15 MARINE PHYSICAL ENVIRONMENT

15.1 Introduction

15.1.1 This chapter of the Environmental Appraisal describes the baseline environment in terms of the marine physical environment and marine processes; identifies the potential pressures associated with the Proposed Marine Works on the receptors; and presents the findings of the environmental appraisal and any proposed mitigation measures where applicable.

15.1.2 The boundary of the Marine Environment Area which nominally follows mean high-water springs (MHWS) within the wider project Area of Search for Permanent and Temporary Works (see Figure 1.1), has been agreed in consultation with Natural Resources Wales (NRW). The Proposed Marine Works are defined as the components of the Proposed Project that fall below MHWS and include the following:

- Removal and dismantling of two pylons and their foundations (4ZC030R and 4ZC031) and the associated temporary access tracks to these locations;
- Removal of the foundations of the previously dismantled pylon 4ZC030; and
- Installation of the tunnel and cables within the tunnel.

15.1.3 The main features of the Marine Physical Environment within the Marine Environment Area are the Dwyryd estuary channel, the estuary sandflats and the surrounding saltmarsh.

15.2 Data Sources

15.2.1 This chapter has been informed by baseline data compiled from publicly available sources. The main information sources include:

- Designated habitat features of the Pen Llŷn a'r Sarnau / Lleyn Peninsula and the Sarnau Special Area of Conservation NRW (2018)[1];
- Detailed topographic levels across the saltmarsh, provided by NRW composite LIDAR data (www.lle.gov.wales/Catalogue/Item/LidarCompositeDataset);
- Bathymetry survey of main channel areas downstream of Pont Briwet from July 2017, Structural Soils (2017)[2];
- Google Earth aerial imagery, providing indications of previous channel alignments and saltmarsh extents, notably for 2006, 2009 and 2016;

[1] Natural Resources Wales (NRW). (2018), 'Pen Llŷn a'r Sarnau / Lleyn Peninsula and the Sarnau Special Area of Conservation. Advice provided by Natural Resources Wales in fulfilment of Regulation 37 of the Conservation of Habitats and Species Regulations 2017.'

[2] Structural Soils (2017), VIP Snowdonia bathymetry survey July 2017.

- Sentinel 2 satellite imagery from 2018 to present day from European Space Agency (ESA) showing contemporary changes in channel alignments and saltmarsh extents;
- Water level measurements from Porthmadog, provided by NRW for period 1993 to 2018;
- Pont Briwet Environmental Statement Gwynedd Council (2011)[3], with reference to:
    - Ground investigation surveys Norwest Holst (2009)[4];
    - Hydraulic modelling study Civil Engineering Solutions (2011)[5];
    - Geomorphological report Fluvio (2011)[6]; and
    - Scour and sediment modelling study Gwynedd Council (2011)[7].
- Environmental Statement for the erection of Pylon 4ZC030R National Grid (2015)[8].

15.2.2 The Pont Briwet Project represents recent major construction works in an area immediately upstream of the Proposed Marine Works and provides both relevant baseline information as well as direct evidence of how the estuary has responded since works were completed.

15.3 Scope and Methodology

Scoping

15.3.1 This chapter of the Environmental Appraisal has been prepared in accordance with the VIP Snowdonia Screening and Scoping Report (National Grid 2018)[9] and subsequent Screening/Scoping Opinion issued by NRW Marine Licensing (on 10 December 2018).

15.3.2 The Screening and Scoping Report concluded that the Proposed Marine Works represent a short-term pressure on the marine physical environment primarily involving the excavation of pylon foundations which although will disturb small areas of saltmarsh, are not expected to interfere with marine processes. The Screening

[3] Gwynedd Council. (2011), '*Pont Briwet – Transportation Improvement Scheme. Environmental Statement.*'

[4] Norwest Holst. (2009), '*Report on a Ground Investigation at Pont Briwet, North Wales*'

[5] Civil Engineering Solutions. (2011), 'Pont Briwet – Transportation Improvement Scheme. Hydraulic Modelling Report'

[6] Fluvio. (2011), 'Geomorphological assessment of the Pont Briwet replacement on the Afon Dwyryd: July 2011 update'

[7] Gwynedd Council. (2011). 'Pont Briwet - Transportation Improvement Scheme. Scour and Sedimentation Modelling Report' (80406 GC 644 ED 09).

[8] National Grid. (2015), 'Environmental Statement – Emergency Erection of a Replacement Tower and Ancillary Works near Penrhyndeudraeth, Gwynedd Retrospective Application for Electricity Act Consent.', TEP.

[9] National Grid (2018), *'Visual Impact Provision Snowdonia National Park, Overhead Line 4ZC Screening and Scoping Report'* October 2018.

and Scoping Report proposed that pressures on marine processes and the marine physical environment be screened out of the Environmental Appraisal.

15.3.3 However, in consultation with NRW (post receipt of scoping opinion), assessment of some aspects of the physical environment has been scoped back into the Environmental Appraisal. This includes the consideration of partial removal rather than full removal of the marine pylon foundations. Details of the consultation are provided in Section 15.4 below.

15.3.4 The aspects of the Proposed Marine Works and the pressures which have been scoped out from further assessment within the Environmental Appraisal and the justifications for this are presented in Table 15.1.

15.3.5 Construction of the tunnel has also been scoped out of this chapter as it lies at least 15m below the ordnance datum Newlyn (ODN) and will not influence marine physical processes.

Table 15.1: Scoping conclusions summary

Key	
N/A	Site is outside marine area or pressure is not applicable at the site
X	Scoped out of further assessment in the Environmental Appraisal
✓	Scoped in for further assessment in the Environmental Appraisal

Pressure	4ZC031	4ZC030R	4ZC030	Receptor / Justification for aspects scoped out
Waterflow (tidal current) changes, including sediment transport considerations	✓	✓	✓	**Estuary and saltmarsh sediments** The Scoping Report concluded that the temporary platform at site 4ZC030 will not have a significant effect on water flow or sediment transport therefore this aspect has been scoped out of the Environmental Appraisal. The assessment of 4ZC030 therefore focuses on the partial removal of the foundations.

Pressure	4ZC031	4ZC030R	4ZC030	Receptor / Justification for aspects scoped out
Physical damage (reversible change) - Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion.	**X**	**X**	**N/A**	**Saltmarsh Sediments** - All excavations that disturb substrate below the surface of the seabed to remove foundations and cofferdam are considered reversible (to a pre- structure condition) with no lasting (permanent) impact on geomorphology. Site 4ZC031 will be backfilled and 4ZC030R is anticipated to infill as part of the natural channel and sandflat process. At 4ZC030R, if there is a residual void then the assumption is this will also infill by natural processes. The temporary access tracks, watercourse crossings (ramp, bridges and culverts) and working areas associated with pylon dismantling, conductor removal and backstay will temporarily cause compaction of saltmarsh sediments directly within the footprint. Plastic or aluminium panels will be used to spread the load of plant and reduce any compaction impacts to saltmarsh sediments. This pressure has been scoped out from further assessment.

