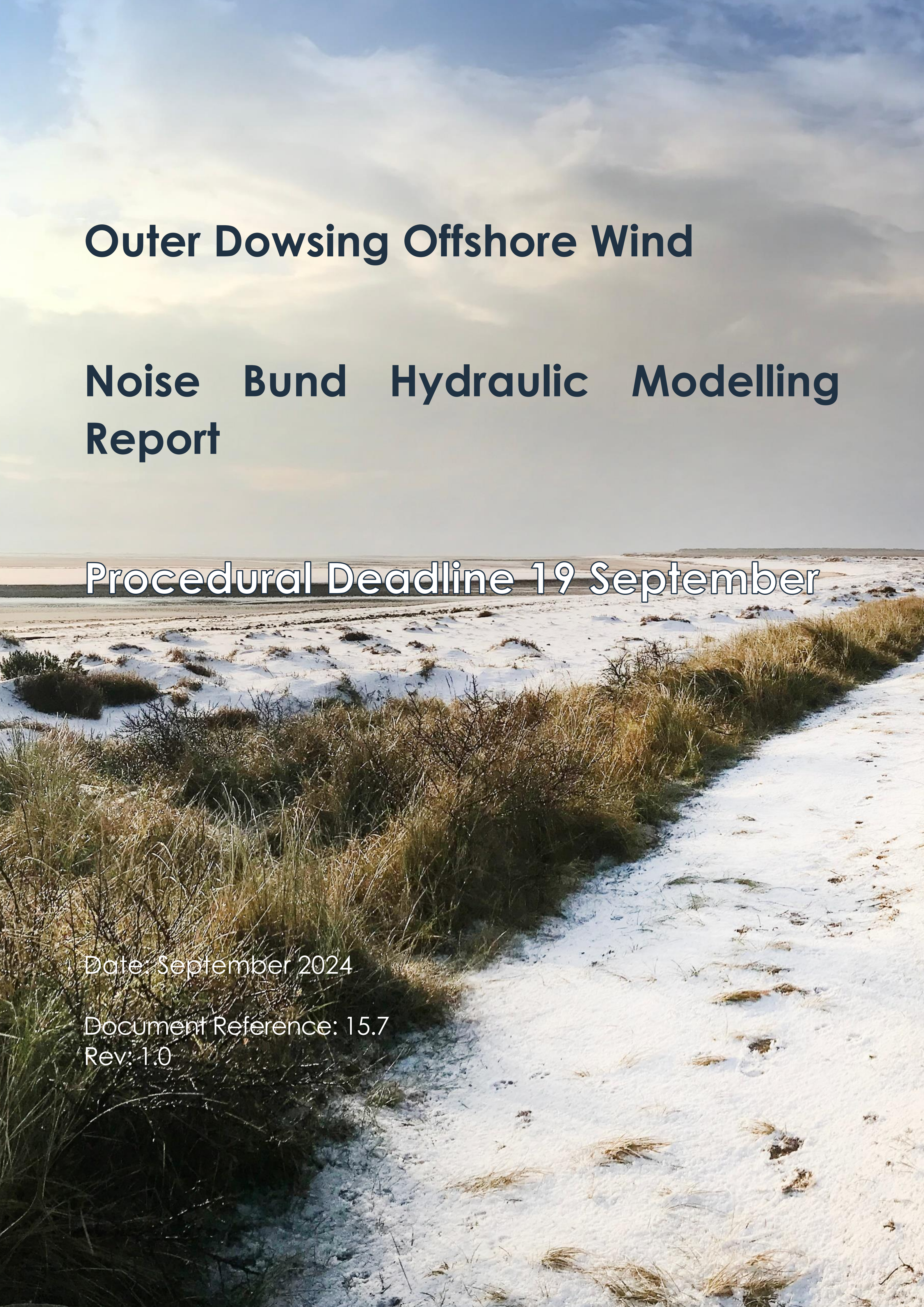

Outer Dowsing Offshore Wind

Noise Bund Hydraulic Modelling Report

Procedural Deadline 19 September

Date: September 2024

Document Reference: 15.7
Rev: 1.0

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<tr><td colspan="2">Project:</td><td colspan="2">Whole Wind Farm</td><td colspan="2">Sub Project/Package:</td><td>Whole Asset</td></tr>
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Noise Bund Hydraulic Modelling Report

Outer Dowsing Offshore Wind

GT R4 Limited

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SLR Project No.: 410.065702.00001

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Appendices

1.0 Introduction and Background

1. This report outlines the hydraulic modelling and results of the flood risk impacts from the installation of a proposed temporary noise bund at landfall as part of the Outer Dowsing Offshore Wind (ODOW) Project. This modelling has been requested by the Environment Agency as part of the Flood Risk Assessment (FRA) of the Export Cable Corridor (ECC), in order to understand whether the temporary noise bund has any potential impact upon flood risk. This report is therefore presented as a clarification of the ECC and 400kV FRA (document reference 6.3.24.2).
2. The primary purpose of the bund is to mitigate noise impacts to Anderby Marsh, located adjacent to the drill pit. The bund is situated within an area shown to be at a residual risk of flooding from breach of the coastal defences (dunes)[1]. The noise bund is located near Anderby Creek, on the west side of Roman Bank. This is a low-lying coastal area surrounded by agricultural fields and a series of ditches with embankments to prevent tidal flooding. Figure 1 shows the location and orientation of the noise bund.

Figure 1: Location of Noise Bund

3. The noise bund tidal model has been constructed using the TUFLOW hydraulic modelling package (Build: 2023-03-AE-iSP-w64).
4. The TUFLOW HPC module was selected as the numerical solver for the development of the coastal 2D hydraulic model. The High-Performance Compute (HPC) module solves the full 2D shallow water equations, including inertia and turbulence, and is suited to floodplain, open channel, and pipe hydraulics. The HPC solver also enables adaptive time-stepping in conjunction with smaller grid resolutions for greater granularity of results

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[1] https://flood-map-for-planning.service.gov.uk/

and topographic features where this is required. This package, which is distributed by BMT is widely used in the UK and has been benchmarked by the Environment Agency.

5. A technical note explaining the methodology was submitted to the Environment Agency prior commencement of the modelling. This was reviewed and the methodology was amended to address the comments received. The methodology technical note and Environment Agency response is appended as Appendix A. Addressed comments and responses are summarised in Table 1-1.

Table 1-1: Technical note review comments/responses matrix

EA Comment	Response
Section 2.1 Hydrology, bullet point 4 states that 'the climate change uplift has been calculated as 70mm'. However, the climate change allowance for 2018 to 2030 is 84mm and this is the uplift included in Table 1. We consider that the climate change uplift of 84mm and tabulated levels presented in the methodology are appropriate to represent the temporary nature of the noise bund, calculated from the base year of 2018 to the year 2030.	Climate change allowances in the report have been updated. **Climate change allowances:** *2018 – 2030 – 12yrs x 7mm = 84mm (end of project life span)* *2018 – 2024 – 6yrs x 7mm = 42mm (present day)*
Time to closure - In line with the Requirements for Hazard Mapping v8, the time to closure for open coast is 72 hours, rather than 70 hours. The model simulation time should be long enough to allow maximum spreading of flood water.	Model has been run for 80 hours allowing maximum spreading of flood water.
Breach widths - The Environment Agency Tidal Hazard Mapping ran a multiple breach scenario at location E20 where the breach width was 100m for the coast and 50m for Roman Bank.	These have been amended accordingly.
Flood progression maps are not proposed. These would be beneficial to show the impacts of any land raising on the surrounding area and third parties as the breach progresses.	Flood animations have been produced for critical events and scenarios.
The methodology confirms that sensitivity runs will be completed for cell size, material roughness, model inflows and design tidal curve. No details of the sensitivity run are provided.	Sensitivity analysis details have been provided in Section 4.0 of this report.
It's not clear from the methodology what the baseline will be based on. Is it CFB 2018 or present day?	Baseline hydrology is based on present day (2024). The CFB boundaries have been adjusted to reflect this.
The methodology doesn't detail how land use will be considered within the 2D Domain i.e., Manning's roughness. The consultant should delineate areas of land use and apply appropriate roughness values.	Land use is based on the UK Land Cover Map 2021 (LCM2021) provided by the UK Centre for Ecology & Hydrology (UKCEH). Details of this have been provided in Section 2.7 of this report.
The methodology doesn't detail any further proposed topographical changes that could influence flow pathways and flood mechanisms within the Site. Has any topographical survey been undertaken within the Site that can be modelled to increase confidence in ground	No topographical survey has been completed for the Site. 12.5cm aerial survey photogrammetry data has been gathered as part of the wider Project and has been used for an increase in resolution of the topography where available.

EA Comment	Response
elevations? If so, it is recommended that survey is incorporated.	
The figures do not show the proposed 2D domain extent, although the Methodology states 'The model will extend significantly far inland from the site, so the key flooding mechanisms are not affected by any model boundary conditions. The 2D domain should be sufficiently large to prevent glass walling and allow flood propagation.	This has been amended accordingly.
The methodology shows that the peak tidal curves occur at the start of the simulation with subsequent tidal peaks subsiding. Normal practice is to apply the highest peak in the middle of the simulation.	The tidal curve has been updated with the highest peak in the middle of the simulation.
Defence crests will be represented using Z lines with crests informed from the 'EA Spatial Flood Defences Including Standardised Attributes' layer and cross referenced against LiDAR. This is considered an appropriate methodology. Z Line node locations should be of sufficient frequency in order to represent variations in crest height along its length.	This has been amended accordingly.
Sensitivity runs on the boundary parameters, should 2D flow boundaries be used.	Sensitivity runs on model inflow boundary conditions have been carried out. Details of this have been provided in Section 2.7 of this report.

2.0 Methodology

6. This section of the report summarises the construction of the 2-Dimensional (2D) hydraulic model.

7. The construction of 2D hydraulic models requires several data sets and parameters, of which the key items are summarised below:

   - Model extent;
   - Floodplain topography in the form of a digital terrain model (DTM);
   - Cell size;
   - Topography edits;
   - Hydraulic structures;
   - Hydraulic boundaries; and
   - Roughness (Manning's n).

2.1 Model Extent

8. The hydraulic model domain extends along the beach from Anderby Creek to Chapel St. Leonards. The A52 High Road borders the model on the south and west sides, while the minor road, Sea Road, delineates the northern boundary. To avoid glass walling due to the flat terrain, the model extent has been extended inland. The model extent is illustrated in Figure 2.

2.2 Topography (DTM)

9. The underlying base topography for the hydraulic model of the study area has been generated from the filtered aerial photogrammetry (LiDAR) data obtained from the Defra website[2] *'TF57ne_DTM_1m.* This 2022 LiDAR dataset adequately represents the floodplain topography, allowing for accurate flood routing for out of bank 2D flow, while also providing coverage of the full model extents as shown in Figure 2 below.

2.3 Topography Edits

10. The following key components were also added to the baseline LiDAR DTM to add more detail to the 2D domain of the flood model:

    - In accordance with EA guidance[3], building footprints within the model extent have been raised by 0.3 meters. OS Open Map – Local (OML)[4] was used to represent the building footprints in the hydraulic model using a 2D_zsh layer.
    - In addition to the LiDAR data, 12.5cm aerial survey photogrammetry data gathered as part of the wider Project has been used where available across the model extent for an increase in resolution of the topography, particularly around the proposed noise bund area. The difference between LiDAR data and the aerial survey is between -0.3m to +0.1m. Since we are using 10m grid cell size, these data sets were incorporated in the model.

