Impacts on Coastal Process - TR545, CPMMP - Response to questions Deadline D7

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This paper is a response to the following question raised for my attention in Document '*ExQ2: 03 August 2021, Responses due by Deadline 7: 03 September 2021'*, as follows:

CG.2.12

Question received from the Examining Authority as follows:

> **Impacts on coastal processes**
> The EA DL5 comments on TR544 and TR545 [REP5-149] makes reference was to the latest beach erosion assessment work in TR545 which uses wave data from a buoy offshore of the Sizewell-Dunwich banks.
> (i) Do you agree that this effectively discounts the influence of the banks on wave height?
> (ii) Does that make it suitably precautionary, and the outputs can therefore accommodate natural dynamics including fluctuations in bank crest elevation for the duration of project?
> (iii) In any event, would the monitoring and mitigation proposed by the CPMMP provide a suitable mechanism to pick up any other fluctuations in bank topography?

Notes:

TR545 is a difficult document to follow and challenging to review for someone external to those involved in its creation. The following represents my best efforts at honest interpretation. The 'Notes' section in my document REP2-393 applies to all papers submitted in my name. The D7 deadline does not provide a sufficient timeframe for me to obtain a review of this paper by experts.

Introduction

TR545 is entitled *'Storm Erosion Modelling of the Sizewell C Soft Coastal Defence [SCDF] Feature using XBeach-2D and XBeach-G'*. TR545 modelling evaluates the sediment loss in the SCDF—which apparently varies between 16 and 82 cubic meters per meter in a storm sequence— and whether the SCDF has effective 'cut and fill' of the shingle and pebbles. TR544 asserts that: *"…the SCDF volume would be substantially larger than that required to withstand 2 – 3 severe sequential storms"*. However, *it would be unjustifiable to consider this modelling exercise outside its defining remit;* it is not indicative of the overall resilience of Sizewell C to a depleted offshore geomorphology. In my view, it must be recognised that **there are major defining limitations in both the scope and the parameters of the storms selected and the modelling presented.** This paper suggests why the modelling cannot be regarded as precautionary and that the ability of the SCDF to cope when faced with this particular modelling exercise is not surprising.

Responses.

Response to question (i) Do you agree that this effectively discounts the influence of the banks on wave height?

TR545 modelling states that "*.. to ensure the model domain was of a size that could be feasibly managed in XBeach, the offshore boundary was actually placed landward of the Sizewell-Dunwich sandbank".*

The relevance and importance of the Sizewell Dunwich banks in reducing the inshore wave climate is, in my view, critical to shoreline security at Sizewell C and therefore discounting the influence of the banks for flood risk and shoreline change modelling should be fundamental to its validity. This is discussed in my papers REP2-393 and REP5-253.

TR545 however, is not studying overall flood risk and shoreline change to the proposed Sizewell C and has a limited scope and remit. TR545's modelling, albeit with 'discounted banks', cannot be considered as indicative of the overall resilience of the Sizewell C shoreline to a depleted offshore geomorphology over the plant's lifetime to 2150/65.

TR545 also appears to retain the concept of 'fixed offshore bathymetry' in its modelling such that it is relying on the wave attenuation of the inner and outer longshore bars which are significant wave relief features if unreasonably assumed to be immutable.

These points are discussed in the next section.

In my view, the key issue raised by TR545 is to expose the Applicant's paradoxical approach to the role of the Sizewell-Dunwich banks in reducing wave heights. There are two directly opposing premises, one found in the recent TR545 and the other in the modelling as presented in the DCO Flood Risk Assessment. This is discussed in the Addendum.

Response to question (ii) Does that make it suitably precautionary, and the outputs can therefore accommodate natural dynamics including fluctuations in bank crest elevation for the duration of project?

It is important to recognise the scope of TR545 and establish the validity of conservative (precautionary) claims, as explained by the following observations:

1) Persistent erosion. TR545 modelling seemingly looks at the effect on the Soft Coastal Defence Feature (SCDF) of a limited number of storms including a simulation of the 'Beast from the East' (BofE) in this century but does not study the *persistent* effects of shoreline erosion over the lifetime of the proposed Sizewell C until 2150/65, an erosion that I consider could be severe if there is loss or major degradation of the Dunwich bank in this period. See TR545 (REP5-149) page 19.
Summary – erosion over plant lifetime is not within the remit of TR545.