Pressure	4ZC031	4ZC030R	4ZC030	Receptor / Justification for aspects scoped out
Physical damage (reversible change) – Changes in suspended solids (water clarity).	X	X	X	**Suspended sediments** - Excavations at 4CZ031 are essentially land based and are unlikely to have any effect on suspended sediments. If sites became inundated during the excavation process, then flows across the saltmarsh are expected to be too weak to create any periods of suspended sediments and no material would be lost from the saltmarsh. During excavation of 4CZ030R water may need to be pumped out of the cofferdam which may contain small amounts of silts (2% of the sediment volume). However, the anticipated small volumes of pumped water and silts are not expected to create any sediment plume that would affect water clarity. At 4CZ030 proposed works include construction of a temporary work platform, excavation of the foundations and removal of the platform. There is a potential to mechanically disturb the local seabed as well as creating scour around the platform. Most of the disturbed sediment will be sandy sediments with a $D50^{10}$ of 0.15mm. The same sediments exist on the sandflats and would be susceptible to the same periods of transport to elevate general background levels of suspended sediments, therefore, any locally disturbed sediments would simply become part of the same elevated levels when the sandflats become mobile. This pressure has been scoped out from further assessment for all the locations.

Pressure	4ZC031	4ZC030R	4ZC030	Receptor / Justification for aspects scoped out
Changes in water quality	X	X	X	**Estuary** - There is some potential for disturbed sediments in the marine environment to impact on water quality through issues such as releasing retained contaminants or anoxic sediments that impact on levels of dissolved oxygen within the waterbody. However, the understanding of the baseline derived from site-specific data e.g. Pont Briwet, show that local sediments are clean, have no associated contaminants, have low levels of organics (and therefore have limited potential to be anoxic). In addition, no water quality issues arose during the construction of Pont Briwet, a period of construction works which would have involved greater volumes of disturbed sediment. For these reasons this pressure has been scoped out from further assessment.
Pollution and other chemical changes - Transition elements & organo-metal contamination	X	X	X	**Estuary and saltmarsh sediments** - There is no evidence for any contaminated sediments within the estuary and the site has no association with any industrial activity of any scale. The upstream catchment is mainly forest and agricultural. This pressure has been scoped out from further assessment.

[10] D50 is the average particle size or median particle size i.e. 50% of the particles have a size of 0.15mm.

Pressure	4ZC031	4ZC030R	4ZC030	Receptor / Justification for aspects scoped out
Pollution and other chemical changes - Deoxygenation	X	X	X	**Estuary and saltmarsh sediments** - The available evidence from site investigations supporting the construction of Pont Briwet (Norwest Holst 2009)[4] indicate that surface sediments in the near vicinity to the depth of excavations have a very low organic content and are not expected to be anoxic. This pressure has been scoped out from further assessment.

Appraisal Methodology

15.3.6 The Environmental Appraisal has been undertaken by assessing the potential adverse and beneficial effects of the Proposed Marine Works on the marine physical environment and marine physical processes. This has been achieved by applying the following steps:

- Characterisation of the existing baseline – a good understanding of the baseline conditions for the environmental receptors scoped into the Environmental Appraisal has been achieved through a detailed review of publicly available data (see Section 15.2) and stakeholder consultation.
- Establish potential pressures - as outlined in Table 15.4, one potential pressure has been taken forward for further assessment in the Environmental Appraisal; waterflow (tidal current) changes, including sediment transport considerations.
- Characterisation of sensitive receptors - one receptor has been identified which is sensitive to the identified pressure - the Dwyryd estuary. 'Estuaries' is a primary designating feature of the Pen Llyn a 'r Sarnau / Lleyn Peninsula and the Sarnau Special Area of Conservation (SAC).
- Assessment of adverse and / or beneficial effects – qualitative and where possible quantitative assessment based on the sensitivity of the receptor to the identified pressure and the magnitude of the change from the baseline conditions i.e. the spatial extent, scale and duration / frequency of change.
- If necessary, propose mitigation measures to avoid, reduce or offset the effect and repeat assessment to ascertain the residual effects.

The Study Area

15.3.7 The study area (or zone of influence) is the spatial extent over which the Proposed Marine Works are predicted to have an effect on the receiving environment. The main activities and their predicted zones of influence are as follows:

- Excavation activities during the partial removal of the pylon foundations at site 4ZC030 are predicted to directly affect the estuary sediments within the footprint of the excavation works.

- Full or partial removal of the pylon foundations at site 4ZC030R and 4ZC030 is predicted to affect the functioning of the estuary channel locally within approximately 200m of the foundations.
- Excavation activities during the partial removal of the foundations at site 4ZC031 is unlikely to affect the functioning of the estuary channel due to its landward position. However, it is included in the Environmental Appraisal at NRWs request to assess each pylon removal scenario (see Table 15.2).

15.3.8 The marine physical processes assessment is largely qualitative, developed by expert judgement and supported by available data and information. The channel form and location remain highly dynamic. The assessment has considered available information up to the present day to ensure the correct extent of channel behaviour is being considered. The location of the channel at the time of the excavation works can be expected to have changed from present day (within the envelope of expected change) which may have implications to the method of removal. Some uncertainties remain in what might be achieved from the excavation works in terms of the actual depth of foundation removal and the consequence of partial removal on the way the estuary might respond. A conservative approach to the assessment provides the most appropriate means to manage these uncertainties.

15.4 Consultation Undertaken

15.4.1 Consultation and stakeholder engagement have been integral to the design and development of the project. For further details of screening and scoping consultations undertaken in relation to the Proposed Project please refer to Sections 3.1 and 3.2 of Chapter 3 - Environmental Appraisal Process.

15.4.2 Table 15.2 summarises consultation responses relevant to the marine physical environment.

Table 15.2: Consultation responses

Stakeholder	Summary of consultation response	How response has been addressed
NRW Technical Experts (TE)	Proposed developments which are likely to significantly affect European Sites either alone or in combination with other plans or projects require special consideration by the competent authority under Regulation 63 of the Conservation of Habitats and Species Regulations 2017. NRW recommends that the proposed Environmental Appraisal Report should contain a section/appendix that includes a statement to inform the Habitats Regulations Assessment (HRA).	A stand-alone Marine HRA has been prepared see (P2048_R4881_Rev0_HRA). This includes an assessment of the likely significant effects on the Pen Llŷn a'r Sarnau / Lleyn Peninsula and the Sarnau Special Area of Conservation (SAC) which is primarily designated for its estuary feature.

Stakeholder	Summary of consultation response	How response has been addressed
NRW TE	Section 7.27 of the Screening and Scoping Report states that if potential impacts are identified that could lead to the deterioration of a water body from its current status or prevent a water body from achieving 'Good' status in the future it is likely that a Water Framework Directive (WFD) assessment will need to be undertaken. NRW note that for the purposes of Marine Licensing it is expected that all applications are accompanied by a WFD assessment.	A WFD assessment will be undertaken in support of the marine licence application.