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[2] Defra Data Services Platform, June 2024. https://environment.data.gov.uk/DefraDataDownload/?Mode=survey

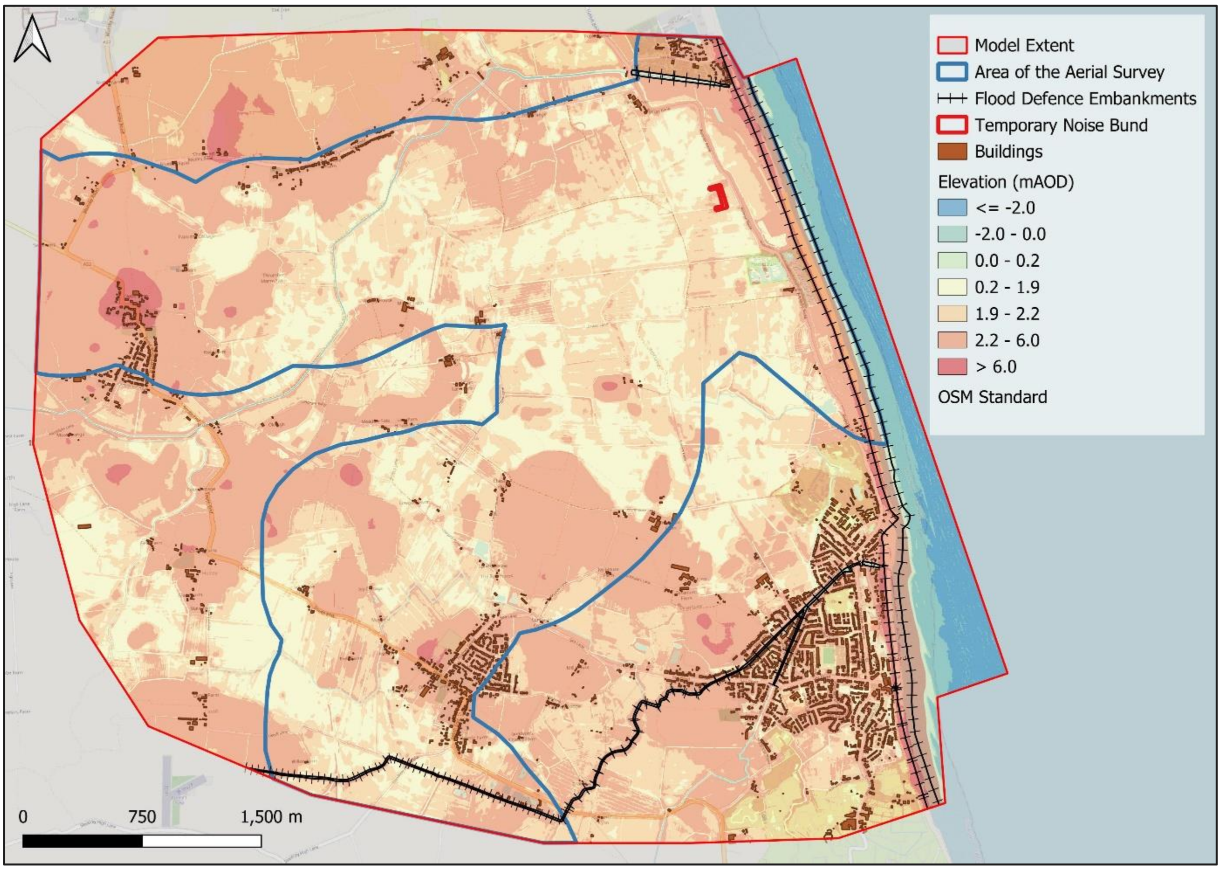
[3] Environment Agency, Anglian Region, Northern Area Requirements for Hazard Mapping. January 2014

[4] Ordnance Survey Platform, June 2024, https://www.ordnancesurvey.co.uk/products/os-open-map-local

- The heights of spatial flood defences in the modelled area will be defined by a series of ZSH polylines in the TUFLOW 2D domain. The elevations used for the defences were obtained from the AIMS Spatial Flood Defences[5] data.
- For the proposed development model scenario, the footprint temporary noise bund has been raised using a 2D_zsh to the design level of 11.4 mAOD.

11. The above key topographical edits are also indicated in Figure 2 below.

Figure 2: 2D Model parameters



2.4 Cell Size

12. A 10m model grid cell size was utilized considering the floodplains expansive area and likely flow paths, relatively minimal variation in regional topography and largely rural nature. This cell size has also been determined to be sufficient for incorporating crucial details such as channel width, breach length, flood embankment width, and the width of main roads surrounding the study area. These factors were carefully considered to provide an accurate evaluation of the flood risk model grid cell size, ensuring a thorough and robust assessment of potential vulnerabilities and hazards. Sub-grid sampling was used to utilise the high resolution DTM data regardless of the TUFLOW grid cell size being used. By utilising the underlying sub-grid scale topography, it is possible to more accurately represent the storage and conveyance that is possible within the system being modelled.

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[5] AIMS Spatial Flood Defences (inc. standardised attributes), June 2024, https://www.data.gov.uk/dataset/cc76738e-fc17-49f9-a216-977c61858dda/aims-spatial-flood-defences-inc-standardised-attributes

2.5 Breach Locations

13. Two primary breach scenarios were considered:

- Breach 1:
    - Dune breach – 1st tidal cycle (100m)
    - Roman bank – No breach
- Breach 2:
    - Dune breach – 1st tidal cycle (100m)
    - Roman bank – 2nd tidal cycle (50m).

14. These breach locations were selected considering the distance to the proposed noise bund location, watercourses surrounding the study area and regional topography. Each breach was triggered to occur one hour before the peak water level on the first tide cycle of the model simulation, as per Environment Agency Guidance[6] and were represented in TUFLOW using variable (2d_vzsh) shapefiles. The level the breach is dropping to is the lowest DTM level around each of these flood defences. The location of the breaches are shown in Figure 3.

Figure 3: Breach Locations

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[6] Environment Agency, Anglian Region, Northern Area Requirements for Hazard Mapping. January 2014

2.6 Hydraulic Boundaries

15. The boundary condition applied to the TUFLOW model was a Head-Time (HT) boundary placed on the model boundary along the sea. This boundary is used to assign the tidal curves for the 1 in 200 annual chance (0.5% Annual Exceedance Probability (AEP)), 1 in 1,000 annual chance (0.1% AEP), 1 in 200 annual chance plus an allowance for climate change (0.5% AEP + CC) and 1 in 1,000 annual chance plus an allowance for climate change (0.1% AEP + CC). This study focuses solely on coastal / tidal flooding mechanisms.

16. The shape of the astronomical tidal curves used in the modelling were taken from the 2011 Hyder River Welland Hydraulic modelling report[7]. These tidal curves have then been scaled to fit the extreme sea levels from CFB chainage at 3948[8] (*CFB conditions for the UK 2018 for 'Location: Chainage: _3948*). CFB 97.5% confidence levels has been selected to minimise the uncertainty. The CFB level were adjusted to present day level (2024) by increasing the water levels by 42mm.

17. Climate change allowances for sea level rise have been calculated from a base year of 2018 using the current guidance from the EA for the Anglian Region for the Upper End Scenario (Flood risk assessments climate change allowances).

18. As the noise bund is a temporary structure for the construction phase only, the expected design life of the structure is 4 years. Therefore, the climate change uplift has been calculated as 84mm (2018 to 2030 – accounting for the adjustment for sea level rise to present day and the addition of 4 years from anticipated construction date (2026) to account for the life span of the development).

19. The resultant tidal curve and the tidal curve from EA report for the 1 in 1000-year event is shown in Figure 4. Peak tidal levels are summarised in Table 2-1.

20. Full tidal curve calculations can be found in Appendix B.

---

[7] April 2011, Hyder/Environment Agency: Strategic Flood Risk Management Framework Tidal Nene and Tidal Welland Hazard Mapping Hydraulic Modelling Report

[8] 2018, Environment Agency: Coastal Flood Boundary Extreme Sea Levels

Figure 4: Scaled Tidal Curve

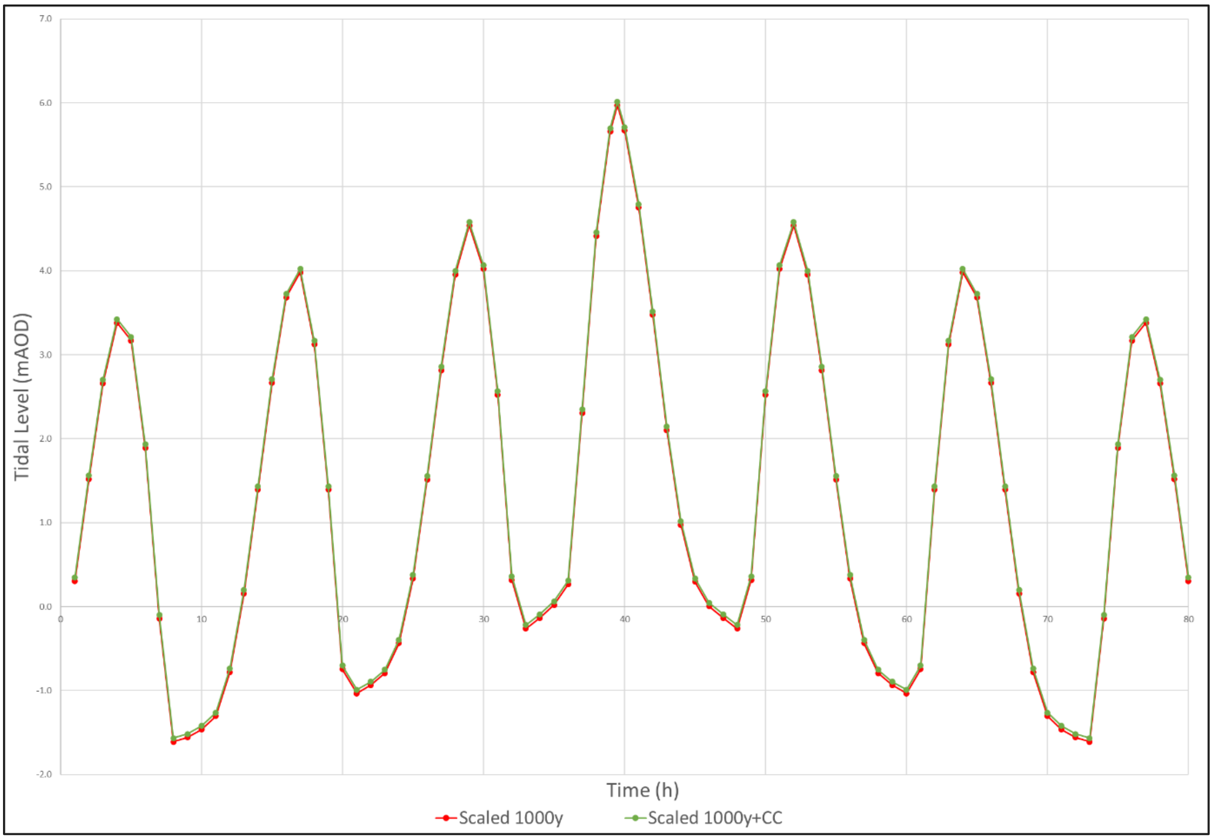

Table 2-1: Summary of Peak Tidal Levels

AEP%	EA Report[9] (mAOD)	CFB (mAOD) 2018	CFB 2018 (97.5% CL) (mAOD)	TUFLOW Modelled Peak HT boundary (mAOD)
1:200 (0.5% AEP)	5.99	4.830	5.260	5.302
1:200 (0.5% AEP) + CC	7.13	4.914	5.302	5.344
1:1000 (0.1% AEP)	6.69	5.240	5.930	5.972
1:1000 (0.1% AEP) + CC	7.83	5.324	5.972	6.014

Climate change allowances:

2018 – 2030 – 12yrs x 7mm = 84mm (end of project life span)

2018 – 2024 – 6yrs x 7mm = 42mm (present day)

2.7 Manning’s n

21. The definition of the extent of each of the roughness values in the 2D domain was determined using the Land Cover Map 2021 (LCM2021) provided by the UK Centre for Ecology & Hydrology (UKCEH). This was correlated with aerial photography to delineate different land use areas based on ground surface characteristics (Table 2-2). Each land

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[9] April 2011, Hyder/Environment Agency: Strategic Flood Risk Management Framework Tidal Nene and Tidal Welland Hazard Mapping Hydraulic Modelling Report

use type was assigned a corresponding Manning's n value in the TUFLOW Materials File as shown below in Table 2-2, with a set default Manning's value of 0.04 (99).

22. In accordance with EA guidance, the roughness value within the model for building footprints has been increased to 0.1.

23. The material roughness across the model domain has been read into the hydraulic model using a TUFLOW standard Material.csv with Manning's n values derived from Chow[10].

