Wylfa Newydd Power Station – Case Work towards the Shadow HRA

Review of case work, literature, and critical load assessment

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Task 1 Undertake a literature review to ascertain the most appropriate analogue habitat for ‘perennial vegetation of stony banks’ (in the absence of defined critical loads for this habitat type).

1. The interest feature is Natura 2000 habitat 1220 ‘Perennial vegetation of stony banks’ which comprises perennial vegetation of the upper beaches of great shingle banks, formed by *Crambe maritima, Honkenya peploides* and other perennial species. A wide range of vegetation types may be found on large shingle structures inland of the upper beach. On more mature stable shingle, coastal forms of grassland, heath and scrub vegetation may develop. Some areas of unusual vegetation dominated by lichens and bryophytes are found on more mature shingle[1].

2. At Cemlyn Bay, the feature is found on the shingle ridge between Bae Cemlyn and the lagoon, and in patches on Trwyn Cemlyn to the north. The feature comprises of two distinct habitats. The more open shingle comprises the NVC SD1 *Rumex crispus-Glaucium flavum* community. This habitat includes the rare *Crambe maritima*. The second habitat occurs leeward of the open shingle towards the back of the ridge, and comprises *Festuca* dominated grassland with salt-spray tolerant species such as *Plantago maritima* and *Armeria maritima*, according to the Core Management Plan, 2008[2] and the SAC monitoring report 2007[3].

3. The vegetation of the shingle bar is described in detail in Sneddon & Randall (1993). Comparing vegetation descriptions in Sneddon & Randall (1993) with community descriptions in Rodwell (2000), these fit most closely to the following National Vegetation Classification communities: The crest and seaward facing parts of the bar consist of the shingle community of SD1 ‘*Rumex crispus - Glaucium flavum’*. The leeward side of the bar facing the lagoon contains maritime cliff community MC8 ‘*Festuca rubra - Armeria maritima* maritime grassland’ in the middle of bar, grading to MC9 ‘*Festuca rubra - Holcus lanatus* maritime grassland’ in more sheltered areas at the ends of the bars. Narrow areas of saltmarsh SM16 ‘*Festuca rubra* salt-marsh community’ fringe parts of the edge of the bar where it joins the lagoon. From these descriptions we conclude that the more stable fixed shingle grassland at the leeward side of the ridge has close affinities with maritime cliff grassland communities.

4. Of note is that the shingle bank is subject to disturbance during storms and high tides, including overtopping of the bar at its narrowest point on very high tides.

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[1] http://eunis.eea.europa.eu/habitats/10013
[2] https://www.naturalresources.wales/media/671214/Cemlyn%20WES32%20plan%20English.pdf
[3] Pybus R. (2007). Bae Cemlyn SAC UK0030114. Perennial Vegetation of Stony Banks 1220. SAC Monitoring report 2007.

5. According to the site Core Management Plan, good quality habitat of the feature will:

    - Show no signs of trampling damage to *Crambe maritima* (crushed or snapped leaves)
    - Have at least two of the following species present:
        - *Atriplex spp*
        - *Beta vulgaris*
        - *Crambe maritima*
        - *Glaucium flavum*
        - *Rumex crispus*
    - Have <5% grass cover
    - Not have *Crocosmia* and /or *Fallopia japonica*

6. These quality characteristics relate primarily to the shingle community SD1, and the 5% cover threshold for grass cover is used solely to identify the boundary between the open shingle and the *Festuca* dominated shingle communities[4]. However, assessment of nitrogen impacts may be relevant to all vegetation types occurring on the shingle bar, and communities considered analogous in terms of potential nitrogen deposition impacts such as maritime cliff grasslands and acidic dune grasslands SD11 '*Carex arenaria - Cornicularia aculeata* dune community' and SD12 '*Carex arenaria - Festuca ovina - Agrostis capillaris* dune grassland'. Aspects relevant to the nitrogen sensitivity of all these communities are discussed below.