Stakeholder	Summary of consultation response	How response has been addressed
NRW TE	NRW TE welcome the complete removal of the pylons and pylon foundations in the marine environment, however noted inconsistencies within the Screening and Scoping Report. Certain pressures have been scoped out of the Environmental Appraisal on the basis that full removal of the structures related to the pylons will be undertaken. However, the report also states that complete removal may not be feasible. The incomplete removal of foundations may present the worst-case scenario when assessing certain impacts as they could lead to scour within the estuary and should be considered. NRW noted significant scour has been experienced in the estuary from anthropogenic activity. NRW recommended that the foundations should, at least, be removed to a sufficient depth so as to not become exposed.	Confidence for full removal of the pylon foundations at the replacement Pylon 4ZC030R is high but not certain until attempted on site. For pylon foundations at 4ZC031 and 4ZC030, full removal is not anticipated because of the design of the foundations which are in discrete sections sat one on top of the other. Further consultation with NRW has identified that removal of the piles and cofferdam sheets to a level sufficient to prevent scour would be the next best option if full removal cannot be achieved. This would allow the estuary to naturally migrate northwards unimpeded by the foundations and without subsequent exposure of the remains of the piles and cofferdam. In response, some pressures on the marine physical environment have been scoped back into the Environment Appraisal and additional realistic scenarios for partial and full removal of foundations has been assessed.
NRW TE	NRW TE note that a working platform is proposed to be constructed for pylon 4ZC030. NRW need assurance that all material can be removed successfully from the estuary.	All working materials including that associated with the working platform will be removed from the estuary.

15.5 Statutory and Planning Context

15.5.1 The legislation and planning policies relevant to the marine physical environment include:

- The Water Environment (Water Framework Directive) (England and Wales) Regulations (2017), as applied to River Basin Management.
- Western Wales River Basin Management Plan (including Dwyryd Estuary) (Natural Resources Wales 2015)11.
- UK Technical Advisory Group on the Water Framework Directive, for issues such as dissolved oxygen standards for transitional and coastal waters UK Technical Advisory Group on the Water Framework Directive (2008)[12].

15.5.2 The legislation and policies that apply to designated habitat features within the SAC (i.e. estuary, sandflats and saltmarsh) are considered in Chapter 16 - Marine Ecology.

15.6 Existing Environment

15.6.1 The baseline is described in the context of the Proposed Marine Works Area within the Marine Environment Area. The main features are the Atlantic salt meadow (saltmarsh) and the adjacent estuary channel cutting through shallow inter-tidal sandflats. These features work together to form the Dwyryd Estuary which is considered here as the macro unit.

Estuary

15.6.2 The Dwyryd Estuary is a bar-built estuary that has characteristic sand bars across the mouth. The estuary can also be described as a partially drowned river valley, formed by Holocene glaciation, that has subsequently been largely infilled with marine sands creating expansive drying conditions around low water (Countryside Council for Wales 2001)[13].

15.6.3 The tidal confluence of the estuary with Tremadog Bay is around 10.2km downstream of the Proposed Marine Works (estimated along the low water thalweg[14]). Ordnance Survey mapping indicates that the normal tidal limit (NTL) is at the A496 bridge near Maentwrog a further 6.3km upstream of the Proposed Marine Works.

15.6.4 The estuary mouth is around 1.4km wide; although at the Proposed Marine Works, this narrows to around 0.36km for the main channel and sandflats, or up to 0.91km including the saltmarsh.

15.6.5 Pont Briwet is around 0.38km upstream of the Proposed Marine Works and represents a major narrowing in the channel due to (geological) higher ground either side of the estuary. This natural narrowing favoured the location of the bridge crossing which now includes stone causeways to further constrict the channel width to around 0.11km. The narrowing focuses tidal flows passing under the bridge and develops an over-deepened scour feature which appears to extend furthest on the upstream side of the bridge.

[11] Natural Resources Wales. (2015), 'Western Wales River Basin Management Plan 2015-2021'

[12] UK Technical Advisory Group (UKTAG) on the Water Framework Directive (WFD). (2008)

[13] Countryside Council for Wales. (2001), 'Morfa Harlech Site of Special Scientific Interest (SSSI) Citation'.

[14] A line connecting the lowest points of successive cross-sections along the course of a valley or river.

15.6.6 The tidal exchange with Tremadog Bay creates ebb and flood flows which cut a series of braided channels through the sands and over time (decadal to sub-decadal) these channels meander from bank to bank through the main body of the estuary.

15.6.7 In many places the estuary is bordered by extensive areas of saltmarsh. The fronts of these saltmarshes are susceptible to bank erosion when channel meandering cuts in their direction, however, in a few places there are hard structures that limit channel meandering and these areas are commonly devoid of any fronting saltmarsh (e.g. developed land such as the sea wall in front of Porthmadog). When the channel is diverted away from the edge of the saltmarsh there is an opportunity for progradation.

15.6.8 Figure 15.1 provides an overview of the Dwyryd Estuary which includes an overlay of main saltmarsh areas presented on a Google Earth image from low water on 2nd June 2016.

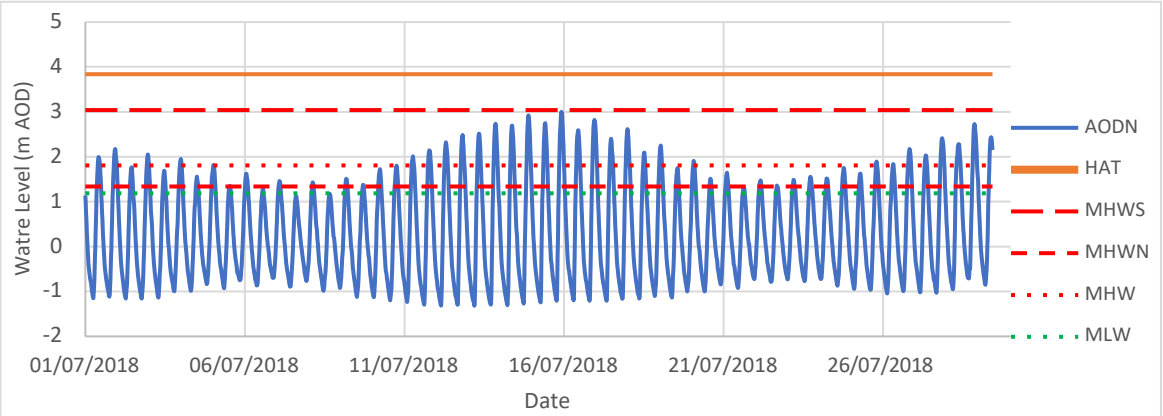
Waterbody

15.6.9 The waterbody within the estuary fluctuates in level (and volume) due to tidal influences from Tremadog Bay. Tides at Criccieth have a mean spring range of around 4.24m and a mean neap range of 1.83m. The narrowing shape and shallowing environment of the estuary act to (further) steepen the flood tide and lengthen the duration of the ebb in an upstream direction until the tidal wave becomes fully dissipated at the tidal limit. This asymmetry in the tide leads to a pulse of relatively stronger (but shorter) flood flows and weaker (but longer) ebb flows.