Table 2-2: Modelled Material Properties

Material ID as referenced in GIS layer	Manning's n value	Land use type
1	0.100	Deciduous woodland
2	0.060	Coniferous woodland
3	0.035	Arable
4	0.030	Improve grassland
5	0.035	Neutral grassland
6	0.035	Calcareous grassland
7	0.030	Acid grassland
8	0.035	Fen
9	0.050	Heather
10	0.050	Heather grassland
11	0.035	Bog
12	0.040	Inland rock
13	0.025	Saltwater
14	0.025	Freshwater
15	0.040	Supralittoral rock
16	0.040	Supralittoral sediment
17	0.050	Littoral rock
18	0.040	Littoral sediment
19	0.035	Saltmarsh
20	0.100	Urban
21	0.060	Suburban
22	0.100	Buildings
99	0.040	Default value

24. Figure 5 below shows the applied Manning's n roughness values applied to varying land uses within the model.

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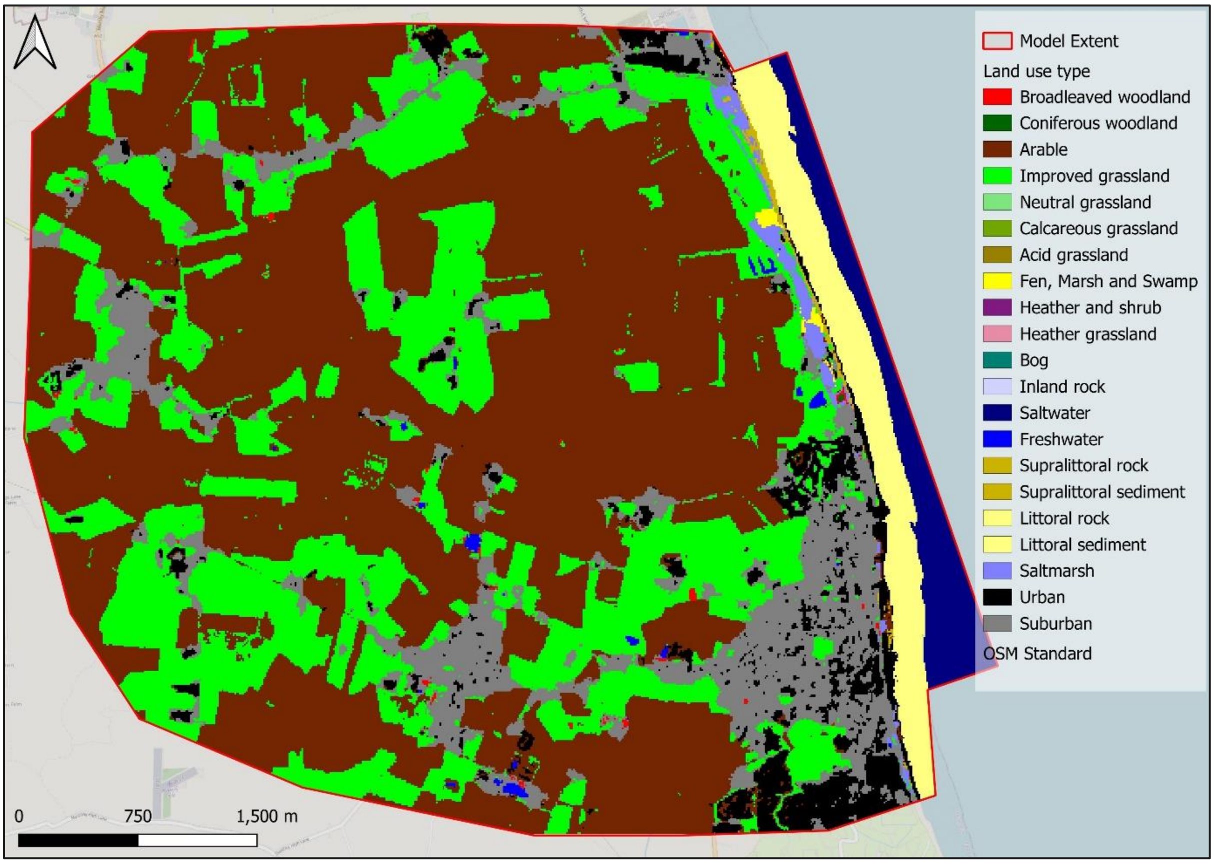
[10] Chow, V.T., (1959). Open-channel hydraulics, McGraw-Hill, New York

Figure 5: Hydraulic Model Material Roughness



2.8 Software Version

25. In line with industry practice, the TUFLOW model was constructed using the latest commercially available software version at project outset: TUFLOW HPC 2023-03-AE (single precision).

2.9 Modelling Parameters

26. The underlying 2D digital terrain model (DTM) was generated using the base 1m LiDAR grid described in Section 2.2. Sub-grid sampling (SGS) testing was undertaken during the initial model build. It was decided to continue using HPC with SGS functionality in 10m grid cell size.

27. All modelled scenarios have been simulated for 80 hours to allow for the inflow boundaries to peak across the model domain. The computational timesteps used by HPC are adaptive over the course of the simulation, with 2D time-varying outputs generated every 15 minutes.

2.10 Model Operation

28. The hydraulic model was simulated using the HPC Solver for TUFLOW build 2023-03-AE single precision (iSP). Initialisation of the TUFLOW model utilised a standard Windows Batch file linking the TUFLOW executable, TUFLOW control file (.tcf) and relevant event and scenario logic, as defined in Table 2-3 below.

Table 2-3: Model Scenario Definitions

Run Reference:	ONB_~e1~_~s1~_~s2~_~s3~_006.tcf
Scenario Description (-s1)	10m (10m cell size) 05m 15m
Scenario Description (-s2)	OVP- Overtopping BR1 - Breach 1 BR2 - Breach 2
Scenario Description (-s3)	EXG (Existing/baseline) PRO (Proposed)
Return Periods (-e1)	0200R 0.5% AEP 0200R_CC 0.5% AEP + Climate Change 1000R 0.1% AEP 1000R_CC 0.1% AEP + Climate Change

3.0 Model Results

29. Maximum flood extents and depths, maximum velocities, and hazard rating results for the areas on and surrounding the noise bund are presented in Appendix C (document reference 15.7A). Figure 6 to Figure 10 below contains flood depths and depth difference outputs for the proposed and baseline model scenarios.

3.1 Scenarios and Events

30. Peak flood events do not result in flood water reaching the site under any of the overtopping or breach scenarios considered for the 0.5% AEP+ climate change event as shown in Figure 30. The peak flood extents of the overtopping scenario and Breach 1 scenario do not reach the site, even during the most extreme event (0.1% AEP + climate change), as shown in Figure 6..
31. The peak flood extents for the Breach 2 scenario under baseline conditions show significant flooding at the site and surrounding areas. The peak flood extents for baseline conditions under all scenarios for the largest event (0.1% AEP + climate change) are shown in Figure 6 to Figure 8.
32. Under the proposed conditions, an increase in flood extent and flood depth can be noticed to the south of the site, and a reduction can be observed to the west and north of the site. However, there are no receptors in these increased areas. In proposed conditions, the installation of the noise bund is limiting the flow of water towards to the west side. Large amount of flood water from the Roman Bank breach has been redirected to the south side of the bund. This causes the increase in flood level on the south side and the decrease in flood level in other areas. Flood depths and depth difference for the Breach 2 proposed scenario are show in Figure 9 and Figure 10.
33. The only small increase in flood depth to sensitive receptors is located at Chapel Point Holiday Park with an approximate increase in water levels of 0.03m. However, this is considered to be an in-channel increase and still leaves a freeboard to property level of around 2m. This mechanism is only observed for the 0.1% AEP + climate change where both flood defences are breached.