7. The shingle community SD1 is the characteristic pioneer vegetation of maritime shingle around England, Wales and parts of southern Scotland (Rodwell, 2000). The substrate can be either calcareous or acidic. It is a widely distributed community within this range on fine to coarse shingle. The vegetation germinates from seed or regrows from plant fragments along the high tide line amongst rotting seaweed and other marine debris. This organic matter acts as fertiliser and helps retain moisture during dry periods. The community includes rare species such as Sea kale *Crambe maritima*. It receives nutrient inputs from saltspray and marine debris in addition to atmospheric nitrogen deposition.

8. Maritime cliff vegetation has similarities to shingle vegetation in that it is also frequently exposed to salt spray, with the associated salt stress and nutrients (see point 11). However, in contrast to vegetation on active shingle, the vegetation is disturbed less frequently, for example, by coastal erosion or by sea birds. Note that the communities present on the Cemlyn bar are not similar to the variants maritime cliff grassland communities regularly disturbed by sea-birds.

[4] Pybus R. (2007). Bae Cemlyn SAC UK0030114. Perennial Vegetation of Stony Banks 1220. SAC Monitoring report 2007.

9. Saltmarsh is an intertidal habitat, with tidal inundation varying according to marsh elevation. The upper marsh may only be inundated on the highest spring tides. Due to this tidal inundation, saltmarsh can be considered to have an 'open' nitrogen cycle, i.e. it receives nutrients from the sea in the form of macro-algae and other marine debris, as well as from atmospheric deposition.

10. Acidic dune grassland has the following characteristics in common with older vegetated shingle which is no longer actively reworked by the sea. The substrate is acidic, and poorly buffered (acidic) habitats typically have a greater sensitivity to N deposition than well buffered (calcareous) habitats (Bobbink and Hettelingh, 2011; Jones et al., 2004; Remke et al., 2009). For fixed dune grassland it is recommended to use the lower end of the critical load range for acidic dunes and the upper end of the critical load range for calcareous dunes (Bobbink and Hettelingh, 2011). Lichens form an important component of the community.

11. In addition to atmospheric deposition, habitats close to the shore also receive nutrients such as nitrogen and potassium from salt spray (Etherington, 1967; Jones et al., 2002). Nitrate from marine aerosols can be detected up to 1 km inland (Lowe et al., 1996). In general, aerosol deposition is greatest near the sea and decreases exponentially inland. For example, salt spray at 100m inland of a cliff edge is only 20% of the values at the cliff edge itself (Malloch, 1997).

Task 2 Identify the most appropriate critical load for nitrogen and acid deposition against which to compare the modelled effect of the Wylfa Newydd Project.

Empirical critical loads for nitrogen for UK habitats were reviewed and recommended by JNCC as part of the nitrogen decision framework (Jones et al., 2016), including for habitats where critical loads have not been defined, based on analogue habitats with similar sensitivity to atmospheric nitrogen deposition. These are shown in

12. Table 1. The critical load for each community is discussed and a decision made on which is the most appropriate analogue for assessment of nitrogen impacts on the feature.

Table 1. Critical loads from Bobbink & Hettelingh (2011) and details of classification and appropriate analogue habitats extracted from the JNCC nitrogen decision framework Factor 1 spreadsheets (Jones et al. 2016).

JNCC CSM Guidance habitat types	NVC/vegetation types (as listed in CSM table where relevant) (*part only)	Annex I types included (*part only)	EUNIS classes for component habitats	EUNIS class name(s)	EUNIS class name for possible analogue habitats	CL range (kg N /ha/yr)
1a. Maritime grassland and rock-crevice communities	MC1-12, CG1f	H1230*	B3.31	Atlantic sea cliff communities		No critical load
3b. Saltmarsh (mid-upper)	SM14*, SM15-20	H1330*	A2.53	Mid-upper saltmarshes & saline & brackish reed, rush & sedge beds		20-30
9a. Shingle beach driftlines and open shingle vegetation	SD1-3*, MC6*, other	H1210 H1220*	B2.1 B2.3	Shingle beach driftlines; B2.3 Upper shingle beaches with open vegetation		Habitat not sensitive to N deposition
9b. Shingle grasslands	Various non-NVC Arrhenatherum and Festuca types	H1220*	B2.4	B2.4 Fixed shingle beaches with herbaceous vegetation	Coastal stable dune grassland (grey dunes)	8-15

13. Maritime cliffs have no critical load defined due to an absence of experiments or surveys addressing this issue for this vegetation type, and no sufficiently similar analogue habitats.