15.6.10 At low water, the tide retreats to expose large areas of sandflats across the estuary. At this time, the remaining flows coming from the Afon Dwyryd provide a source of freshwater draining off the upstream catchment. The volume of freshwater passing through the estuary is relatively small in comparison to the tidal prism (the amount of water exchanged through a section of estuary between high and low water), but these river flows also persists while the tide has retreated to help develop and maintain the low water channel.

15.6.11 Water levels are measured by NRW behind Porthmadog Cob, on the tidal sluices of Afon Glaslyn. Whilst this site is around 7.8km downstream of the Proposed Marine Works, the tidal variations are still considered to provide a good indication of local water levels. Plate 15.1 illustrates a 28-day sequence of water level variation which encapsulates a full lunar cycle of spring-neap-spring tides for July 2018. This period of observations includes close approximations to both mean high water springs (MHWS) (around 16 July 2018) and mean high water neap (MWHN) (around 22 July 2018) tides.

Plate 15.1: Water level observations from Porthmadog



Sandflats and channels

15.6.12 The estuary contains extensive areas of sandflats comprising of material considered to be largely of marine origin that has infilled the estuary.

15.6.13 Borehole samples from several locations in the estuary channel, just downstream of Pont Briwet, indicate that the depth of sands is over 13m below the channel bed with the top layer of material (2 to 3m below channel bed) comprising of 98% sands and 2% silts (Norwest Holst 2009)[4]. The general description of this material is given as 'loose brown grey slightly silty fine to medium sand with a few coarse to gravel sized shell fragments'.

15.6.14 The sediment gradings analysis indicates a D50 of 0.150mm, equivalent to fine sands. In addition, the organic content of the soils was assessed to be <0.1 %. The description of loose material suggests this material is mobile, with the comment about shell content endorsing a marine origin.

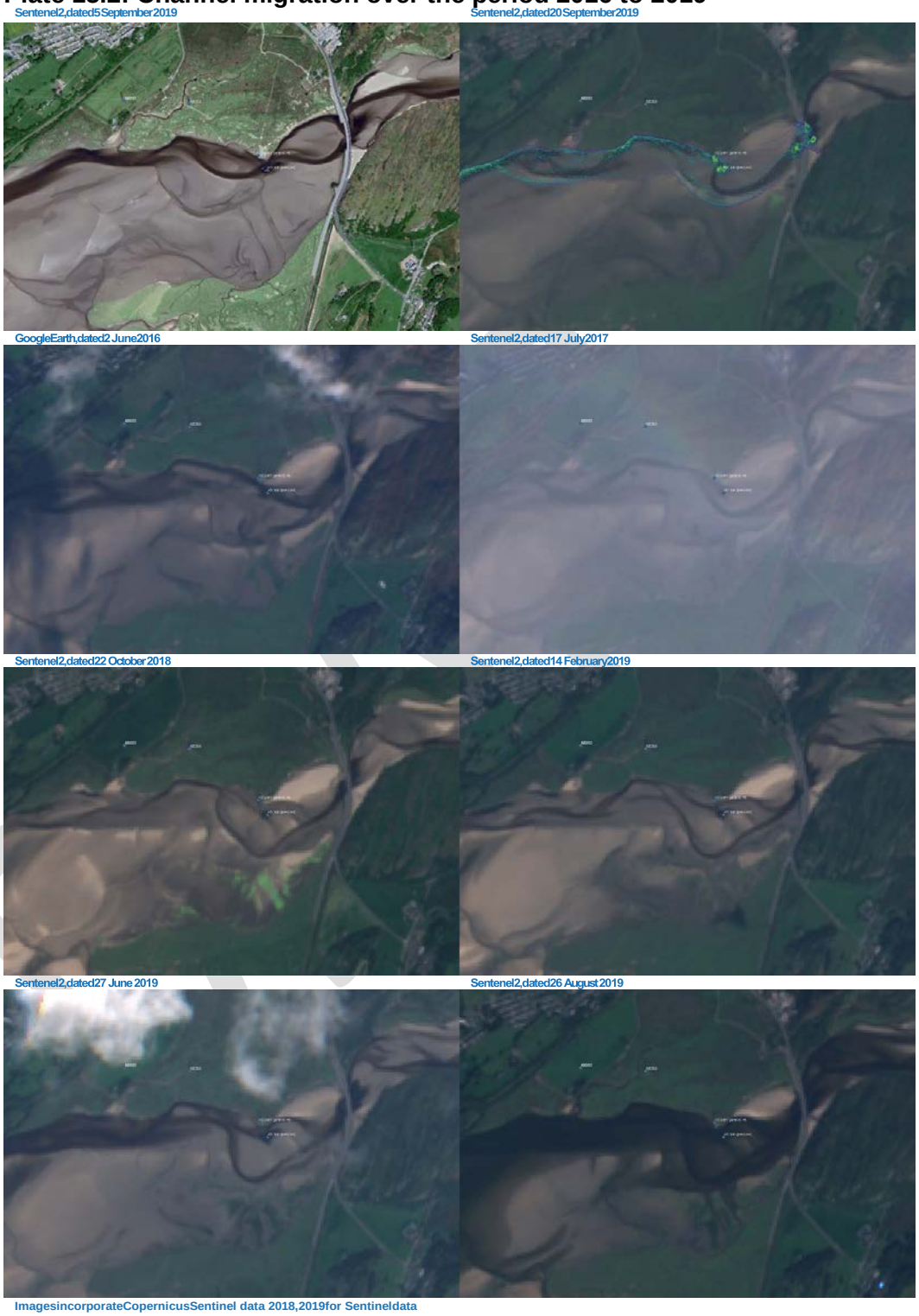
15.6.15 A series of braided channels cut through the sandflats due to the action of tidal exchange and river flows. From time to time these channels migrate from bank to bank, a process which can also lead to erosion of the corresponding saltmarsh edge. These channels are most apparent when the tide retreats and exhibit a ‘natural’ depth which is determined by the river flows and the ability of the estuary to erode to this level.

15.6.16 Figure 15.2 shows evidence of past channel migration compiled from old maps covering the period 1889 to 2009. The analysis of channel migration suggested that within a 2km reach of the estuary, centred on Pont Briwet, 92% of the active channel environment (defined by sandflats and channel) has been reworked (Fluvio 2011)[6].

15.6.17 Plate 15.2 provides a view of more recent channel migration based on Google Earth aerial imagery from 2016 and a series of Sentenel-2 satellite images from 2017 to present day. The date of the satellite image from 2017 is selected to be coincident with the bathymetry survey from July 2017 which is overlain as a series of contours. The timing of the satellite images is not necessarily coincident with periods when the tide has fully retreated (e.g. 20 September 2019) and image quality is also highly susceptible to weather conditions (e.g. cloud cover and daylight), nevertheless the images convey a clear pattern of continual channel migration for the main area of interest. At the present time, the low water channel from Pont Briwet initially flows to the south-west then abruptly turns north to encounter the edge of the saltmarsh

just to the west of 4ZC030. Also of note is the recent development of new saltmarsh on the opposite side of the channel to 4ZC030 visible as extended greening areas.