Figure 6: Maximum Flood Depths Baseline Overtopping 0.1% AEP+CC

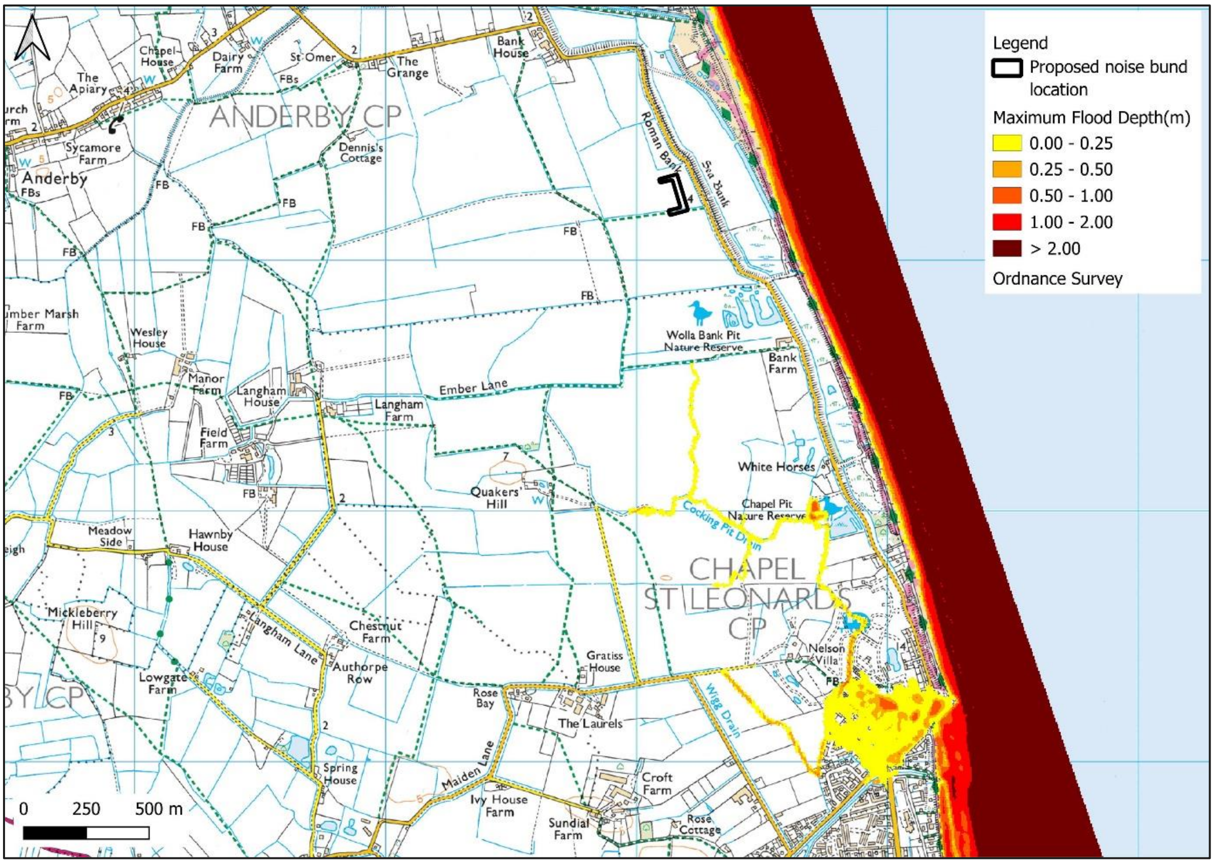


Figure 7: Maximum Flood Depths Baseline Breach 1 - 0.1% AEP+CC

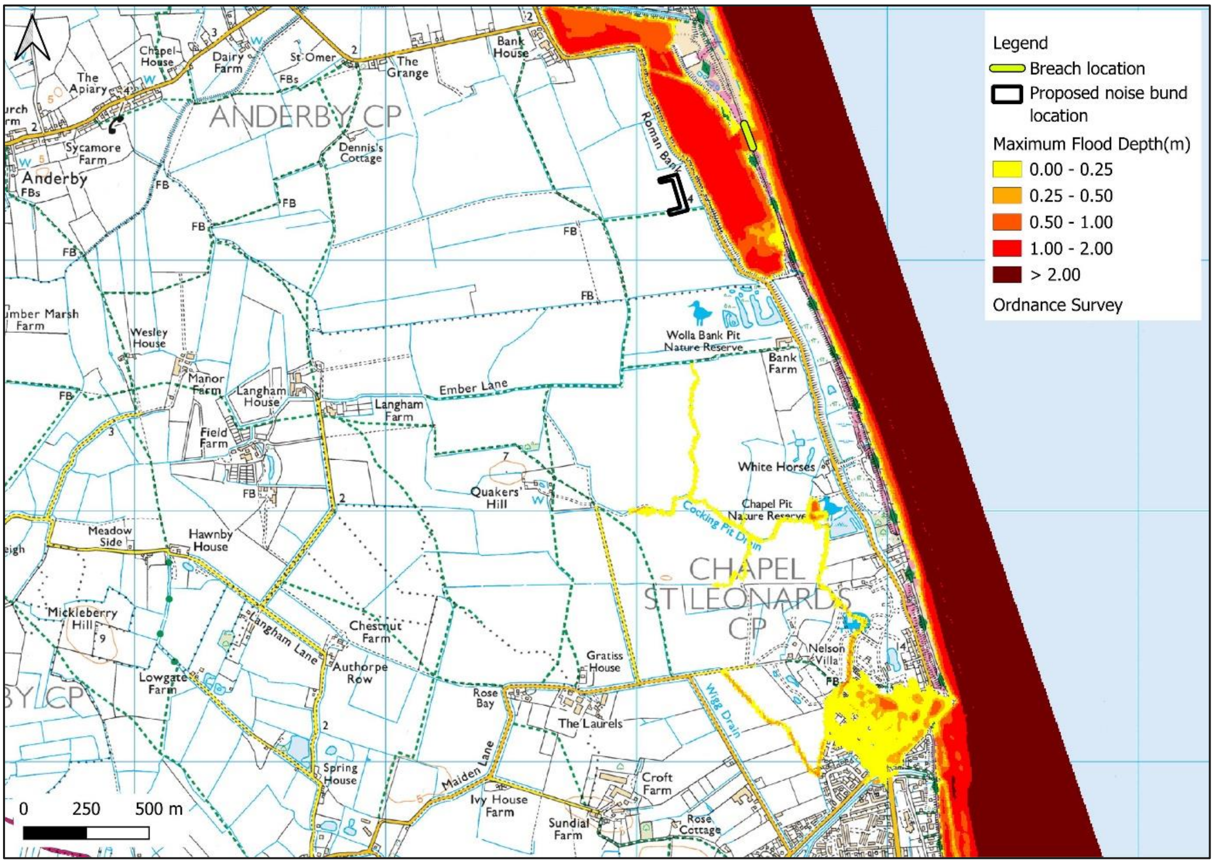


Figure 8: Maximum Flood Depths Baseline Breach 2 - 0.1% AEP+CC

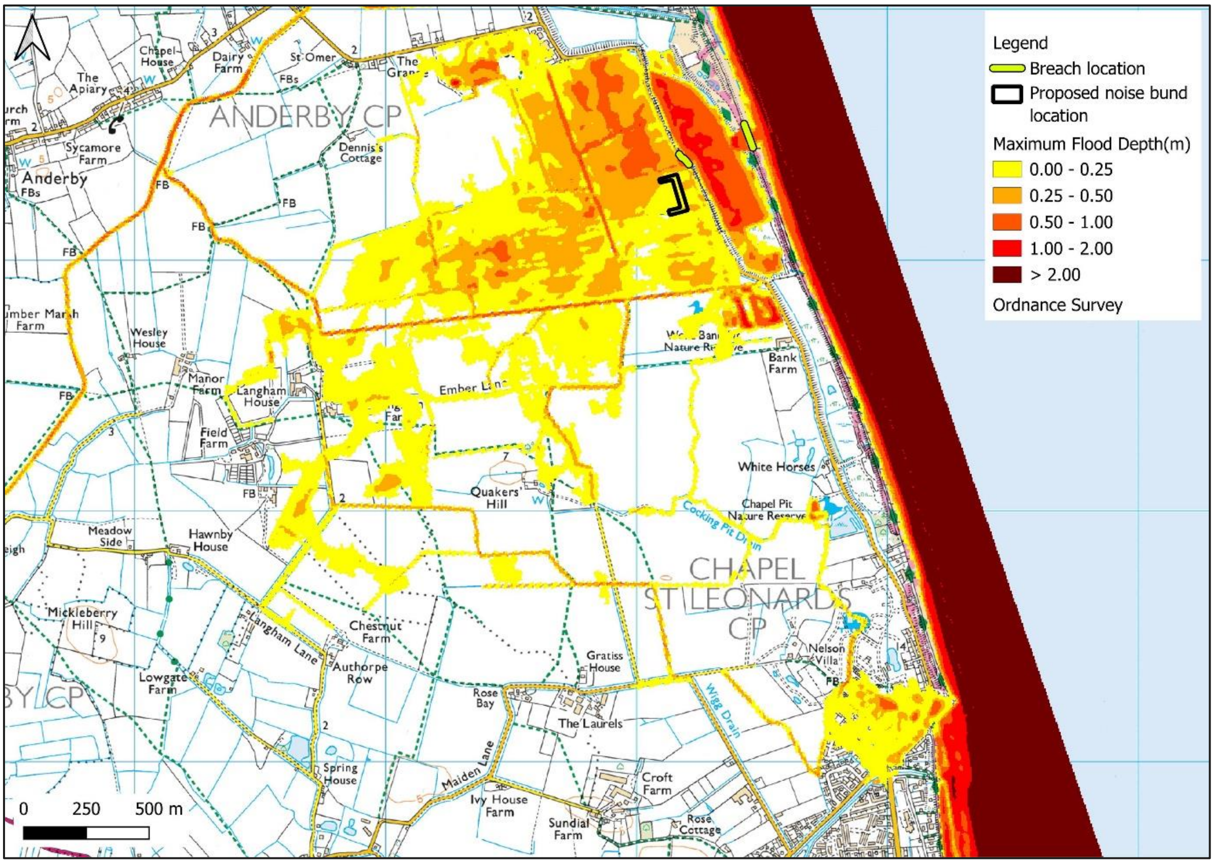


Figure 9: Maximum Flood Depths Proposed Breach 2 - 0.1% AEP+CC

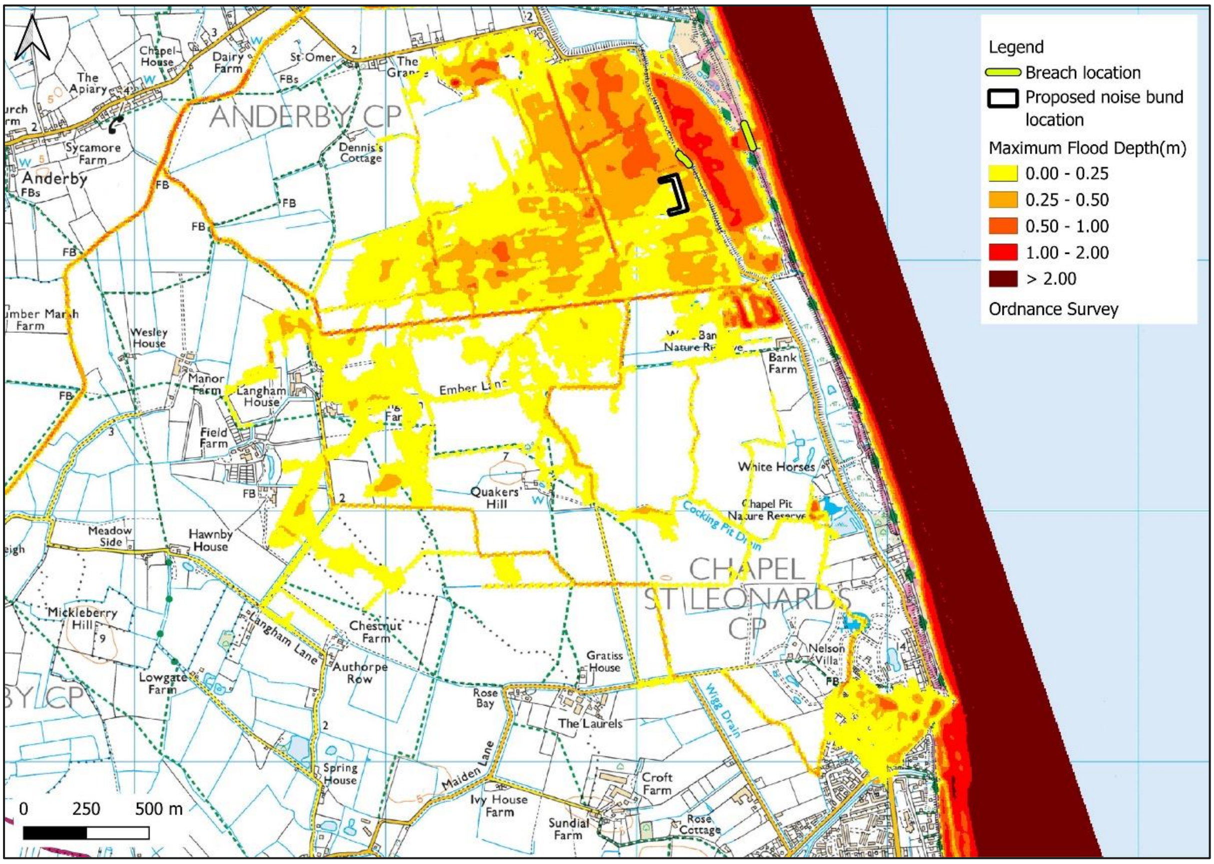
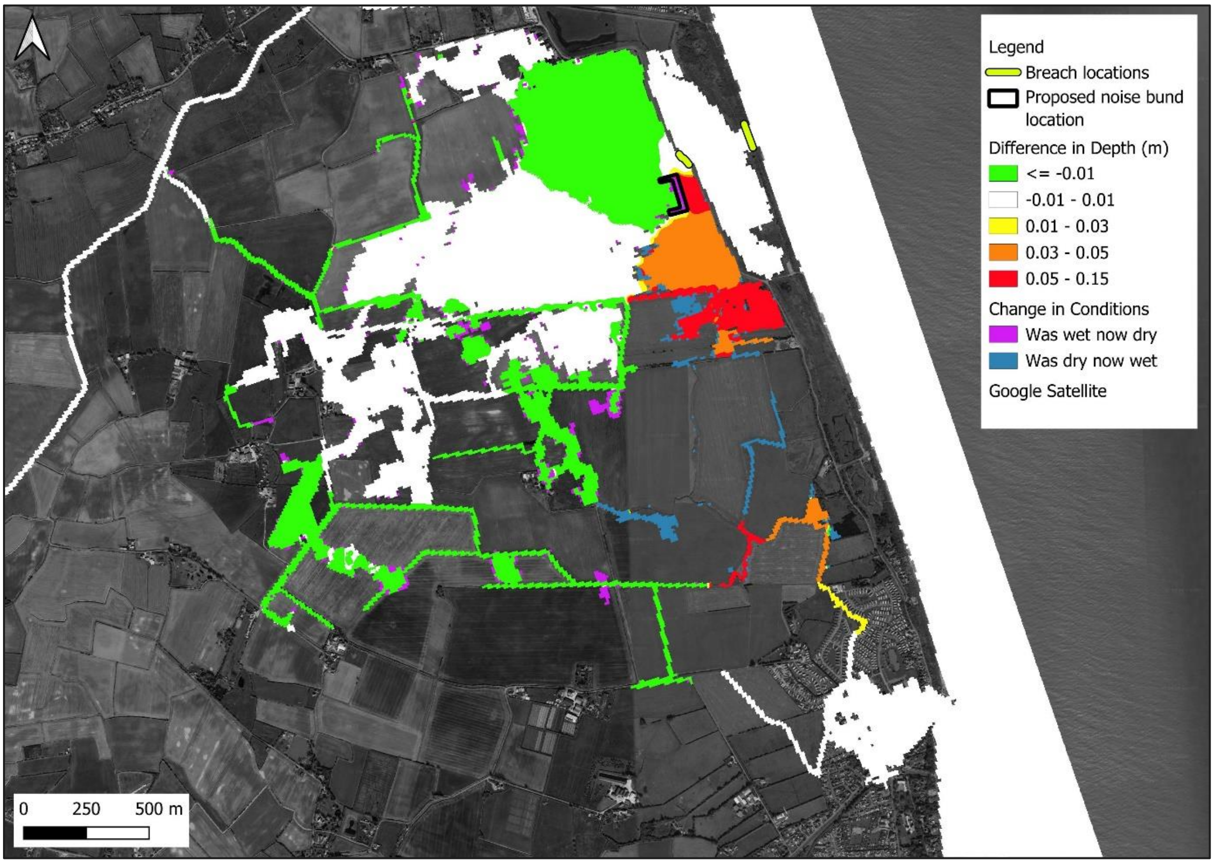


Figure 10: Flood Depth Difference Breach 2 - 0.1% AEP+CC



3.2 Quality Assurance

34. This section outlines the Quality Assurance (QA) measures undertaken in developing the hydraulic model.

35. Part of the general model QA process involves reviewing the TUFLOW messages generated during the model compilation stage and resolving any issues. Warnings produced by TUFLOW during the run are also investigated. Locations causing recurring warnings were identified and a solution implemented to reduce or remove the source of the issue. Model logs have also been utilised to record the key decisions made when developing the model, allowing for traceability and aid in the transfer of the models between different users. The main components of the model build, configuration and application were recorded and have been reviewed and signed-off by a senior hydraulic modeller.