2) Shoreline scope. TR545 concentrates on the SCDF and not the Minsmere shoreline—in my view, the flood risk to Sizewell C will come from breaches in the Northern shoreline of Sizewell/Minsmere flooding the contiguous marshland that will surround Sizewell C (the Minsmere Levels and Sizewell marsh).

The Minsmere breaches are noted, however, by TR545:
TR545 Page 13: "However, under the 1-in-20 year NE storm scenario with 2099 SLR… conditions are predicted to cause substantial natural overtopping and breaching of the south Minsmere shingle ridge, just north of Sizewell C… ***Overall, these results show that SCDF overtopping is unlikely to be a concern over the period modelled, but that natural*** **[natural?]** ***overtopping and breaching is increasingly likely on the southern Minsmere frontage toward the end of the century."*** My highlight and comment in square brackets.
Summary – TR545 modelling scope is particular and limited to the SCDF yet the document notes that 'substantial' Minsmere shoreline overtopping, and breaching is expected to occur with minor to moderate storms before 2100.

3) The climate change sea level rise used by TR545 is seemingly RCP4.5 95th. These levels in my view are too modest to be called 'conservative or precautionary' and RCP8.5 95th should be utilised as a minimum. (UKCP18 recommends planners use H++ which is significantly higher levels than RCP8.5). See TR545 (REP5-149) page 24. The new IPCC (Intergovernmental Panel on Climate Change) 6th AR6 report of August 21 should be considered.
See: https://sealevel.nasa.gov/data_tools/17
Summary – RCP4.5 is not a conservative or precautionary modelling variable.

4) TR545 is claiming that the BofE storm has *"a combined return period of 1-in-107 years in terms of cumulative wave power"*. This return period appears to be a consequence of regarding *"…three significant easterly storms in succession…"* as one overall storm. It is important to note however the individual component of these three storms such as storm surge and wave height:

- Storm surge: For the BofE modelling in TR545 ***no storm surge water level rise appears to be considered***. The maximum water levels considered by the modelling is limited to 1.52m ODN and 2.10m ODN. See TR545 (REP5-149) Figure 2-3, page 23-24 for water levels:

  TR545: "2.3.1.2 Water Levels…water levels used to force the model were those measured during each storm at the Sizewell tide gauge (Section 2.2.2.2). The calibration, "May Storm" simulation has a maximum water level of 1.52 mODN. The validation, 'Storm Ciara' simulation has a maximum water level of 2.10 mODN." For comparison a 1953 storm surge was 3.44m.
  A less particular study might consider historical storms at Sizewell / Minsmere: ***"Large surges combined with high tides occurred in 1817, 1883, 1897, 1912, 1928, 1938, 1949, 1953, 1976 and 1978 [and 2013] and caused regional damage to flood defences."*** *See:* Pye Blott, 2005, Coastal Processes and Morphological Evolution of the Minsmere Reserve and Surrounding Area, Suffolk. Page 5.
  Summary – not a conservative or precautionary modelling in view of storms chosen for modelling and no storm surge consideration for the BofE.

- Waves: For the Beast from the East modelling (BofE) the 'offshore' wave data used by TR545 were max. H(s) of **3.02m (May storm)** and max. Hs of **3.63m (Storm Ciara)**, maximum 4.31m. By contrast, the 1:100-year wave heights according to Mott Macdonald and Pye and Blott are: 1 in 100-year offshore Hm0 (significant wave height) value of 7.8m for waves from the N –NNE sector"; According to Pye and Blott the 1:100 would be 7.3- 7.8m.

(See: *'Thorpeness Coastal Erosion Appraisal Final Report December 2014'*, Mott Macdonald, Page 15. See TR545 (REP5-149) para 2.3.1.1., page 24 for wave heights, TR545 page 22 for wave runup values.)

The maximum actual wave recorded off Sizewell in the last 12 years was H(s) 4.72m according to Tr544 (page 25). Conservative, precautionary modelling must reasonably use much greater wave heights. I am not clear how Tr545 is quantifying and addressing maximum wave heights, but it appears from Figure 2-3, page 23 of TR545 that brief periods of waves in the region of 4m are used.
Summary- not conservative or precautionary modelling unless waves well in excess of 4.71m have been considered.