Plate 15.2: Channel migration over the period 2016 to 2019

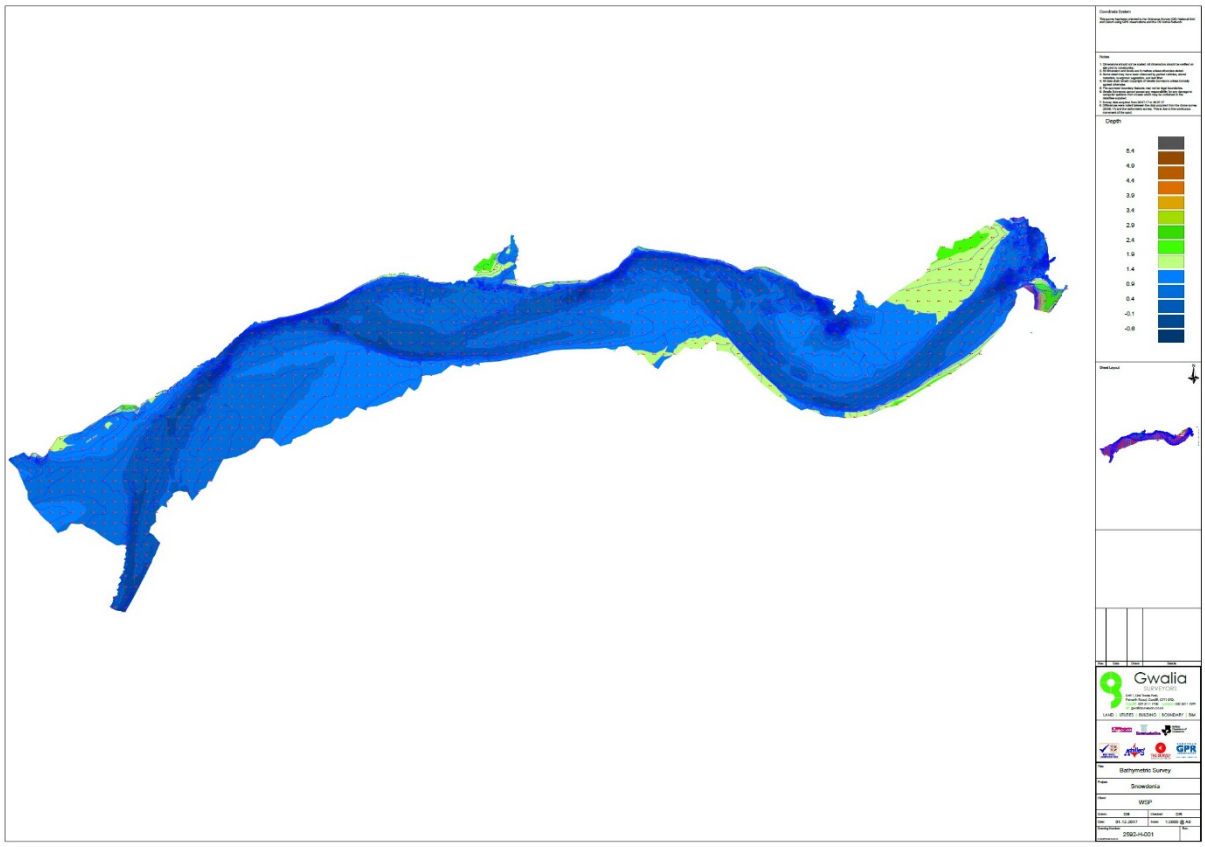


15.6.18 The bathymetry survey (Structural Soils 2017[2]) (Plate 15.3) provides a means to examine the depth of the low water channel both in proximity to structures around which local scouring is evident (such as 4ZC030) and away from structures where the depth is related to the capacity of the low water flows to cut through the sandflats and establish a 'natural' channel cross-section and depth. Close to structures the process of local scouring exceeds the 'natural' channel depth and reaches around 2m below ordnance datum Newlyn (ODN). A similar situation exists where the channel abuts and is held against the saltmarsh and where erosion of the edge of saltmarsh appears to be occurring, at these locations the channel width narrows, and depths can increase to around 1.6m below ODN in some places. When the channel is unbounded and cuts through the sandflats then the 'natural' channel depth in the vicinity of the Proposed Marine Works is much shallower reaching up to 0.4m below ODN, and the channel is generally wider. On some occasions and locations, there may be more than one low water channel, for example a flood dominant channel and an ebb dominant channel, or the relict of former channels.

15.6.19 Composite LIDAR data (Lle Geo-Portal 2019[15]) provides detailed levels across the saltmarsh and sandflats. The nature of the composite data means this information is an amalgamation of surveys spanning different (unspecified) years. The profile of local sandflats, based on the available LIDAR data, suggests a variable height of between 1.2 and 1.9 m above ODN. The level of mean high-water neap (MHWN) tides is estimated as 1.34m (based on Porthmadog) suggesting that some areas of the higher standing sandflats remain exposed during neap tides. The corresponding (MHWS) level is estimated as 3.04m above ODN (based on Porthmadog) indicating that the sandflats are fully submerged during high water periods of spring tides. On this basis, only spring tides can be responsible for sediment mobility and transport across the shallowest areas of the sandflats.

[15] Lle Geo-Portal (2019). LiDAR Composite Dataset. Available online: http://lle.gov.wales/Catalogue/Item/LidarCompositeDataset/?lang=en (Accessed October 2019)

Plate 15.3: Coloured contours of channel depth from 2017 bathymetry survey



Saltmarsh

15.6.20 There are extensive areas of saltmarsh bordering the estuary. The LIDAR data indicates that the saltmarsh sits relatively high in the tidal frame at heights of between 2.3 to 2.6m above ODN. These levels are only reached by high water periods on spring tides. Based on the water level data from Porthmadog, high water periods of neap tides would be insufficient to inundate the saltmarsh.

15.6.21 During periods of inundation there is an opportunity for saltmarsh levels to "warp up" with any sediments carried in suspension onto these areas also able to settle out. Typically, these will be fine sediments such as silts and muds held in suspension.

15.6.22 Mudflat areas appear to be present (and are mapped as such by NRW) in some of the creeks draining and bordering the saltmarsh. The source of muddy material is likely to be from the upstream catchment, which is mainly rural and partly forested, with inputs heightened during periods of increased rainfall creating a washload.

15.6.23 The site investigation work for Pont Briwet included a trial pit (TP04) on the edge of the saltmarsh (Norwest Holst 2009)[4]. The top layer (above bedrock at this location) to 1.3 m below ground level was described as 'Brown silty fine to coarse SAND'.

15.6.24 A photograph of the trial pit (TP04, Plate 15.4) shows the uniform composition of material covered with a relatively thin layer of grass. Whilst other areas of the saltmarsh may have different types of vegetation the sub-soils are still expected to be similar to TP04. Apart from the surface vegetation, the organic content in trial pits was assessed to be <0.1%.