14. While frequently inundated, saltmarsh suffers less disturbance than the above communities. Its open nitrogen cycle means that it receives more nitrogen than terrestrial plant communities, from marine sources. Nonetheless, experiments have shown some sensitivity to elevated nitrogen inputs at levels ranging from 50 kg N/ha/yr and higher (Van Wijnen and Bakker, 1999). Based on evidence from limited studies and expert judgement the critical load is set at 20 – 30 kg N/ha/yr (Bobbink and Hettelingh, 2011; Boorman and Hazelden, 2012).

15. Shingle beach driftlines and open shingle vegetation are suggested to be ‘Not sensitive to N deposition’ since they are frequently disturbed by tidal activity and receive nutrient inputs from seawater, marine debris and from salt-spray, in addition to atmospheric deposition. Although the magnitude of these marine inputs of nitrogen has not been quantified to our knowledge, it is not insignificant. This is borne out by the relatively nitrophilic nature of the species growing in these habitats. For example, the mean Ellenberg N (nutrient) index for strandline communities on sandy beaches (SD3) is 6.1, compared with a value of 3.9 for

fixed calcareous dune grassland SD8 or 3.4 for acidic dune grassland SD12 (Jones and Stevens, 2017; Jones et al., 2002). The mean Ellenberg N index for the shingle community SD1 was not calculated in those studies, which focused on dune vegetation only. Higher Ellenberg N values indicate more nitrophilic vegetation. For comparison, the Ellenberg N index for *Urtica dioica* (stinging nettle) is 8. The frequency of disturbance is likely to be the dominant ecological influence on plant growth and community composition in this habitat. This also means that only rapidly growing plants are able to persist in such communities which, by necessity, require reasonably high levels of nitrogen input.

Both acidic dune grassland and (inland) shingle grassland (Type 9b in

16. Table 1) are likely to be more sensitive to nitrogen than the vegetation of shingle on and immediately adjacent to beaches. They experience relatively little physical disturbance and are typically located further inland where saltspray influence is reduced and they have closed nutrient cycles. In the critical loads guidance, the choice of analogue habitat of acidic dune grassland as a proxy for vegetated shingle is based primarily on comparison with extensive areas of vegetated shingle on the southern English coast. This may not be the most appropriate proxy for the vegetation types occurring on shingle at Cemlyn Bay. Given its proximity to the sea, and floristic affinities with maritime cliff grasslands, we feel that some of the maritime cliff grassland communities might be a better analogue habitat for nitrogen effects.

17. We summarise the appropriate critical loads for nitrogen and for acidity below:

18. For the **vegetation on the shingle bank at Cemlyn which corresponds to SD1 shingle vegetation**: Based on the characteristics of the vegetation of stony banks, its proximity to the sea, the frequency with which it is disturbed by tidal action and storms, and the Ellenberg N values of the dominant species (*Crambe maritima* = 7; *Glaucium flavum* = 6; *Rumex crispus* = 6 (Hill et al., 1999)), we suggest that this community is considered **not sensitive to nitrogen deposition**, following guidance from the JNCC nitrogen decision framework (Jones et al., 2016).

19. For the ***Festuca* dominated vegetation on the lee of the shingle bank corresponding to MC8 and MC9 maritime cliff vegetation, and the SM16 saltmarsh vegetation:** In the absence of a critical load for the maritime cliff communities, and given their proximity to the sea and associated saltspray, we recommend that **a critical load of 20 – 30 kg N/ha/yr** is applied, using saltmarsh as the most appropriate analogue.

