey;
- consist of native species to the greatest practicable extent;
- contain functional groups necessary for continuous development and/or stability of communities;
- consist of a physical environment capable of sustaining reproductive populations;
- are suitably integrated into the larger ecological matrix or landscape;
- are sufficiently resilient to endure the normal periodic stress events characteristic of the area; and
- are self-sustaining to the same degree as reference habitats or environments, and have the potential to persist indefinitely under existing environmental conditions.

The monitoring programme described in Section 4.4 would also cover the area intended to be restored in order to assess the effectiveness of this mitigation measure against the broad ecological objectives described above.

5. Conclusions

This technical memo has sought to demonstrate to NRW, Horizon's understanding of ecological enhancement and how ecological enhancement measures can be incorporated into the design of the Marine Works to mitigate effects to marine habitats and species of conservation importance arising from these construction works.

Horizon has carried out an ecological enhancement feasibility study to examine whether each measure can be applied to the Project in light of the engineering and project constraints; this information is detailed in Section 3.

The information outlined in Section 4 provides additional detail in relation to ecological enhancement mitigation which is above and beyond that outlined in the DCO application (see the Marine Works sub-CoCP, Application Reference Number: 8.8). Horizon considers this additional detail to have addressed NRWs comment made during the recent SoCG meeting in relation to this topic and welcomes agreement from NRW that in light of this information, the assessment of direct habitat loss made within chapter D13 (Application Reference Number: 6.4.13) of the Environmental Statement remains appropriate.

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