Plate 15.4: Trial pit at edge of saltmarsh, TP04 (Norwest Holst, 2009)

Sediment transport

15.6.25 Present evidence points to sediment supply to the estuary of mainly marine sands from Tremadog Bay, especially sources in the littoral zone at the mouth of the estuary. These marine sands form the extensive sandflats across the estuary. Silts and muds may also be supplied from the upstream catchment by the river and carried downstream as a suspended sediment load, albeit these concentrations appear very low during typical conditions due to observed good water clarity. The further sources of sediment are from reworking of sandflats and erosion of the saltmarsh edge, although these areas may switch between acting as temporary sources to acting as temporary sinks, depending on conditions acting upon them.

15.6.26 Sediment transport occurs when the movement of the water body through the estuary creates flow conditions that exceed a threshold for sediment mobility allowing the material to be moved either as suspended load or bedload. Such thresholds depend on many factors, but principally the particle size for non-cohesive sediments. Transport ceases when flows drop below the level to hold material in suspension or below the level to overcome friction on the bed (for bedload).

15.6.27 Whilst flood and ebb flows may both act on sediments and carry material upstream and downstream, the asymmetry in magnitude and duration of flows between flood and ebb determines the direction of net transport. Present information suggests the stronger flows on spring flood tides provide the mechanism for upstream transport of sands, whereas the longer duration of the ebb (for both spring and neap tides) is likely to create net downstream transport of silts and muds, when present in suspension. Whilst conditions in the main body of the estuary provide areas for sand deposition, the muds only deposit in areas where flows are weaker and allowing for material to settle out of suspension. These areas include shallower margins of the estuary, across the saltmarsh or within small tidal creeks.

15.6.28 Local scouring is observed around the remaining foundation structures of 4ZC030 and along the southern perimeter of the cofferdam of 4ZC030R. This scouring appears to be (partly) holding a low water (flood) channel at this location, noting the main ebb channel from Pont Briwet has now moved across the estuary to the south where this abuts with a stable area of sandflat that now appears to exhibit growth of saltmarsh (Plate 15.2).

15.7 Key Parameters for Appraisal

15.7.1 Removal of the marine pylon foundations on the estuary is anticipated to be difficult due to the surrounding environment and in the case of 4ZC031 and 4ZC030 due to the age and type of foundation used. These pylons and associated foundations have been in the ground since the 1960s and the foundations are in non-continuous sections driven into the ground one on top of the other.

15.7.2 NRW requested that there be enough time in the works programme and the appropriate machinery to be present for full removal of foundations. National Grid is committed to removing as much as is feasible and practicable and this will be reflected in the contractor specifications.

15.7.3 The saltmarsh level is around 2.5m above ODN. National Grid engineers have estimated the realistic minimum achievable depth of extraction (i.e. the worst-case scenarios) for each pylon in comparison to this level. These parameters are presented in Table 15.3, Plates 15.5 and 15.6, and have been used in the Environmental Appraisal.

15.7.4 All practicable attempts to remove additional lower sections will be made for pylons 4ZC031 and 4ZC030; however, the assessment in this chapter is based on the worst-case scenario.

15.7.5 National Grid plans to schedule the 4ZC031 pylon works first so that an understanding of the ground conditions can be gained ahead of attempting 4ZC030 and 4ZC030R.

Table 15.3: Parameters for appraisal

Pylon site	Scenario	Method of extraction	Minimum depth of removal
4ZC030	Partial removal Worst case	Construction of temporary platform to access foundations, excavator with hydraulic breaker	3.75m below ground level (-1.25m ODN)
4ZC030R	Scenario 1 Full removal Best case	Excavate sand to 2m, Collars removed by hydraulic breakers, steel tube piles & cofferdam removed by leader pile rig	Full removal
	Scenario 2 Partial removal Worst case	Excavate sand to 2m, collars removed by hydraulic breakers, steel tube piles and cofferdam cut at 2m depth	2m below ground level (+0.5m ODN)
4ZC031	Partial removal Worst case	Excavate sand around foundations and then mechanically break up pile caps and remove piles to depth excavator arm can reach	3.75m below ground level (-1.25m ODN)

Note: Ground level refers to the saltmarsh level which has been estimated to be 2.5m above ODN.

Plate 15.5: Schematic showing the pylon removal scenarios 4ZC030, 4ZC031 worst case, 4ZC030R preferred case