20. With respect to acid deposition, it is likely that the input of sodium and magnesium ions from salt spray and other material from marine debris will provide sufficient buffering of small quantities of deposition of acidic compounds. **Therefore, we do not expect these communities to be sensitive to acid deposition**. It should be noted that this constitutes expert judgement and the amount of buffering capacity from the sea has not been measured.

Task 3 Advise on the likely effect of nitrogen and acid deposition on the perennial vegetation of stony banks qualifying feature (e.g. species composition, distribution and extent).

21. Gradient surveys and experiments have established the likely responses to elevated nitrogen of a number of species found in coastal communities, which

may be relevant to perennial vegetation of stony banks. These are summarised below.

22. As a general rule across most habitats, including coastal habitats, the percentage cover and species richness of bryophytes and lichens declines with increasing nitrogen above the critical load (Caporn et al. 2016; Field et al. 2014). This has been demonstrated in calcareous and in acidic dunes (Jones et al. 2004; Field et al. 2014). In dunes, the moss *Hylocomium splendens* is considered an indicator of nitrogen enrichment in UK surveys, declining in abundance with additional N above deposition loads of 20 kg N ha^{-1} yr^{-1} (Caporn et al. 2016; Field et al. 2014). Another moss, *Campylopus introflexus* is also considered an indicator of nitrogen enrichment in dunes and heaths in the Netherlands, particularly in drier dune habitats (Sparrius & Kooijman 2011). By contrast, this moss increases in response to nitrogen. Neither of these species are present on the bar at Cemlyn to our knowledge. The community composition of moss and lichen species in the vegetation on the bar is likely to be fairly specialised due to salt spray inputs and disturbance from wave action.

23. Another widespread response of plant communities is an increase in the cover of graminoids (grasses, sedges and rushes) (Maskell et al. 2010). In acidic dune grasslands in the Baltic, and in species mixture experiments, the sand sedge *Carex arenaria* increases with N deposition above the critical load for dunes (van den Berg et al. 2005; Remke et al. 2009). The biomass of some nitrogen-tolerant species found in coastal dunes has been shown to increase with added nitrogen: the grass *Dactylis glomerata* increased above 24 kg N ha^{-1} yr^{-1}, and the forb *Plantago lanceolata* at rates between 2 - 24 kg N ha^{-1} yr^{-1} (Jones et al. 2013).

24. The grass *Festuca rubra* is commonly found in neutral to calcareous soils and is an important component of many coastal communities, including the vegetation of stony banks and of maritime cliffs, the suggested appropriate analogue vegetation for assessing nitrogen impacts. There is limited evidence in the literature on its response to N. In two experiments as part of a species mixture in open-top chambers and in polytunnels, it increased in biomass with an increase in N addition from 2 to 24 kg N ha^{-1} yr^{-1} under ammonia fumigation, and an increase from 6 to 14 kg N ha^{-1} yr^{-1} using simulated wet deposition. However, in a field exposure of species mixtures in pots along an ammonia gradient it showed no change in biomass (Jones et al. 2013). Another coastal species for which nitrogen responses are known is *Ononis repens* which, in calcareous grassland starts to decline in abundance above nitrogen loads of 8 kg N ha^{-1} yr^{-1} (Caporn et al. 2016). However, we are not aware whether it occurs on the shingle bar at Cemlyn.

25. Rates of species loss above the critical load have been defined for a number of communities. In sand dunes, the rate is just under 1 species (per 20 m^2) lost for each additional kg of nitrogen in deposition, above the critical load of 8 kg N ha^{-1} yr^{-1} (Caporn et al. 2011).

26. The estimated increases in nitrogen deposition for different phases of the Project are summarised in Table 2 below. The increases are relatively low and well below the proposed critical load to be used for the perennial vegetation of stony banks feature.