36. Further QA over the course of the model build was undertaken, including:

- Material roughness was checked by importing and thematically mapping the grd_check file to ensure surface resistance was applied correctly with respect to aerial images.
- The extent of the 2D domain was reviewed to ensure it was not limiting flood extents in the larger flood events within the area of interest.
- Minimum dT values across the 2D domain were reviewed to highlight any troublesome areas that were slowing down overall run time; and
- Flow rates within the river channel were reviewed to check for high velocities and potential instabilities.

3.3 Model Stability

37. The model has been reviewed and found to be generally stable and appropriate for its intended use. TUFLOW HPC is inherently stable by nature of the adaptive time-stepping, with low time-steps (dT) typically occurring along or near the 2D HT boundary where high velocities are passing through 2D cells. Nu, Nc, Nd and dt output for HPC indicted that the model runs were all within the suitable stability threshold (Nu<1.0, Nc<1.0, Nd<0.03). CHECK 3524 message (Flat cells/faces will be used for VARIABLE Z SHAPE in SGS) was shown for the each of the breaches. Since the breach level has been set to be at lowest DTM level around the breach, this will not affect the final results. A few instability messages have been shown in 5m sensitivity run, but this will not impact the results or conclusion.

Figure 11: Values of HPC run parameters.

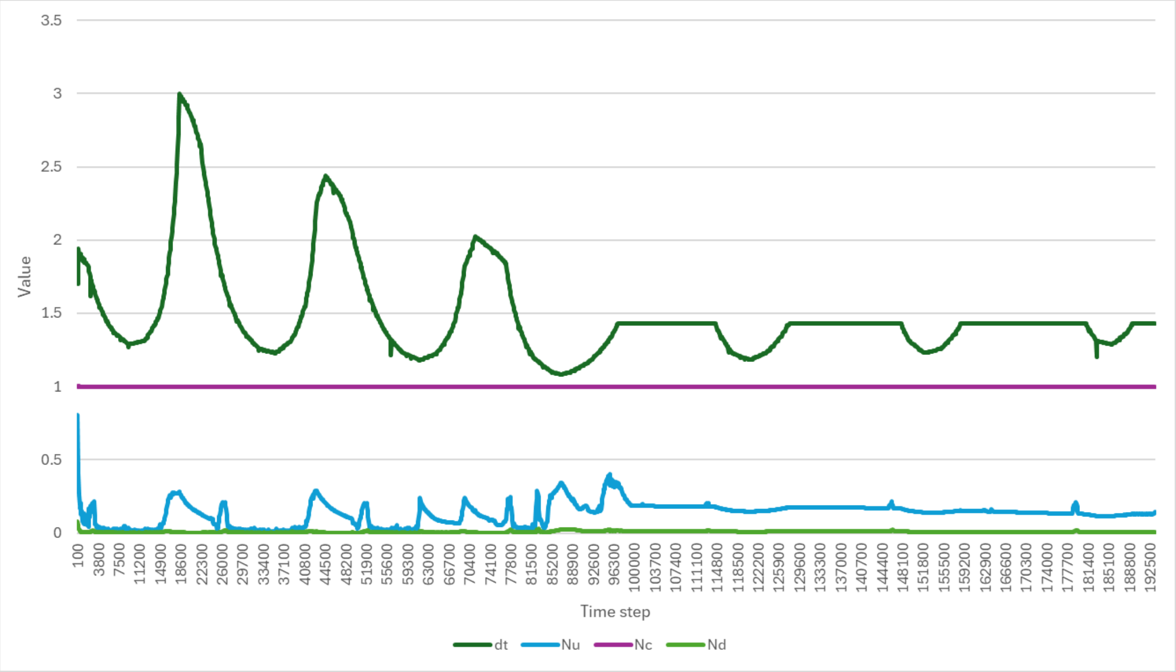
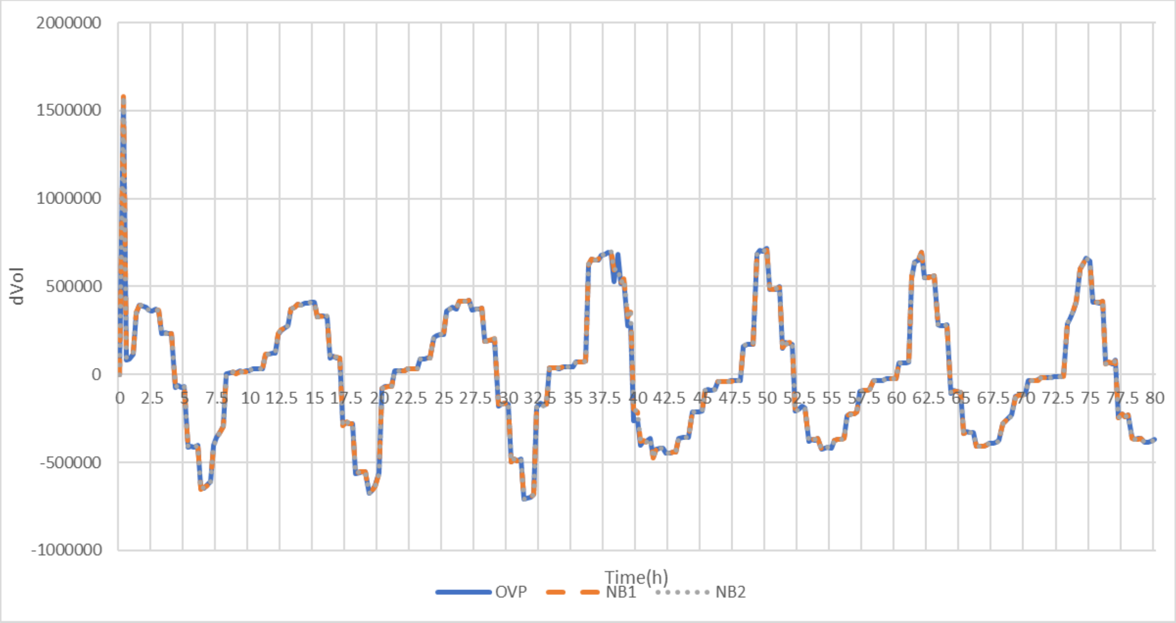


Figure 12: Comparison of dVol for Overtopping and Breach Scenarios



3.4 Model Limitations

38. This model has been developed to take advantage of the most accurate available data to help inform flood risk at the site. There are however several limitations to the hydraulic model worth noting:

    - The tidal hydrograph that is based on the original coastal model produced by Mott MacDonald only has a relatively small number of data points per tide cycle, resulting in a sparsely defined curve. This may mean that the full complexity of the tidal hydrograph may not be reproduced in the model.
    - The breach base levels were determined solely on ground profiles on a hypothetical basis, which is likely to provide conservative results. No consideration was given to the structural integrity and probability of failure of the defences and embankments.
    - The fluvial inflows have not been considered in this study.

4.0 Sensitivity Analysis

39. Sensitivity analysis is the study of how the variation in the output of the model (depth) can be apportioned, qualitatively or quantitatively, to difference changes in the model inputs (model variables, boundary conditions and parameters). Appendix C (document reference 15.7A) contains figures of selected sensitivity results.

40. Sensitivity analysis is used to identify:

    - The factors that potentially have the most influence on the model outputs.
    - The factors that need further investigation to improve confidence in the model; and
    - Regions in space where the variation in the model output is greatest.

41. In line with industry practice, the following parameters, and variables for the hydraulic model have been varied in accordance with the % uplift / parameter change specified below. All the sensitivity runs have been carried out for the 0.1% AEP + climate change event baseline scenario.

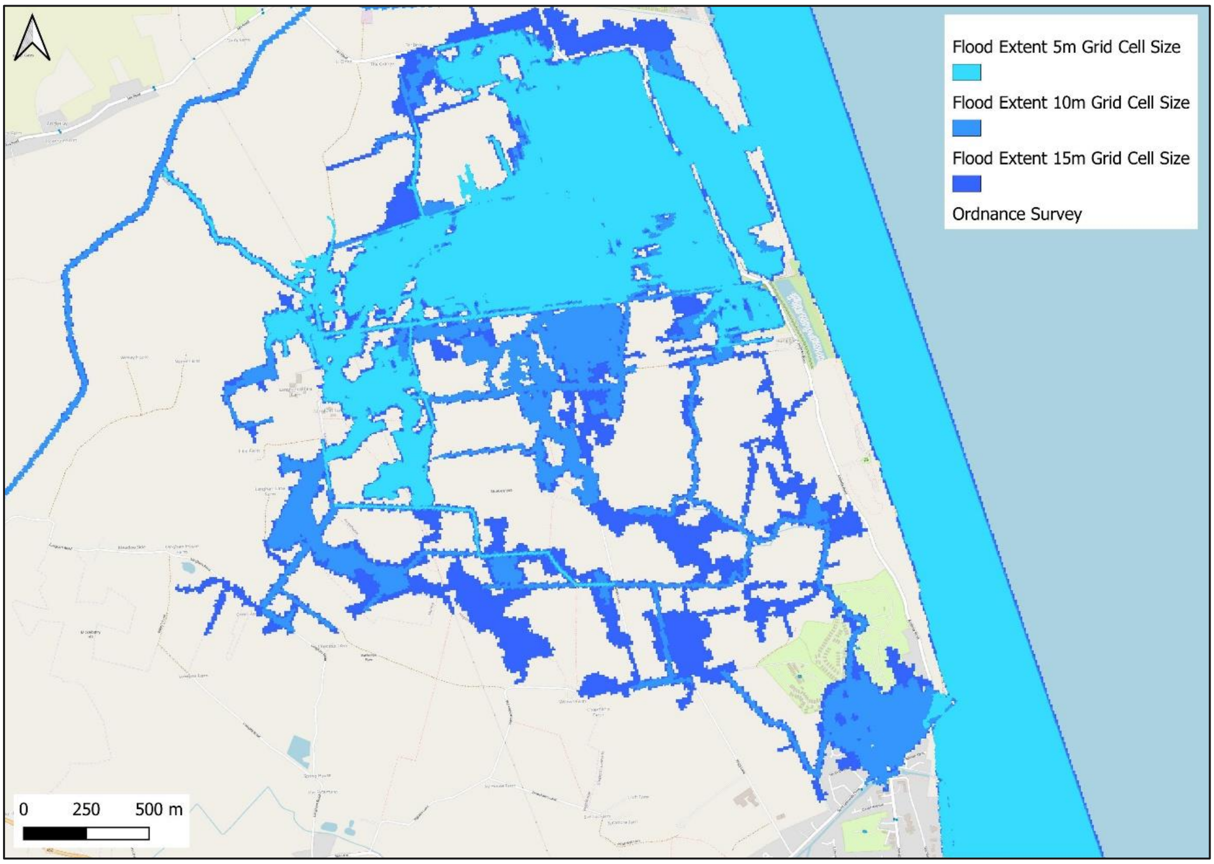
Table 4-1: Sensitivity Analysis Variables

Parameter	Value change
Model Cell Size	15m and 5m
Channel and floodplain roughness	± 20 %
Model Inflows	H++ CC on the 0.1% and 0.5% AEP

4.1 Model Cell Size

42. The initial run was conducted with a 10m cell size. Subsequent sensitivity tests were carried out with 15m and 5m cell sizes. The flood extents of the sensitivity test are as expected, as the 5m grid has the smallest flood extent and 15m grid has the largest while 10m grid flood extent in the middle. These findings indicate that the 10m cell size strikes a balance, effectively capturing important features in the floodplain while reducing the model run time without compromising result quality. Peak depth results for 15m and 5m can be seen in Appendix C (document reference 15.7A). Within key areas, peak difference of ± 150mm between each cell size scenario can be observed. The flood extent of model cell size sensitivity runs is presented in Figure 13.