5) Immutable offshore bathymetry and fixed wave relief features: Modelling of all scenarios is seemingly limited by the '*2017 Titan/BEEMS bathymetry offshore'*. **In other words, the offshore geomorphology is fixed in the modelling—the inner and outer longshore bars and the Sizewell Dunwich banks are immutable.** This has implications for the modelling that need careful study, not least the fact that even if the Dunwich bank is fully discounted by the modelling (and this is not clear – see the section 'The difficulty of interpreting TR545') **the limitation of 'present bathymetry means the claimed 'conservative' modelling is *not seemingly considering any loss or degradation of the inner and outer longshore bars as a wave relief feature as* confirmed by the quotation below:**

> *TR545 "As the model domain extends in the marine environment, the beach topography is combined at the water line with the multibeam bathymetry from 2017. Whilst in reality storm conditions will alter the inner and outer longshore bars along the Sizewell frontage over time, **the 2017 bathymetry** is the most recent and accurate data available relative to the selected storms and is deemed to represent the position of the inner and outer longshore bars sufficiently to achieve the aims of the present modelling activity."* See TR545 (REP5-149) Page 25.
> Red highlight is mine.
>
> Summary – If, *'in reality'* the inner and outer longshore bars will '*alter*', conservative modelling cannot then reasonably consider them immutable wave relief features. 'Present bathymetry' (as I have previously stated in my reviews of the main FRA and EGA) would be an unreasonable assumption and unsupportable premise over plant lifetime and cannot be regarded as a conservative, precautionary modelling approach.

6) Water levels over the banks: The claim to 'conservative' modelling in TR545 is also not, in my view, correct for an additional reason: the effects of the wave attenuation and wave moderation features of the Sizewell-Dunwich banks will essentially be lost with climate change sea level rise and the incorporation of a storm surge sea level rise. Therefore, without these conditions fully considered the modelling cannot be regarded as conservative.

Overall summary of question (ii) In my opinion, when the above points are considered, it is unsurprising that the SCDF was neither overtopped nor overwhelmed by the modelled storms in TR545. The modelling offered in TR545 cannot be regarded as sufficiently precautionary and conveys little information relating to the security from flood and erosion risk to the Sizewell C plant over its full lifetime. The modelling does not represent a substitute for full flood risk and shoreline change assessments that take into account the persistent effects of shoreline flood and erosion risks that could result from significant 'fluctuations' (depletion) of the Sizewell-Dunwich banks and nearshore bars over the lifetime of the plant.

Response to question (iii) In any event, would the monitoring and mitigation proposed by the CPMMP provide a suitable mechanism to pick up any other fluctuations in bank topography?

Fluctuations in bank topography may be recorded successfully or otherwise, but the key importance rests with the actual mitigation options available in event of shoreline erosion resulting from bank depletion.

The mitigation proposed by CPMMP appears to be limited to 'beach sediment recycling' (moving pebbles along the beach), and 'beach sediment recharge' (adding pebbles to the beach)—this is described in sections 7.5.1 to 7.5.3 of the CPMMP 6.14 Revision: 2.0 PINS Reference Number: *EN010012 Coastal Processes Monitoring and Mitigation Plan*.

However, If the Dunwich bank were to deplete significantly or not be present, which is not without historical precedent (i.e., the rate and location of erosion prior to the development of the Dunwich bank which is explained in chapter 2 of my document REP2-393), I consider it reasonable to expect accelerated erosion of the Sizewell shoreline all the way to Minsmere Sluice. Shoreline management, maintenance and 'mitigation' would thus be required along the Sizewell foreshore to the Minsmere sluice. This appears to be acknowledged by the CPMMP.

I find it concerning however, that as in the flood risk and shoreline change assessments in the DCO application, and as explained in my documents REP2-393 and REP5-253, **there is an implicit reliance on northern shoreline erosion resupplying the Sizewell shoreline**, as follows:

> *CPMMP 7.5: "It is important to note that changes to the broad coastal regime and coastal processes may occur within the operation and decommissioning phases, some of which may reduce or obviate the need for mitigation. In particular, decay and/or removal of the Minsmere Sluice and erosion of the Dunwich – Minsmere Cliffs are likely to increase shingle supply and alter the shoreline shape."* My red highlight. This is covered in my document REP2-393 Section 2 (2.7).

In my view, this is an unreasonable premise: sediment transport from erosion cannot be relied upon to specifically relocate. The premise also de facto assumes the retention of the Sizewell-Dunwich banks and does not consider the opposite effect; immediate northern shoreline erosion might reasonably extend all the way to the Sizewell frontage, especially on depletion of the Dunwich bank, providing an extremely challenging environment for a 'hold the line' policy.