Table 2. Nitrogen deposition, baseline and predicted change due to the Project

	Nitrogen deposition (kgN/ha/yr)		
Activity	**2020 baseline**	**Nitrogen from activity**	**Total**
2020 peak earthworks and Marine Works scenario – change to nitrogen deposition rate at Bae Cemlyn/Cemlyn Bay SAC	9.9	1.1	11
2023 peak construction scenario – change to nitrogen deposition at Bae Cemlyn/Cemlyn Bay SAC	9.9	0.2	10.1
Operational combustion plant long-term scenario – change to nitrogen deposition rate at Bae Cemlyn/Cemlyn Bay SAC	9.9	0.05	10

27. The combined total deposition will be below the critical load for the *Festuca* dominated vegetation on the lee of the shingle bank (corresponding to MC8 and MC9 maritime cliff vegetation), and the SM16 saltmarsh vegetation. The vegetation on the shingle bank (which corresponds to SD1 shingle vegetation) is considered to be not sensitive to nitrogen deposition. The individual species specified in the conservation objectives are relatively nitrogen-loving species as inferred from their Ellenberg nutrient scores.

28. Therefore, we expect no ecological effects of nitrogen on the botanical composition within individual communities. However, it is possible that extent may be altered (see Task 4).

Task 4 Provide an opinion on the potential for effect on the perennial vegetation of stony banks qualifying feature as a whole with reference to the conservation objectives for the qualifying feature.

29. The conservation objectives for the site in the Core Management Plan specify that the target of <5% grass cover is used solely to identify the boundary between the open shingle SD1 community and the *Festuca* dominated shingle communities (which are similar in character to maritime cliff grasslands).

30. While ecological impacts of nitrogen within communities have been widely studied, there have been almost no studies of changes in boundaries of adjacent communities due to nitrogen. This essentially amounts to competition between

communities. One study with potential relevance to this issue is work conducted on relative competition between heather *Calluna vulgaris* and bracken *Pteridium aquilinum* in upland grasslands. This study showed that the competitive balance between heather and bracken was complex, and was in part controlled by interacting effects of nitrogen and climate (Gordon 1999).

31. On the Cemlyn shingle bar it is possible that with increasing nitrogen *Festuca rubra* will expand in cover, thereby altering the boundary between the two adjacent communities, essentially expanding the shingle bank community similar to MC8 and MC9 to the detriment of the extent of the open shingle community SD1. However, at the deposition levels currently at the site, and with the projected increases in N deposition from the Project, we feel that this is unlikely. It is also probable that physical disturbance from wave action exerts a greater influence on the abundance of *F. rubra* than current or projected levels of nitrogen deposition.

References cited

Bobbink, R., Hettelingh, J.-P., 2011. Review and revision of empirical critical loads and dose-response relationships: Proceedings of an expert workshop, Noordwijkerhout, 23-25 June 2010. Rijksinstituut voor Volksgezondheid en Milieu RIVM.

Boorman, L.A., Hazelden, J., 2012. Impacts of additional aerial inputs of nitrogen to salt marsh and transitional habitats. Countryside Council for Wales.

Caporn S., Field C., Payne R., Dise N., Britton A., Emmett B., Jones L., Phoenix G., Power S., Sheppard L., Stevens S. (2016). Assessing the effects of small increments of atmospheric nitrogen deposition (above the critical load) on semi-natural habitats of conservation importance. Report to Natural England, 2016.

Etherington, J.R., 1967. Studies of nutrient cycling and productivity in oligotrophic systems 1. Soil potassium and wind-blown sea-spray in a South Wales dune grassland. J. Ecol. 55, 743-752.

Field C., Dise N., Payne, R., Britton, A., Emmett, B., Helliwell R., Hughes S., Jones L., Leake J., Leith I., Phoenix G., Power S., Sheppard L., Southon G., Stevens C., Caporn S.J.M. (2014). Nitrogen drives plant community change across semi-natural habitats. Ecosystems 17, 864-877.

Gordon, C., Woodin, S.J., Mullins, C.E. and Alexander, I.J., 1999. Effects of environmental change, including drought, on water use by competing Calluna vulgaris (heather) and Pteridium aquilinum (bracken). Functional Ecology, 13(s1), pp.96-106.