Figure 13: Flood Extent of Difference Cell Size Sensitivity Runs



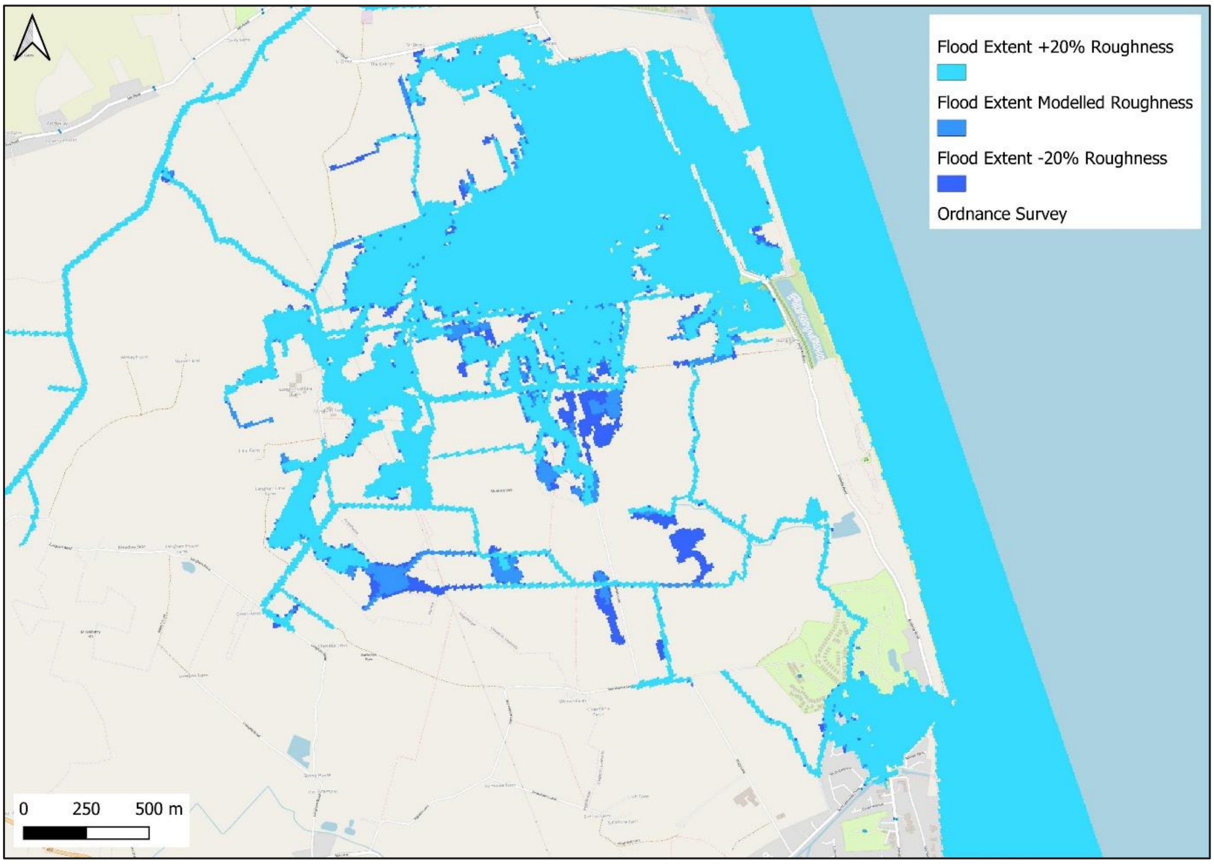
4.2 Channel and Floodplain Roughness

43. A universal separate increase and decrease of 20% to the Manning's roughness values was applied across the entirety of the model domain. Generally, the model results

demonstrated little difference in the extents of the flooding resulting from these changes. This is due to the generally even nature of the topography. Within key areas, peak difference of ± 100mm between each roughness scenario can be observed.

44. As such the hydraulic model is seen as insensitive to changes in Manning's roughness, which is expected with the flat terrain of the model extent.

Figure 14: Flood Extent of Difference Roughness Sensitivity Runs



4.3 Model Inflows

45. The H++ climate change allowance is a scenario in which sea levels are projected to rise significantly due to climate change. The "H++" terminology is often used in climate change assessments to represent a high-end or extreme sea-level rise scenario. This means that a substantial increase in sea levels, which may be driven by factors such as the melting of terrestrial ice masses and thermal expansion of seawater due to global warming, is given consideration.

46. Environment Agency guidance[11] states that tidal H++ runs should apply an increase of 1.9m for total sea level rise to the year 2100*. In this case, the sensitivity check is aimed at understanding how the tidal model responds to changes in sea level driven by the H++ climate change allowance. Results for the baseline Breach 2 scenario for both the 0.1% and 0.5% with H++ climate change allowance events can be seen in Appendix C (document reference 15.7A). * It should be noted that the noise bund is a temporary

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[11] Flood risk assessments: climate change allowances https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#H-plus-plus

structure expected to be in place during a construction period between 2026 and 2030 and therefore, this long-term consideration is largely irrelevant.

5.0 Conclusion

47. This report outlines the hydraulic modelling used to quantify the impact on flood risk by the proposed noise bund using the latest available information.
48. The detailed hydraulic modelling has confirmed that flood water does not reach the proposed noise bund during an overtopping, or any of the breach scenarios considered under the 0.5% AEP conditions. It does not reach the site during overtopping conditions or solely by breaching of the sand dune defences (Breach 1 scenario) during the 0.1% AEP + climate change event.
49. In the event that both the sand dune defences and Roman Bank defences are breached (Breach 2 scenario) a slight increase in flood levels is noted to the west and south of the noise bund during the 0.1% AEP + climate change event.
50. The results will be discussed further in the Onshore Electrical Cable Corridor (ECC) and 400kV cable Flood Risk Assessment (FRA).

Appendix A Methodology Technical Note and Environment Agency Correspondence

Technical Memorandum

To:	Rebecca Sylvester	**From:**	Katrina Riches
Company:	Environment Agency	**SLR Consulting Limited**	
cc:	Heather Tysoe, Annette Hewitson	**Date:**	28 June 2024
		Project No.	410.065702.00001

RE: Outer Dowsing Offshore Wind - Noise Bund Breach Modelling

1.0 Introduction and Background

This technical note outlines the hydraulic modelling methodology SLR proposes to take with regard to assessing the flood risk impacts from the installation of a temporary noise bund, proposed as part of the Outer Dowsing Offshore Wind (ODOW) Project.

The primary purpose of the bund is to mitigate noise impacts on a nature area adjacent to the drill pit. The bund is situated within an area shown to be at a residual risk of flooding from breach of the coastal defences (dunes). The development site is located near Anderby Creek, on the west side of Roman Bank. This is a low-lying coastal area surrounded by agricultural fields and a series of ditches with embankments to prevent flooding from seawater. Figure 1 shows the location and orientation of the noise bund.

Figure 1: Location of Noise Bund

A data request was submitted to the Environment Agency for model data relating to the onshore element of the Project. The 2010 NTM (Nearshore Transformation Model) Breach and Overtopping data was received with regard to scenarios for coastal areas and for the tidal reach of the River Welland.

The Environment Agency recommend that the FRA supporting the DCO application must include an appropriate assessment to demonstrate the impacts of any land raising and set out any mitigation required. Factors such as breach parameters, expected depths and nearby receptors must be reviewed and considered before concluding the level of assessment required. The baseline and post-development (with noise bund) should be assessed before determining what mitigation is required.

The Environment Agency have provided guidelines for undertaking breach modelling which are appended to this note (Environment Agency, Anglian Region, Northern Area Requirements for Hazard Mapping, Version 8, Jan 2014).

2.0 Proposed Breach Modelling Methodology

The proposed approach is consistent with the agreed methodology accepted for the River Welland Breach Modelling (Appendix 24.3 Annex 1) submitted as part of the DCO to support the Onshore Substation (OnSS) for the Project.

2.1 Hydrology

- The shape of the astronomical tidal curves to be used in the modelling will be taken from Environment Agency Flood Risk Mapping and Data Management: Anglian Region Report (2016). These have been scaled to fit extreme sea levels from CFB chainage at 3948. This is consistent with the agreed approach taken to assess the River Welland Breach modelling at the OnSS location.
- These tidal curves will be scaled to fit the extreme water levels (CFB conditions for the UK 2018 for ‘Location: Chainage: _3948).
- The climate change allowances for the sea level will be calculated from a base year of 2018 using the current Guidance from EA for the Anglian Region for Upper End Scenario (Flood risk assessments climate change allowances[1]).
- As the noise bund is a temporary structure for the drilling phase only, the expected design life of the structure is 4 years. Therefore, the climate change uplift has been calculated as 70mm (2018 to 2030 – accounting for the adjustment for sea level rise to present day and the addition of 4 years from anticipated construction date (2026) to account for the life span of the development).
- CFB 97.5% confidence level will be used for the hydraulic modelling and will assess all return periods noted in Table 1.
- The proposed peak tidal levels are summarised in Table 1 below.

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[1] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#sea-level-allowances

Table 1: Proposed Tidal Levels

AEP %	EA Report (m)	CFB 2018 (m)	CFB 2018 (97.5% confidence levels)
0.5%	5.99	4.83	5.26
0.1%	6.69	5.24	5.93
0.5%+CC	7.13	4.91	5.34
0.1%+CC	7.83	5.32	6.01

Climate change allowances

2018 – 2030 – 12 yrs x 7mm = 84mm

Full head time boundary conditions can be found in the accompanying excel sheet.

2.2 Hydraulic Modelling

The following is proposed for the hydraulic breach modelling:

- The proposed breach locations along the AIMS spatial flood defences assets have been located to align with existing watercourse, which will allow for worst case flood events to the Proposed Development. These locations have high levels of hydraulic connectivity to the site due to proximity to the existing watercourse. The breach locations are shown in Figure 1.
- Figure 2 shows the topography of the area. The sand dune flood defence assets are at a higher elevation than the extreme tidal level of 6m with over 1.6m freeboard, so the site will only be at risk in the event of a breach of the defences.
- Modelling will be completed using 2D TUFLOW software with a grid size of 10m. Use of HPC and SGS to allow for underlying 1m LiDAR to be taken into account.
- LiDAR Composite DTM (1m 2022) will be used (Example tile: LIDAR-DTM-1m-2022-TF57nw).
- The heights of spatial flood defences in the modelled area will be defined by a series of ZSH polylines in the TUFLOW 2D domain.
- A Head Time boundary will be applied at the seaward side of the current defences.
- The Head Time boundary will simulate four tidal cycles with the largest cycle occurring on the first tidal peak.
- The model will extend significantly far inland from the site so the key flooding mechanisms are not affected by any model boundary conditions.
- The crest elevations for the defences will be obtained from ‘EA Spatial Flood Defences Including Standardised Attributes’ layer and cross referenced against LiDAR.
- Breach of flood defences will be represented in TUFLOW using variable shapefiles.
- Breach criteria (as per EA guidance):
    - Ground level behind defence extracted to Lidar.
    - Breach width = 100m
    - Breach duration 70hr
- Table 2 summaries the model run scenarios and model will be run for the following events.
    - 0.5% AEP
    - 0.5% AEP + CC
    - 0.1% AEP
    - 0.1% AEP + CC

- Hazard, Depth and Velocity Mapping will be completed in line with the EA guidance.
- Sensitivity runs will be completed for cell size, material roughness, model inflows and design tidal curve.
- Results will be reported in a standalone modelling report.

