Appendix C - Modelling summary

1 Modelling in Level 2 SFRA

1.1 Summary of Level 2 SFRA modelling

Modelling tasks undertaken for the purposes of the Greater Norwich Level 2 SFRA included:

Existing Environment Agency models were rerun in line with the latest Environment Agency climate change guidance. The extreme H++ climate change scenario was run for the largest proposed development sites.

To understand flood depth and hazard a 2D domain to represent the floodplain was added for some sites, where the Environment Agency model did not have one

The Tidal Broads (BESL) model was run to inform tide levels at the downstream boundary of fluvial models. The model was also run to see if a tidal breach could affect flooding in Norwich.

New and simple strategic 2D models were built to inform flood risk decision making for sites where there are currently no detailed models

1.2 Using existing fluvial models

The majority of the modelling used existing reviewed Environment Agency fluvial models. The following models were run to provide Flood Zone data incorporating climate change allowances:

- River Wensum (2017)
- River Yare (2014)
- River Waveney (2013)
- Spixworth Beck (2006)

The majority of the sites are on the Wensum in Norwich, which is a 1D-2D model in this area although it does not have complete coverage of the sites in 2D. Site GNLP0608 was not covered by the 2D domain. This is because an assessment of the risk to site from current modelling, topography and Environment Agency Flood Zones showed the risk to be minimal.

Local 2D domains were added to the River Yare, River Waveney and Spixworth Beck models to provide depth and hazard outputs. The models were run for the following return periods (and to align with the Flood Zones in the NPPF):

- FZ2 – 0.1% AEP (1 in 1000yr)
- FZ3a – 1% AEP (1 in 100yr)
- FZ3b – 5% AEP (1 in 20yr)

Where 2D results for these events exist already, models were not re-run for present day conditions, only for climate change scenarios (see section 1.3). Where a 2D domain was added to models, these were run for present day conditions as well as for climate change scenarios.

There is a limited difference between the defended and undefended models because there are few flood defences in the study area. There is a modelled defence line on the western bank of the River Wensum in Norwich which stretches for about 1km, from St Helens Wharf to Prince of Wales Road Bridge. There are no defences modelled elsewhere on the River Wensum.

1.3 Climate Change scenarios

In line with Environment Agency requirements, our modelling accounted for the following climate change scenario allowances for fluvial flooding:

- The Fluvial Central allowance (+25%) and Fluvial Upper end allowance (+65%) for Flood Zone 3b.
- The Fluvial Central allowance (+25%), Fluvial Higher Central allowance (+35%) and Fluvial Upper end allowance (+65%) for Flood Zone 3a and Flood Zone 2.

The Tidal Broads model was joined to the River Wensum model to inform the tidal boundary for the River Wensum, for the latest climate change allowances for sea level rise. Given the location of the sites for Level 2 assessment on the River Waveney and the Spixworth Beck, these sites would not be impacted by tidal levels and so the downstream boundaries were not amended for tidal conditions. The existing downstream boundary was retained for the River Yare model. The year used for this assessment was 2120, 100 years ahead of the baseline year. Where tidal boundaries were updated, they used the 2018 Coastal Flood Boundary dataset with design tidal levels for the year 2017. They were then adjusted using the latest climate change guidance to 2120. A Mean High Water Spring (MHWS) tide in the BESL model was used for all fluvial return periods. Corresponding climate chane scenarios were used for the tidla and fluvial models e.g. a Higher Central fluvial model run was accompanied by a higher central sea level rise.

Following advice from the Environment Agency, the H++ scenario was applied for two areas due to significant urban development. These areas and the corresponding site codes are:

East Norwich Regeneration Site, >2,000 properties (Wensum)

GNLP0360, GNLP3053, R10

Three Score Urban Extension, >500 properties (Yare)

R38

An 80% increase was applied to existing fluvial modelled flows for the 5%, 1% and 0.1% AEP scenarios. A 1.9m rise was applied to current day sea levels for the 5%, 0.5% and 0.1% AEP

1.4 Future flood zones

The local Environment Agency office required Future Flood Zones to be developed for the Level 2 SFRA. Future flood zones within this Level 2 SFRA use the Upper End climate change allowance (+65%) on the undefended model, based on the Year 2080 band (2070 to 2115) for fluvial and Year 2120 for tidal boundaries. To inform future flood zones, the only model with defended and undefended scenarios was the River Wensum through Norwich. All others watercourses modelled a single scenario as defences were not relevant to the them.

2 Additional strategic modelling

Three sites identified for Level 2 assessment required new modelling as only catchment or national scale mapping existed. These are smaller watercourses adjacent or through the sites identified through OS mapping. The sites and their location are as follows:

Site Ref	Site Name	Location	EA LIDAR DTM used
BKE3	Brooke Industrial Park	Brooke	2m, 10m
DIS3	Land north of Stanley Road	Diss	1m
FOU2	Old Railway Yard, Station Road	Foulsham	1m

Sites DIS3 and FOU2 were modelled using TUFLOW software with topography from EA 1m LiDAR data. 2D modelling for site BKE3 at Brooke used lower quality topography sources in parts and therefore modelling results are not as accurate.

OS Mastermap informed the roughness applied to these models, and they also took account of hydraulic structures such as road bridges and culverts where information was made available.

Return periods for present day and climate change scenarios were run consistently with other fluvial models.

2.1 Environment Agency model review

The 2D strategic modelling has been produced for the purpose of informing the Level 2 SFRA. All three 2D models have been reviewed internally, although it should be noted that these have not been subject to external review by the Environment Agency. Therefore they have not been used to update the Environment Agency formal Flood Zones as shown on the online Flood Map for Planning.

Therefore, when considering these sites, both the Level 2 SFRA Flood Zones and the Environment Agency Flood Zones (whichever is greater) should be used. In addition, new detailed modelling would need to be submitted with any FRA for development in these sites and this should be subject to external review by the Environment Agency.

3 Surface Water modelling

Surface water modelling that accounts for an increase in rainfall intensity of 40% was undertaken for the 2017 Level 1 Strategic Flood Risk Assessment. This was reused for this study to take account of the impact of climate change on surface water flood risk.

4 Breach modelling

Previous work looking at the possibility of a tidal breach near the coast was undertaken in the 2017 Level 1 SFRA. It showed that a breach near Great Yarmouth could pose flooding risks across a wide area, but in that case were not shown to extend to the sites being considered in this study.

To determine whether sites to the eastern side of Norwich were vulnerable to tidal flooding, modelling work for the Level 2 SFRA was undertaken to test climate change uplifts in the tidal BESL model. As some sites in East Norwich required the H++ scenario, the most extreme event was tested at 0.1% AEP 1.9m sea level to determine the impact on the Norwich area.

At this extreme scenario, tidal levels were around 5.6mAOD at the coast but decreased rapidly upstream towards Norwich due to the extensive floodplain areas area within the Tidal Broads. Peak levels during the extreme scenario in Norwich were around 1.65mAOD which remained within the river channel.