Hill, M.O., Mountford, J.O., Roy, D.B., Bunce, R.G.H., 1999. Ellenberg's indicator values for British plants. ECOFACT Volume 2 technical annex. Institute of Terrestrial Ecology, Huntingdon.

Jones L., Nizam M.S., Reynolds B., Bareham S., Oxley E.R.B. (2013). Upwind impacts of ammonia from an intensive poultry unit. Environmental Pollution 180, 221-228.

Jones, L., Hall, J., Strachan, I., Field, C., Rowe, E.C., Stevens, C.J., Caporn, S.J.M., Mitchell, R., Britton, A., Smith, R., Bealey, B., Masante, D., Hewison, R., Hicks, K., Whitfield, C., Mountford, E., 2016. A decision framework to attribute atmospheric nitrogen deposition as a threat to or cause of unfavourable habitat condition on protected sites. JNCC Report No. 579. , Peterborough.

Jones, L., Stevens, C., 2017. Development of a nitrophobe/nitrophile classification for sand dunes. Report to SEPA, contract DK1605b. CEH project number NEC06197.

Jones, M., Wallace, H., Norris, D., Brittain, S., Haria, S., Jones, R., Rhind, P., Reynolds, B., Emmett, B., 2004. Changes in vegetation and soil characteristics in coastal sand dunes along a gradient of atmospheric nitrogen deposition. Pl. Biol. 6, 598-605.

Jones, M.L.M., Reynolds, B., Stevens, P.A., Norris, D., Emmett, B.A., 2002. Changing nutrient budgets of sand dunes: Consequences for the nature conservation interest and dune management. 1. A review. Contract Report March 2002. CCW Contract No: FC 73-01-347. CEH Project No: C01919. Centre for Ecology and Hydrology, Bangor, pp. 1-84.

Lowe, J.A.H., Reynolds, B., Fowler, D., Brittain, S.A., Hughes, S., 1996. Orographic enhancement of acidic deposition in Snowdonia. Final report to Welsh Office. Institute of Terrestrial Ecology, Bangor, p. 41.

Malloch, A.J.C., 1997. Influence of salt spray on dry coastal vegetation, in: Van der Maarel, E. (Ed.), Ecosystems of the World 2c. Dry Coastal Ecosystems. General aspects. Elsevier, Amsterdam.

Remke, E., Brouwer, E., Kooijman, A., Blindow, I., Esselink, H., Roelofs, J.G.M., 2009. Even low to medium nitrogen deposition impacts vegetation of dry, coastal dunes around the Baltic Sea. Envir. Pollut. 157, 792-800.

Rodwell, J.S., 2000. British Plant Communities. Volume 5. Maritime communities and vegetation of open habitats. Cambridge University Press, Cambridge.

Sneddon, P., Randall, R.E., 1993. Coastal vegetated shingle structures of Great Britain. Joint Nature Conservation Committee, Peterborough, UK.

Sparrius, L.B. and Kooijman, A.M., 2011. Invasiveness of Campylopus introflexus in drift sands depends on nitrogen deposition and soil organic matter. Applied vegetation science, 14(2), pp.221-229.

Stevens, C.J., Smart, S.M., Henrys, P., Maskell, L.C., Walker, K.J., Preston, C.D., Crowe, A., Rowe, E., Gowing, D.J. & Emmett, B.A. 2011. Collation of evidence of nitrogen impacts on vegetation in relation to UK biodiversity objectives. JNCC Report, No. 447

Van Wijnen, H., Bakker, J., 1999. Nitrogen and phosphorus limitation in a coastal barrier salt marsh: the implications for vegetation succession. J. Ecol. 87, 265-272.

Van den Berg, L.J., Tomassen, H.B., Roelofs, J.G. and Bobbink, R., 2005. Effects of nitrogen enrichment on coastal dune grassland: a mesocosm study. Environmental Pollution, 138(1), pp.77-85.

Maskell, L.C., Smart, S.M., Bullock, J.M., Thompson, K.E.N. and Stevens, C.J., 2010. Nitrogen deposition causes widespread loss of species richness in British habitats. Global Change Biology, 16(2), pp.671-679.

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