Figure 2: LiDAR Elevation (m AOD)

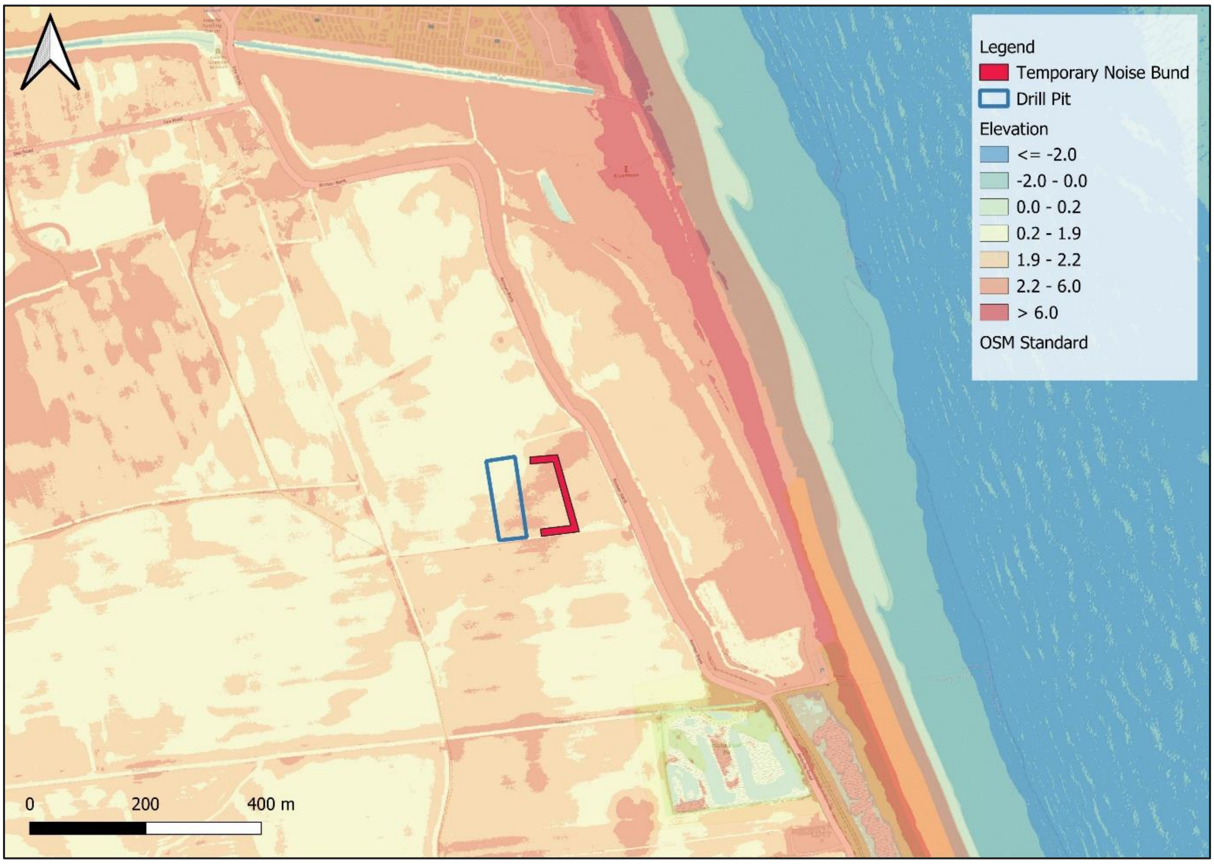


Table 2: Model Run Scenarios

Run #	Scenario 1	Scenario 2
1	Baseline	Dunes breached 1st tidal cycle Roman bank – No breach
2		Dunes breached 1st tidal cycle Roman bank – 2nd tidal cycle
3	Proposed	Dunes breached 1st tidal cycle Roman bank – No breach
4		Dunes breached 1st tidal cycle Roman bank – 2nd tidal cycle

Katrina Riches

From: Sylvester, Rebecca [redacted]environment-agency.gov.uk>
Sent: 12 July 2024 12:55
To: Katrina Riches
Cc: Hewitson, Annette; Tysoe, Heather; Hugh Morris
Subject: RE: ODOW : Noise Bund Modelling Criteria - Technical Note

Dear Katrina,

Thank you for providing the proposed methodology for the flood modelling of the temporary noise bund at landfall for our review.

The technical note for the noise bund breach modelling is based on the OnSS modelling technical note which has previously been reviewed by our E&R team. As such, PSO have made comments on the technical note, and it has not been submitted to our E&R team for their formal review. We also understand the modelling is underway.

We have highlighted several clarifications and recommendations that should be carried forward into the modelling assessment.

- Section 2.1 Hydrology, bullet point 4 states that ‘the climate change uplift has been calculated as 70mm’. However, the climate change allowance for 2018 to 2030 is 84mm and this is the uplift included in Table 1. We consider that the climate change uplift of 84mm and tabulated levels presented in the methodology are appropriate to represent the temporary nature of the noise bund, calculated from the base year of 2018 to the year 2030.
- Time to closure - In line with the Requirements for Hazard Mapping v8, the time to closure for open coast is 72 hours, rather than 70 hours. The model simulation time should be long enough to allow maximum spreading of flood water.
- Breach widths - The Environment Agency Tidal Hazard Mapping ran a multiple breach scenario at location E20 where the breach width was 100m for the coast and 50m for Roman Bank.
- Flood progression maps are not proposed. These would be beneficial to show the impacts of any land raising on the surrounding area and third parties as the breach progresses.
- The methodology confirms that sensitivity runs will be completed for cell size, material roughness, model inflows and design tidal curve. No details of the sensitivity run are provided.
- Its not clear from the methodology what the baseline will be based on. Is it CFB 2018 or present day?

As per comments on the OnSS technical note:
- The methodology doesn’t detail how land use will be considered within the 2D Domain i.e., Manning’s roughness. The consultant should delineate areas of land use and apply appropriate roughness values.
- The methodology doesn’t detail any further proposed topographical changes that could influence flow pathways and flood mechanisms within the Site. Has any topographical survey been undertaken within the Site that can be modelled to increase confidence in ground elevations? If so, it is recommended that survey is incorporated.
- The figures do not show the proposed 2D domain extent, although the Methodology states ‘The model will extend significantly far inland from the site so the key flooding mechanisms are not affected by any model boundary conditions’. The 2D domain should be sufficiently large to prevent glass walling and allow flood propagation.
- The methodology shows that the peak tidal curves occurs at the start of the simulation with subsequent tidal peaks subsiding. Normal practice is to apply the highest peak in the middle of the simulation.
- Defence crests will be represented using Z lines with crests informed from the ‘EA Spatial Flood Defences Including Standardised Attributes’ layer and cross referenced against LiDAR. This is considered an appropriate methodology. Z Line node locations should be of sufficient frequency in order to represent variations in crest height along its length.
- Sensitivity runs on the boundary parameters, should 2D flow boundaries be used.

For further guidance on modelling for FRAs, please refer to: https://www.gov.uk/guidance/using-modelling-for-flood-risk-assessments#when-to-consider-using-modelling

For guidance on what we will expect to see included within the model scope please refer to: Hydraulic modelling: best practice (model approach) - GOV.UK (www.gov.uk)

Please let me know if you have any further queries,

Kind regards,

Rebecca

Rebecca Sylvester
Flood and Coastal Risk Management Advisor

Environment Agency | **Partnership & Strategic Overview Team** | **Lincolnshire and Northamptonshire** | **South Humber and East Coast**
[redacted]environment-agency.gov.uk
Phone: +44 [redacted]

I work part time and my normal working days are Tuesday – Thursday (8:45 – 17:15).

From: Katrina Riches [redacted]
Sent: Friday, June 28, 2024 4:11 PM
To: Sylvester, Rebecca [redacted]nvironment-agency.gov.uk>; Hewitson, Annette [redacted]@environment-agency.gov.uk>; Tysoe, Heather [redacted]environment-agency.gov.uk>
Cc: Sophie Brown [redacted]outerdowsing.com>; Martin Baines [redacted] Andy Gregory [redacted]lrconsulting.com>; Jon Ongley [redacted]@outerdowsing.com>; Hugh Morris [redacted]outerdowsing.com>
Subject: RE: ODOW : Noise Bund Modelling Criteria - Technical Note

Hi Rebecca,

Please find attached our technical note and associated documents summarising the proposed methodology for the flood modelling of the temporary noise bund at landfall.

If you have any questions please do not hesitate to contact us,

Katrina

Katrina Riches *(she/her/hers)*
Senior Hydrologist - Hydrology & Hydrogeology

O +44 [redacted]
M +44 [redacted]
E [redacted]

SLR Consulting Limited
5th Floor, 35 Dale Street, Manchester, United Kingdom M1 2HF

Appendix B Tidal Calculation

	EA		**Scaled**					
Time (hrs)	**200y**	**1000y**	**200y**	**1000y**	**200y+CC**	**1000y+CC**	**200y+H++**	**1000y+H++**
1	0.297	0.297	0.30	0.31	0.34	0.35	2.16	2.16
2	1.669	1.669	1.51	1.52	1.55	1.56	3.37	3.38
3	2.954	2.954	2.64	2.66	2.68	2.70	4.49	4.52
4	3.766	3.766	3.35	3.38	3.39	3.42	5.21	5.24
5	3.528	3.528	3.14	3.17	3.18	3.21	5.00	5.03
6	2.086	2.086	1.87	1.89	1.92	1.93	3.73	3.75
7	-0.210	-0.210	-0.14	-0.14	-0.10	-0.10	1.72	1.71
8	-1.864	-1.864	-1.59	-1.61	-1.55	-1.57	0.26	0.25
9	-1.812	-1.805	-1.55	-1.56	-1.51	-1.52	0.31	0.30
10	-1.713	-1.699	-1.46	-1.46	-1.42	-1.42	0.40	0.39
11	-1.538	-1.518	-1.31	-1.30	-1.27	-1.26	0.55	0.55
12	-0.953	-0.926	-0.80	-0.78	-0.75	-0.74	1.06	1.08
13	0.093	0.127	0.12	0.15	0.17	0.20	1.98	2.01
14	1.482	1.523	1.34	1.39	1.39	1.43	3.20	3.25
15	2.909	2.958	2.60	2.66	2.64	2.71	4.45	4.52
16	4.050	4.106	3.60	3.68	3.64	3.72	5.46	5.54
17	4.379	4.443	3.89	3.98	3.93	4.02	5.75	5.84
18	3.405	3.478	3.03	3.12	3.07	3.17	4.89	4.98
19	1.441	1.523	1.31	1.39	1.35	1.43	3.17	3.25
20	-0.979	-0.888	-0.82	-0.74	-0.78	-0.70	1.04	1.11
21	-1.314	-1.214	-1.11	-1.03	-1.07	-0.99	0.75	0.82
22	-1.212	-1.10	-1.02	-0.94	-0.98	-0.89	0.84	0.92
23	-1.06	-0.94	-0.89	-0.79	-0.85	-0.75	0.97	1.07
24	-0.67	-0.54	-0.54	-0.44	-0.50	-0.39	1.32	1.42
25	0.20	0.33	0.21	0.33	0.26	0.38	2.07	2.19
26	1.52	1.66	1.37	1.51	1.42	1.55	3.23	3.37
27	2.98	3.13	2.66	2.82	2.70	2.86	4.52	4.67
28	4.25	4.41	3.78	3.95	3.82	4.00	5.63	5.81
29	4.90	5.07	4.35	4.54	4.39	4.58	6.20	6.40
30	4.31	4.49	3.83	4.02	3.87	4.07	5.69	5.88
31	2.61	2.80	2.33	2.52	2.37	2.57	4.19	4.38
32	0.10	0.31	0.13	0.32	0.18	0.36	1.99	2.18
33	-0.57	-0.34	-0.46	-0.26	-0.41	-0.22	1.40	1.60
34	-0.44	-0.20	-0.34	-0.13	-0.30	-0.09	1.52	1.72
35	-0.29	-0.02	-0.22	0.02	-0.17	0.06	1.64	1.88
36	-0.04	0.25	0.00	0.26	0.05	0.31	1.86	2.12
37	2.24	2.56	2.01	2.31	2.05	2.35	3.87	4.17
38	4.60	4.93	4.08	4.41	4.12	4.46	5.94	6.27
39	5.99	6.33	5.30	5.66	5.34	5.70	7.16	7.52
39.5	**5.99**	**6.69**	**5.302**	**5.972**	**5.344**	**6.014**	**7.16**	**7.83**
40	5.99	6.35	5.30	5.67	5.34	5.71	7.16	7.53
41	4.98	5.31	4.41	4.75	4.45	4.79	6.27	6.61
42	3.55	3.87	3.16	3.47	3.20	3.52	5.01	5.33
43	2.02	2.33	1.82	2.10	1.86	2.15	3.67	3.96
44	0.77	1.05	0.71	0.98	0.76	1.02	2.57	2.83
45	0.02	0.28	0.06	0.29	0.10	0.34	1.91	2.15
46	-0.30	-0.04	-0.22	0.00	-0.18	0.05	1.64	1.86
47	-0.44	-0.20	-0.34	-0.13	-0.30	-0.09	1.52	1.72