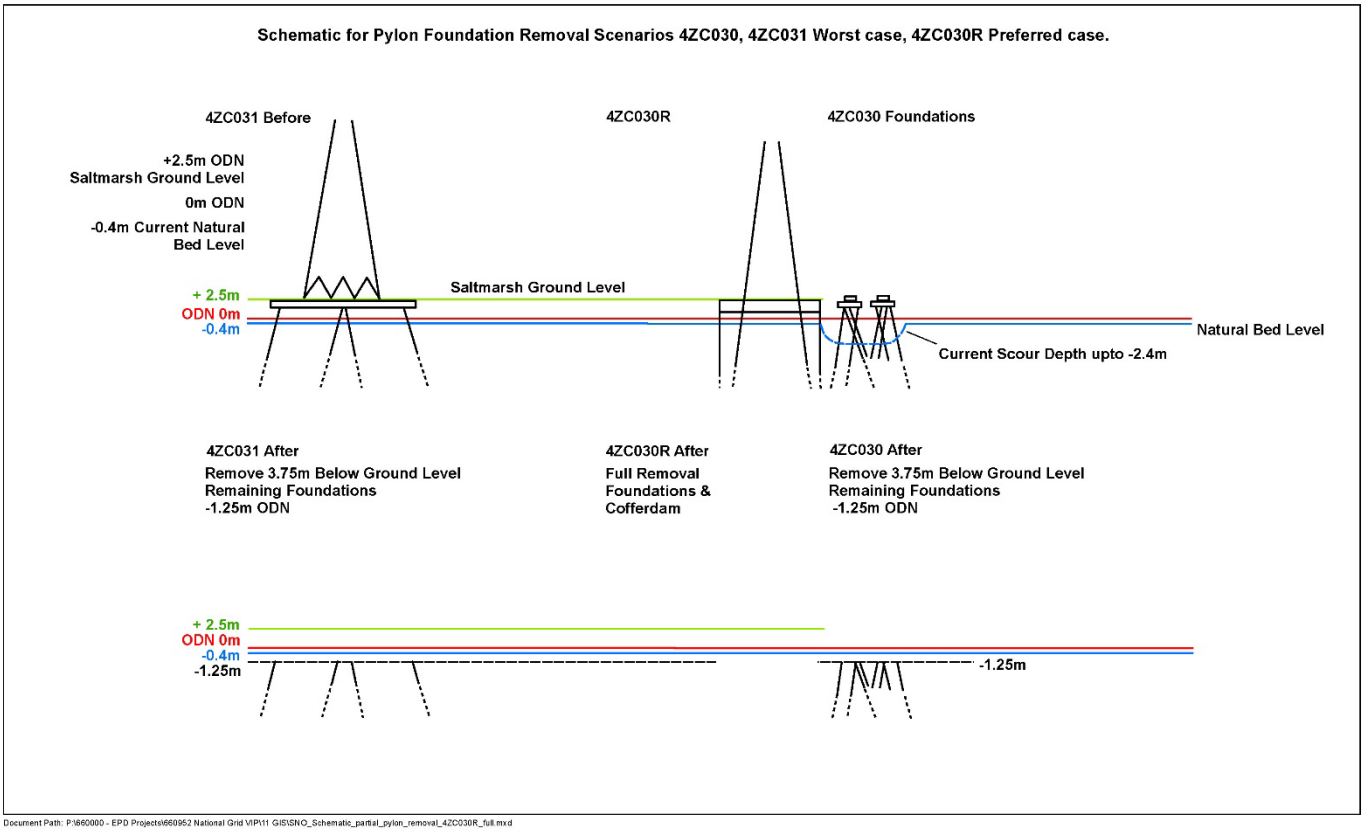


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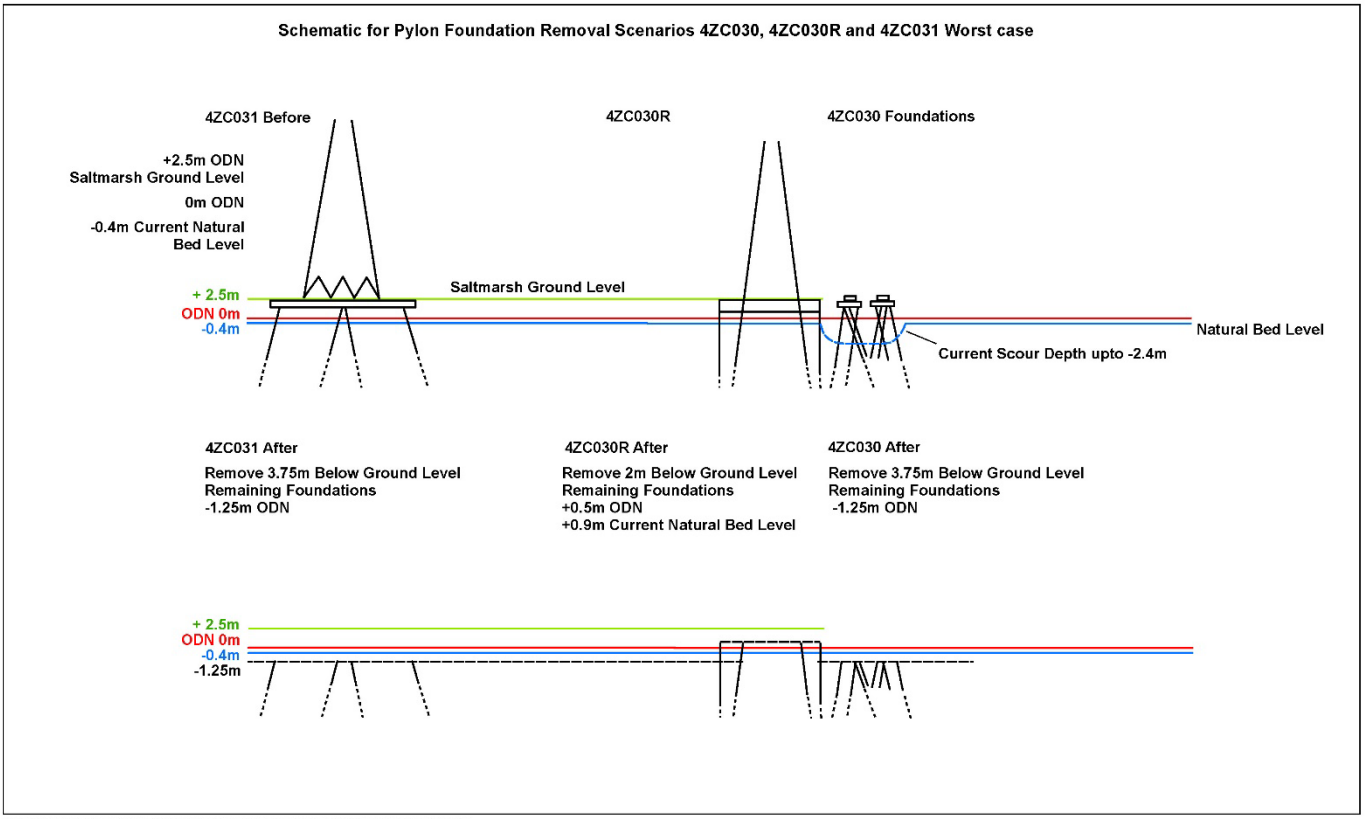
Plate 15.6: Schematic showing the pylon removal scenarios 4ZC030, 4ZC031 worst case, 4ZC030R worst case



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15.8 Predicted Impacts During Construction

Removal of Existing Infrastructure (VIP subsection)

15.8.1 The main effect on the physical environment occurred at the time of pylon installation i.e. in the 1960s for 4ZC031 and 4ZC030, and in 2013 for the replacement pylon at 4ZC030R. The presence of these foundations has resulted in there being small-scale artificial barriers to the natural functioning of the estuary and some local scouring in the estuary around the remnants of foundation structures at 4ZC030 and along the southern margin of the cofferdam surrounding 4ZC030R (Plate 15.7).

15.8.2 Potential adverse effects from the Proposed Marine Works on the marine physical environment are expected to be localised and short-term and generally have been scoped out of the Environmental Appraisal. For example, the construction of the temporary platform to reach the 4ZC030 foundations in the estuary (Plate 15.8) may have a short-term effect on water flows and temporarily lead to local scour development, but since this is in an area already heavily scoured the effects would not be noticeable. Once the platform is removed the estuary will quickly recover.

Plate 15.7: Pylon 4ZC030R – scouring along the southern margin of the cofferdam

Plate 15.8: Site 4ZC030 remaining pylon foundations located within the estuary channel

15.8.3 Long term effects of the full removal of the foundations (best case) would be greatly beneficial, restoring the natural behaviour of channel migration for this part of the estuary. However, full removal is unlikely to be possible at 4ZC031 and 4ZC030, and not guaranteed at 4ZC030R, where only partial removal may be achieved; which still has beneficial effects.

15.8.4 This assessment focuses on the effects on the estuary and saltmarsh sediments based on the best-case scenario (full removal for 4ZC030R) and worst-case scenarios (partial removal) for 4ZC031, 4ZC030R and 4ZC030 as presented in Table 15.4 below.

Table 15.4: Potential Pressures

Pressure	Project Activity	Receptor
Waterflow changes, including sediment transport considerations	4ZC030 partial removal of foundations to 3.75m depth below ground level	Estuary and Saltmarsh Sediments
	4ZC030R full removal of foundations and cofferdam	
	4ZC030R partial removal of foundations and cofferdam structures to 2m depth below ground level	
	4ZC031 partial removal of foundations to 3.75m below ground level	

Waterflow changes, including sediment transport considerations

15.8.5 The presence of man-made structures creates existing pressures on the natural behaviour of channel migration within the estuary. These pressures are a combination of local changes in water flows passing around the structures which in

turn create an increased capacity to erode the local seabed (and saltmarsh edge). The increased erosion is mainly demonstrated in the form of local scouring of the channel bed around the man-made structures. Collectively these pressures are assessed as “Waterflow changes, including sediment transport considerations”.