As shown in my document REP2-393 storm breaches of the shoreline in, around and even above Minsmere sluice could flood the contiguous wetlands and hence increase flood risk to the main nuclear platform.

In my view, the mitigation proposed by CPMMP is significantly compromised by the inability of human agency to control or maintain the geomorphological receptors themselves, namely: the nearshore, longshore bars, the Sizewell-Dunwich banks and in particular the Dunwich bank established and agreed by EDF pre-DCO to be '*critical*' to shoreline protection—see my paper REP3-119 and REP2-393.

The difficulty of interpreting TR545

In my view, the paper is somewhat ambiguous as explained below:

The following wording in TR545 implies a present-day DEM (Digital Elevation Models) where beach profile and offshore bathymetry are 'stitched together', as follows:

> *"Baseline – 2017 DEM: This model domain represents the Baseline "As Now" case. This domain is made up of the 2017 LIDAR data in the intertidal areas and 2017 Titan Bathymetry offshore. It represents the most recent co-incident terrestrial and subtidal elevation data. These combined data have a resolution of 1 m."* See TR545 (REP5-149) page 19.

So, this suggests that 'present bathymetry' (immutable offshore banks) is yet again assumed for the modelling as it is in the FRA and EGA, but then the following suggests that the Sizewell-Dunwich banks are not in fact included in the model domain:

> *"The offshore boundary of the model domain was initially placed to coincide with a water depth similar to that at the location of the Sizewell waverider buoy, used to provide forcing scenarios for the model. The buoy is located seaward of the Sizewell-Dunwich sandbank, in approximately 10 m water depth at mid tide. However, to ensure the model domain was of a size that could be feasibly managed in XBeach,* ***the off****shore boundary was actually placed landward of the Sizewell-Dunwich sandbank, at the equivalent water depth. Some frictional dissipation and even breaking of the largest waves would occur over the sandbank (-5.8 m ODN crest elevation), but is not accounted for in this study as the sandbank is not present in the model domain. Therefore, the beach response predicted by the model is considered to be conservative (i.e., more erosive than in reality), as the cumulative wave energy reaching the shore is likely to be larger than in reality under storm wave conditions.* See TR545 (REP5-149) page 19.

The final sentence however, says the DEM has been simplified to a depth of 20m offshore. This suggests a simplified model domain that maybe does include all the submarine morphological features (present bathymetry, defined by the Titan 2017 survey) - for the purpose of making the model run:

> *"As per the recommended XBeach guidelines (https://xbeach.readthedocs.io), an artificial offshore slope to a depth of 20 m was added at the offshore boundary of the model domain."* See TR545 (REP5-149) page 19.

It is also seemingly the case that, as stated, the inner and outer longshore bars are retained in the model domain as immutable wave relief features.

Overall conclusion:

In my view, the modelling of relatively short duration specific storms presented in TR545, is a particular exercise in studying soft defence (SCDF) 'cut and fill' and shingle loss. It cannot be regarded as having any wider remit of studying Sizewell shoreline resilience over the plant lifetime.

TR545 is also confined by its defining parameters which also make it unsuitable for wider consideration:

1) the choice of storms modelled (wave heights and water levels);

2) the use of mid-range climate change sea level rise;

3) no regard for storm surge in the BofE modelling (and only a very limited consideration in other modelling);

4) limited scope in not considering the impacts of northern coastline breaches;

5) an unsupportable reliance, in my view, on treating offshore wave attenuating geomorphology such as at least the inner and outer longshore bars as 'immutable'—i.e., permanently resilient.

The limited and 'particular' nature of TR545 modelling, in and of itself, could be acceptable. However, the meaning of TR545 needs careful consideration; TR545's claims to conservative (precautionary) modelling are, in my opinion, mainly misplaced as shown in this document *and particularly so if such claims are contextualised to be representative of overall flood and erosion risk modelling of the proposed Sizewell C.*

In my opinion also, the mitigation proposed by CPMMP, a 'hold-the-line shoreline pebble rearrangement and supply', does not provide reassurance when considering the scale and potential consequences to shoreline erosion resulting from the degradation or loss of the major geomorphological receptors— i.e., the Dunwich bank and inner and outer longshore bars. As stated above, the mitigation proposed by CPMMP is unable to address the critical offshore geomorphological receptors themselves.