48	-0.57	-0.34	-0.46	-0.26	-0.41	-0.22	1.40	1.60
49	0.10	0.31	0.13	0.32	0.18	0.36	1.99	2.18
50	2.61	2.80	2.33	2.52	2.37	2.57	4.19	4.38
51	4.31	4.49	3.83	4.02	3.87	4.07	5.69	5.88
52	4.90	5.07	4.35	4.54	4.39	4.58	6.20	6.40
53	4.25	4.41	3.78	3.95	3.82	4.00	5.63	5.81
54	2.98	3.13	2.66	2.82	2.70	2.86	4.52	4.67
55	1.52	1.66	1.37	1.51	1.42	1.55	3.23	3.37
56	0.20	0.33	0.21	0.33	0.26	0.38	2.07	2.19
57	-0.67	-0.54	-0.54	-0.44	-0.50	-0.39	1.32	1.42
58	-1.06	-0.94	-0.89	-0.79	-0.85	-0.75	0.97	1.07
59	-1.21	-1.10	-1.02	-0.94	-0.98	-0.89	0.84	0.92
60	-1.31	-1.21	-1.11	-1.03	-1.07	-0.99	0.75	0.82
61	-0.98	-0.89	-0.82	-0.74	-0.78	-0.70	1.04	1.11
62	1.44	1.52	1.31	1.39	1.35	1.43	3.17	3.25
63	3.41	3.48	3.03	3.12	3.07	3.17	4.89	4.98
64	4.38	4.44	3.89	3.98	3.93	4.02	5.75	5.84
65	4.05	4.11	3.60	3.68	3.64	3.72	5.46	5.54
66	2.91	2.96	2.60	2.66	2.64	2.71	4.45	4.52
67	1.48	1.52	1.34	1.39	1.39	1.43	3.20	3.25
68	0.09	0.13	0.12	0.15	0.17	0.20	1.98	2.01
69	-0.95	-0.93	-0.80	-0.78	-0.75	-0.74	1.06	1.08
70	-1.54	-1.52	-1.31	-1.30	-1.27	-1.26	0.55	0.55
71	-1.71	-1.70	-1.46	-1.46	-1.42	-1.42	0.40	0.39
72	-1.81	-1.81	-1.55	-1.56	-1.51	-1.52	0.31	0.30
73	-1.86	-1.86	-1.59	-1.61	-1.55	-1.57	0.26	0.25
74	-0.21	-0.21	-0.14	-0.14	-0.10	-0.10	1.72	1.71
75	2.09	2.09	1.87	1.89	1.92	1.93	3.73	3.75
76	3.53	3.53	3.14	3.17	3.18	3.21	5.00	5.03
77	3.77	3.77	3.35	3.38	3.39	3.42	5.21	5.24
78	2.95	2.95	2.64	2.66	2.68	2.70	4.49	4.52
79	1.67	1.67	1.51	1.52	1.55	1.56	3.37	3.38
80	0.30	0.30	0.30	0.31	0.34	0.35	2.16	2.16

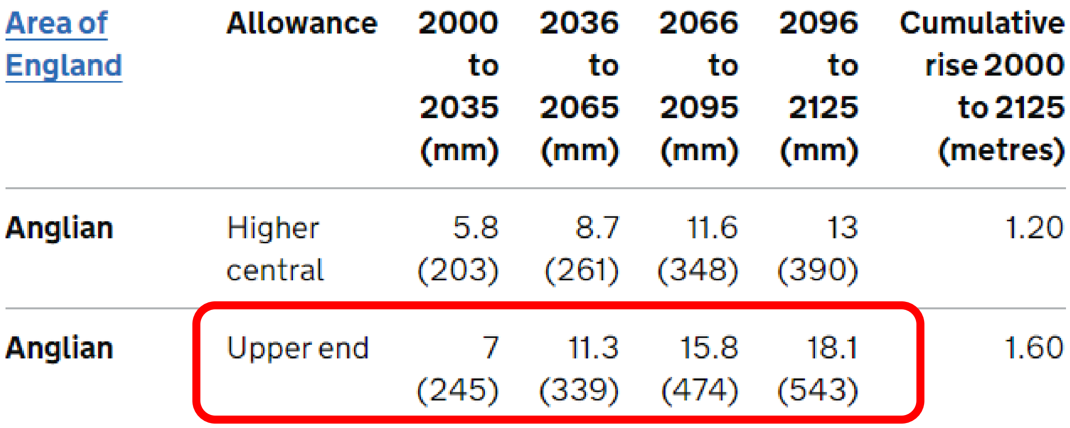
Peak Tidal Levels at Fosdyke Bridge

AEP%	EA Report	CFB	CFB (97.5%confidence levels)
0.5%	5.990	4.830	5.260
0.1%	6.690	5.240	5.930
0.5%+CC	7.130	4.914	5.344
0.1%+CC	7.830	5.324	6.014

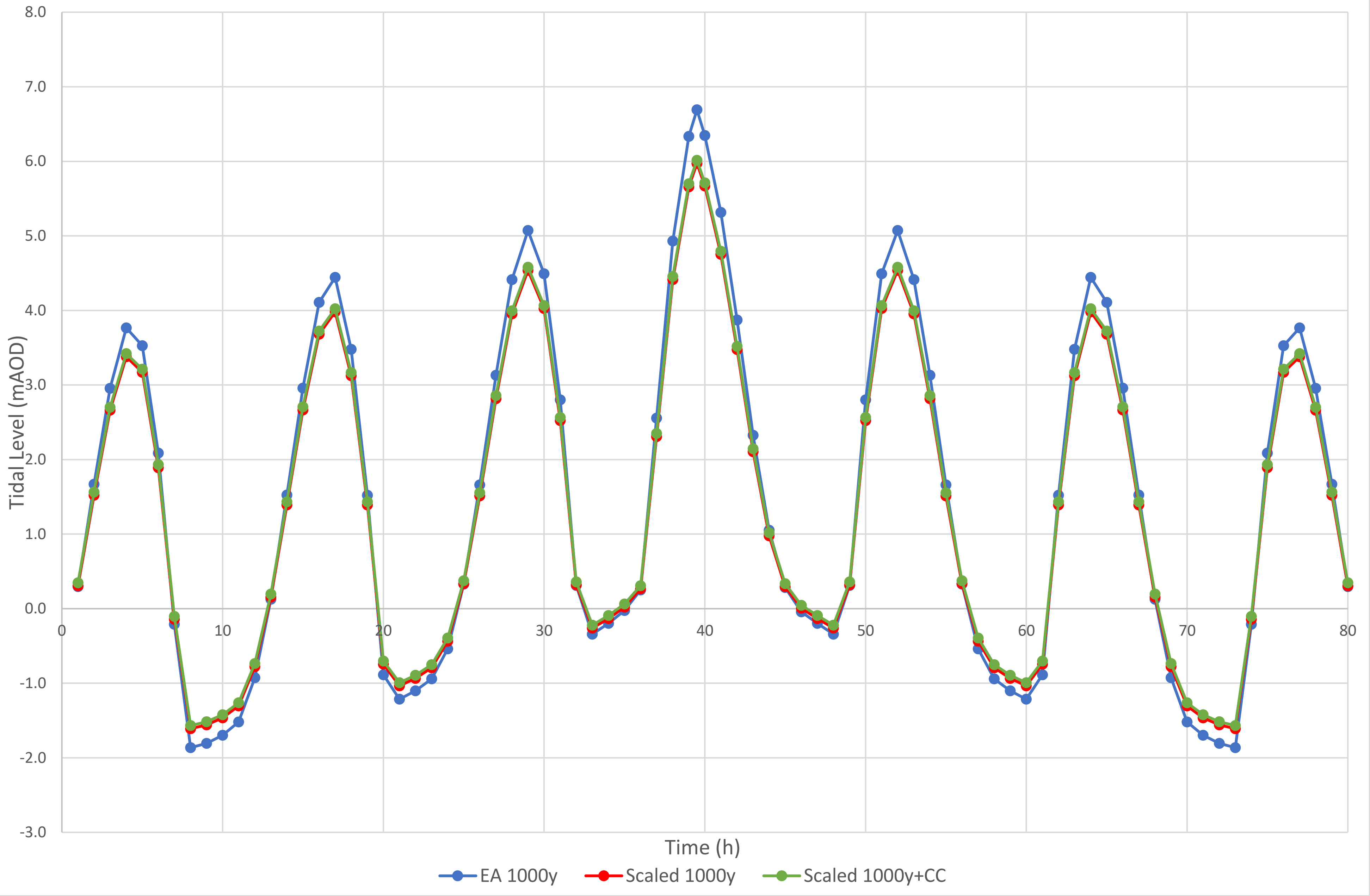
* check the guidence

Climate change allowances

2018 – 2030 – 12yrs x 7mm = 84r	0.084
2018 – 2024 – 6yrs x 7mm = 42m	0.042

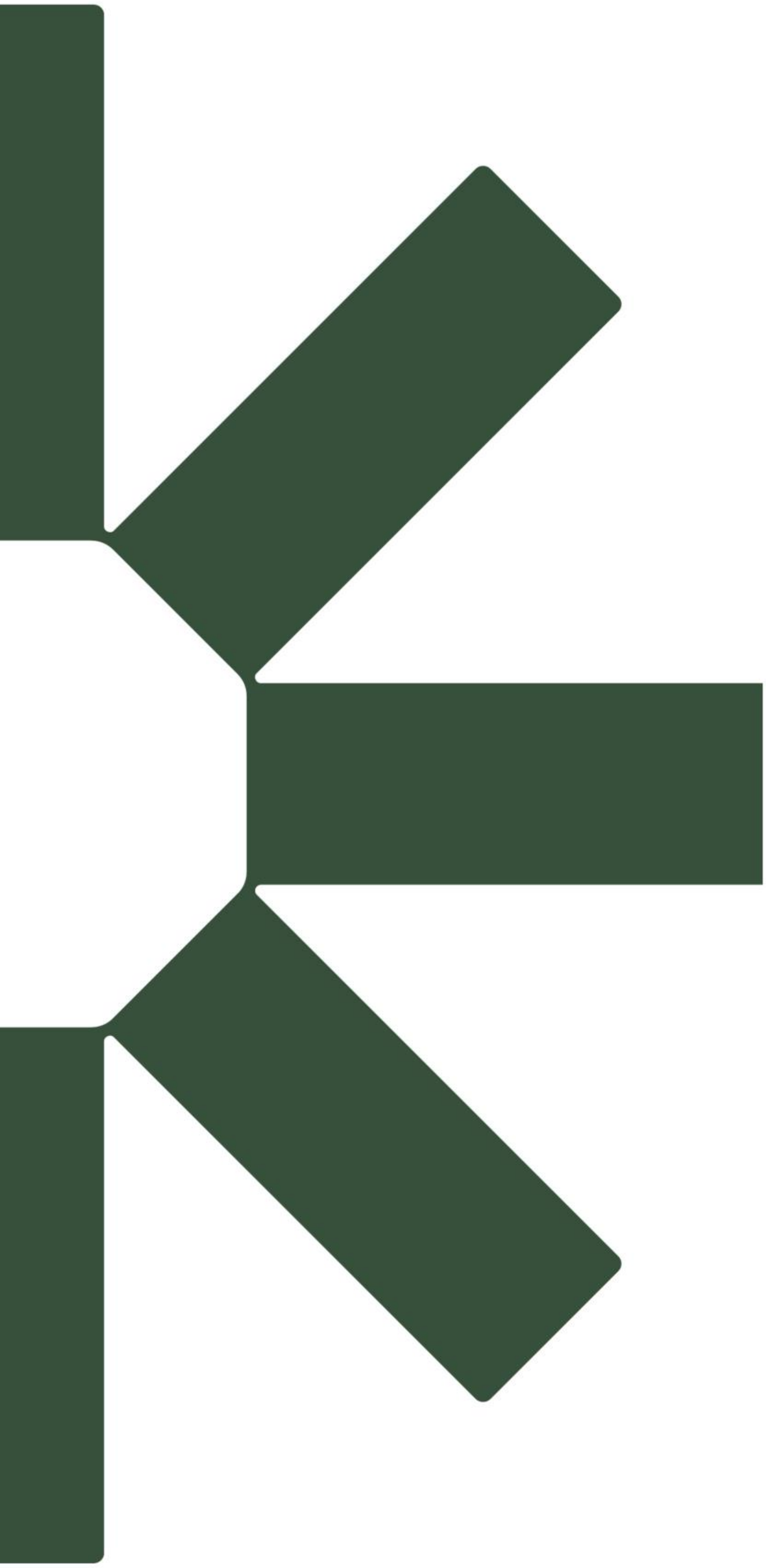


Area of England	Allowance	2000 to 2035 (mm)	2036 to 2065 (mm)	2066 to 2095 (mm)	2096 to 2125 (mm)	Cumulative rise 2000 to 2125 (metres)
Anglian	Higher central	5.8 (203)	8.7 (261)	11.6 (348)	13 (390)	1.20
Anglian	Upper end	7 (245)	11.3 (339)	15.8 (474)	18.1 (543)	1.60


8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
Tidal Level (mAOD)
0
10
20
30
40
50
60
70
80
Time (h)
EA 1000y
Scaled 1000y
Scaled 1000y+CC

Appendix C Flood Maps (Document Reference 15.7A)

[These are included in separate documents Appendix C Parts 1-4]



Making Sustainability Happen