15.8.6 The key receptor is the ‘estuary’ as the primary feature of the Pen Llyn a ‘r Sarnau / Lleyn Peninsula and the Sarnau SAC which comprises the estuary and mudflats and sandflats.

15.8.7 The way the estuary is likely to respond to the removal of foundation structures depends on what remains in the estuary that may interfere with future channel migration. The relevant vertical level against which to establish any impact is the “natural” channel depth. Any foundations which remain below this depth are not expected to have any influence on present or future channel migration whereas foundations above this level still have the potential to interact with flows which may then lead to local scouring effects. The higher any remaining foundations protrude above the “natural” channel depth the larger the anticipated influence would be to waterflow changes and sediment transport. Similarly, where the effective width (i.e. a single structure of a group of closely spaced structures) of remaining foundations is proportional to the low water channel width then the combination of scouring and remaining foundations may still impede full channel migration. Three situations are possible:

- Remaining foundations are below the natural channel depth and channel migration is no longer impeded by foundations and local scour and natural channel migration is dominant.
- Remaining foundations protrude above the level of high water and fully interfere with passing flows at all states of tide, developing local scour (e.g. existing condition at 4ZC030). Foundations and scour are dominant and channel migration may be impeded.
- Remaining foundations slightly protrude above the natural channel depth but remain well below the level of high water. In this situation, the scouring is likely to be reduced from a fully protruding foundation and flows above the level of the foundations can pass without significant deviation. Channel migration may only be partially and temporarily impeded by foundations and scouring and is likely to eventually bypass slightly protruding foundations.

4ZC030

15.8.8 The foundations at 4ZC030 are currently located within the main body of the channel system. Local scouring around the four residual foundation structures has exaggerated local channel depths at this location with scour observed to depths of at least 2.4m below ODN. The scouring has effectively locked the estuary channel at this location (and with influences from 4ZC030R) limiting further migration.

15.8.9 Based on 3.75m removal below local ground level (which is 2.5m above ODN), then any remaining foundations would be at 1.25m below ODN (-1.25m ODN) or approximately 1.15m above the presently scoured channel depths. Some scouring influence may still occur but based on the recent survey data from 2017 (Plate 15.3), the tendency would be for the natural channel to be at a depth of around 0.4m below ODN, or shallower. The likelihood is that the natural channel migration process would be able to dominate over any residual influence of foundations maintaining local scour and the remaining foundations will become buried relatively quickly. Once buried there is unlikely to be any tendency for unburial as natural channel

depths would not reach the foundations in the future. The removal of foundations and cessation of local scouring would therefore be able to unlock the natural behaviour of channel migration at this location.

15.8.10 The magnitude of any effect on channel migration in the estuary will be positive with the capacity for natural channel migration extending both up and downstream. There will therefore be a beneficial effect on the estuary at this location from the removal of the foundations.

4ZC030R - Full removal

15.8.11 If full removal is achieved, then the likelihood is the low water channel would rapidly occupy the excavated area. The present area of scour observed along the southern margin of the cofferdam is expected to infill to a depth of around 0.4m below ODN (i.e. re-establish the natural channel depth) from the present scoured depth of around 2.6m below ODN. The full removal would enable the channel to migrate in an unconstrained manner at this location and once the channel has migrated away from this area then the site would become part of the wider sandflat (migration to the north) or saltmarsh (migration to the south).

15.8.12 The magnitude of any effects on present and future channel migration in the estuary will be positive, with the capacity for natural channel migration extending both up and downstream. There will therefore be a beneficial effect on the estuary at this location from the full removal of the foundations.

4ZC030R - Partial removal

15.8.13 Presently, the southern margin of the 4ZC030R cofferdam borders the channel and is acting like a hard headland type influence on the southern edge of the saltmarsh. There is evidence of local scouring against the cofferdam of up to 2.6m depth below ODN.

15.8.14 Partial removal of the pylon structures (foundations and cofferdam) to 2m below local ground level equates to the residual structures being at a depth of 0.5m above ODN. At this depth the foundations would still protrude above the natural channel depth of 0.4m below ODN by around 0.9m.

15.8.15 Should the channel continue to migrate northwards the remaining foundations which protrude above the natural channel depth may still lead to some local scouring and potentially slow down natural channel migration at this location. The amount of scouring is likely to be less severe than what is already observed and temporary until the channel migrates past this foundation, albeit at a slower rate.

15.8.16 The magnitude of any effects on present migration in the estuary will be positive. Overall there will be a beneficial effect on the estuary at this location, although it will take longer to materialise in comparison to the full removal scenario.

4ZC031

15.8.17 4ZC031 is the most landward pylon of the three sites, being located on existing saltmarsh around 130 m from the channel, and only becomes inundated during high waters on spring tides. Historical records of channel movements in the Dwyryd estuary shown in Figure 15.2 and Plate 15.2, indicate that the estuary channels have never migrated as far as site 4ZC031 over the period 1889 to 2009. This suggests the risk of any foundations being involved with channel flows is minimal. On the basis that the worst-case depth of removal is 3.75m below local ground

level[16], then any remaining foundations would be at 1.25m below ODN. After removal the excavated material will be backfilled and the net loss of material through removal of concrete will be replaced with locally imported material. Even if the channel were to migrate this far then the remaining foundations are expected to be sufficiently deep not to interfere with long-term channel migration (equating to low water channel depths of 0.4m below ODN) across this area, should that ever occur.

15.8.18 The magnitude of any effects on channel migration in the estuary will be positive, with a beneficial effect on the estuary at this location as anthropogenic structures are removed.

15.9 Predicted Pressures and Study Areas During Operation

15.9.1 The scope of the Proposed Marine Works is limited to works as part of the construction phase only. There will be no impacts during operation.

15.10 Predicted Pressures and Study Areas During Decommissioning

15.10.1 The scope of the Proposed Marine Works is limited to works as part of the construction phase only. There will be no impacts during decommissioning.

15.11 Mitigation and Summary of Residual Effects

During Construction

15.11.1 No mitigation is required.

During Operation

15.11.2 No impacts predicted therefore no mitigation required.

During Decommissioning

15.11.3 No impacts predicted therefore no mitigation required.

15.12 Cumulative Effects

15.12.1 Gwynedd Council and Snowdonia National Park Authority have confirmed (02 September 2019) that there are no current or future developments to be assessed cumulatively with VIP Snowdonia. A search of applications on the NRW marine licensing portal for plans and projects within 10km of the Proposed Marine Works was undertaken in November 2019 however, no plans and projects within this area were found. Given the Proposed Marine Works are planned for 2025 it is unlikely that information on any projects which could overlap spatially and temporarily with the Proposed Marine Works will be in the public domain yet. Should any future projects have the potential to overlap cumulatively with the Proposed Marine Works, they would need to consider the Snowdonia VIP project in their cumulative effect assessment.

15.12.2 Given the Proposed Marine Works are geographically separated from the terrestrial elements of the wider project and all predicted effects are confined to the marine

[16] Local ground level is 2.5m above ODN.

environment, no intra-project effects on the marine physical environment are anticipated.