EDF's beach erosion modelling should be clear, explicitly stated and unambiguous. In my view, unless particularities are clearly stated, any flood and erosion modelling claiming to be *conservative* (precautionary) should be considered over the full lifetime of the plant; run with the Sizewell Dunwich banks and nearshore, longshore bars *degraded and absent*; RCP8.5 95th climate change sea level rise data and including at least 1953 level storm surges and significant wave heights between 4.71m and 7.8m.

The modelling presented in TR545 does not then appear to discount the need for flood risk and shoreline change assessments (FRA and EGA) that take full account of the detailed and accredited comments made in my papers REP2-393 and REP5-253.

Addendum

One of my main concerns in the original flood risk assessment (FRA) presented in the DCO is the Applicant's claim to 'conservative', (precautionary) modelling of wave data. This is covered in my document REP2-393 section 7. **My concern is clearly illustrated by a paradox created by the difference in approach between TR545 and the DCO, as follows:**

In TR545:

The Applicant is suggesting in the wording copied below that the use of offshore wave data from outside the Dunwich bank, if utilised in the model inside the Dunwich bank, will result in conservative (precautionary) modelling:

> *"…The [waverider] buoy… located seaward of the Sizewell-Dunwich sandbank… was actually placed landward of the Sizewell-Dunwich sandbank, at the equivalent water depth. Some*

> *frictional dissipation and even breaking of the largest waves would occur over the sandbank (-5.8 m ODN crest elevation), but is not accounted for in this study…Therefore, the beach response predicted by the model is considered to be* ***conservative*** *(i.e. more erosive than in reality),* ***as the cumulative wave energy reaching the shore is likely to be larger than in reality****" TR545 Page 19.*
>
> *"…the modelling [TR545] discounts the influence of the banks on wave height. So, immediately it is precautionary in that regard."* Environment Agency comments in 'Transcript ISH6' doc ref EV-126 op cit., 34:25.

TR545 is thus indicating that its model's conservative (precautionary) approach is due to the *absence* of the Sizewell-Dunwich banks acting as a wave attenuating feature in the modelling. As shown, this is also confirmed by the Environment Agency.

In the DCO:

This is in direct contrast however, with the Flood Risk Assessment (FRA) in the DCO, where the Applicant claims that conservative (precautionary) modelling is represented by the *presence* of the Sizewell-Dunwich banks in the modelling:

> *"Overall, the 'baseline' scenario* [The Sizewell Dunwich banks present in immutable form] *predicted slightly higher nearshore waves than the other scenarios and was therefore taken forward for assessment for the FRA overtopping model runs."*
> DCO: Main Development Site Flood Risk Assessment Appendices 1-7 Part 1 of 14. APP-094 Section 1.3.13.
>
> In case of doubt, it is repeated as follows:
>
> *"The derived nearshore wave conditions for the baseline (with sand bar) and lowered sand bar scenarios were compared showing that the baseline scenario predicted higher nearshore waves than the lowered bar scenario. Therefore, the baseline scenario was taken forward for wave overtopping assessment for the Sizewell C FRA, as it is more conservative."* DCO Main Flood Risk Assessment APP-093 Section FRA, Section 5.3.17. The word 'sandbar' refers to the Sizewell-Dunwich bank. Note that this 'scenario' also effectively underpins the shoreline change assessment.

The Applicant and its advisor Haskoning, supported by wave data and recommendation from Cefas, with no concerns raised by the Environment Agency that I am aware of, are therefore affirming what I consider to be the most 'perplexing' aspect of the FRA—that the *'baseline scenario*' (i.e., with the Sizewell-Dunwich banks in situ) *"predicted higher nearshore waves" and is consequentially more conservative and precautionary.* This subject is covered in my main document REP2-393 Section 7.2.

Each of the two directly opposing geomorphological scenarios are being suggested by the Applicant as the premise for justifying conservative (precautionary) modelling.

These two modelling scenarios, one from the recent modelling in TR545 and the other from the FRA, appear to me therefore, to be mutually incompatible in their claims.

TR545, rather than addressing the limitations of the DCO flood risk and shoreline change assessments, is a technically limited study that in my view, even with its limitations, serves only to *highlight the unjustifiable premise underpinning the methodology of the wave modelling utilised in the DCO documentation.*