Tendring District Council

Strategic Flood Risk Assessment

March 2009

TUFLOW modelling record

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CONTENTS

APPROVAL

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ABBREVIATIONS

LiDAR	Light Detection And Ranging
TUFLOW	Two-dimensional Unsteady Flow
GIS	Geographical Information System
ISIS	One-dimensional flow modelling software
SMS	Surface-water Modelling Sofeware

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1 INTRODUCTION

This document provides a full record of the assumptions, limitations, and decisions made during the construction of the 2D hydraulic TUFLOW model for the 2008s3779 – Babergh and Tendring District Council Strategic Flood Risk Assessment project. The information given in this document should enable the work to be reproduced in the future.

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The models developed are deemed suitable for the purpose of this study; more detailed additional information should be sought when undertaking site specific studies.

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2 MODEL OVERVIEW

2.1 Model overview

This section provides an overview of the model including the purpose of building this model and type of model was employed. Details of the model, such as the construction of the model grid, the calculation and construction of the 1D boundary, define floodplain roughness and set up simulation control files will be explained in section 3 and the last section provides details on the configuration used for each model run.

2.1.1 Model Basics

- The model was run using the most up to date version of TUFLOW available at the time of construction.
- The space required to hold the full set of twelve breach scenario runs is 1.6 GB
- The correct projection has been checked and is used in MapInfo. For British National Grid each .mif file should begin with the line:-

  CoordSys Earth Projection 8, 79, "m", -2, 49, 0.9996012717, 400000, -100000 Bounds (-7845061.1011, -15524202.1641) (8645061.1011, 4470074.53373)

Purpose of model	To map the flood inundation dynamics and residual risks (including depths, velocities and flood hazards) with time immediately after a breach of flood defences in the Tendring DC as part of Tendring DC SFRA level 2 outputs.
TUFLOW version used	2008-08-AE-iSP
Location of TUFLOW files	The models were run from the following locations: N:\2008\Projects\2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\Tuflow

2.1.2 Breach Locations

Six locations were chosen within Tendring DC to carry out breach analysis. Map 1 in the report shows the breach locations in Tendring DC.

The breach locations are mainly along the coastline of the Tendring DC boundary:

- Manningtree
- Walton-on-Naze 1 (To north)
- Walton-on-Naze 2 (To south)
- Holland Haven (at Clacton-on-Sea)
- Point Clear
- Brightlingsea

2.1.3 Type of TUFLOW model

The overall complexity of the TUFLOW model is determined by several factors. Most importantly amongst these will be the number and type of hydraulic boundary conditions required by the model. This in turn will be largely determined by the nature of the interaction between the channel and floodplain.

The Tendring breach scenario modelling uses simple (single breach scenarios along a short section of tidal defence) interactions. This simplicity is reflected in the single hydraulic boundary used for each breach scenario and simplicity of the 2D domain.

Six breach locations were modelled, with three scenarios simulated for each.

Each breach was modelled separately using a single 2D domain and hydraulic boundary condition for each scenario.

How many hydraulic boundaries does the model have?	Each model has 1 boundary
Does the model make use of a dynamic link (e.g. ISIS-TUFLOW)?	No
Does the model include multiple 2D domains?	No

2.2 Creating the Model Grid

2.2.1 Incorporating the available topographic data in TUFLOW

TUFLOW model topography is defined by point elevations (or Zpts) at the cell centres, mid-sides and corners. A number of factors need to be considered in order to optimally present the available topographic data to the TUFLOW model. These include:

- The type of topographic data available
- The choice of filtered or unfiltered LIDAR data.
- An assessment as to whether important topographic features are adequately represented by the TUFLOW z-points or whether the model would be enhanced by adding extra GIS layers or manually editing either the DEM or z-points.

	Description and comments
Main Data Source (s) for DEM (e.g. SURVEY DATA / LIDAR / NEXTMAP / Combined/ Other)	Airborne LiDAR data were used to build the model bathymetry. All data were supplied by the Environment Agency.
IF LIDAR, list type used (e.g. Unfiltered / Filtered / Combined). Reasons for choice?	Filtered LiDAR was used. This data has been passed through new supervised classification and filtering routines that attempt to strip out vegetation and buildings from the LiDAR derived surface model. This produces more accurate and representative bare-earth DTM's than the fully automated technique applied previously. The use of LiDAR data accurately represents the expected flow pathways on the floodplain as recommended by the Environment Agency.
List any problems with data quality e.g. NULL areas / overlapping LIDAR tiles.	The filtered LiDAR tiles have a large of amount of null areas throughout the whole Tendring DC. There are also overlapping LiDAR tiles around the coastal areas.
List any amendments to the DEM before creating the TUFLOW z-points.	No changes were made.
List all linear structures added to the model as .zlr or. zlg layers.	None
Were any other adjustments made to the topography (i.e. manual adjustment of z-points or additional _zpt layers?	The following z pts file was used. 1. Null values have been filled in by using Z polygon files which was given the surrounding average LiDAR values. File name follows this template: *2d_z_xxx(breach location)_LidarHoles.tab* 2. Topography at breach locations was adjusted by using Z polygon files to simulate breaches in defences. File name follows this template: *2d_z_xxx(breach location)_Breach.tab*

2.2.2 Defining grid properties

The 2D grids were produced so that they were perpendicular to the breaches. The active boundaries were defined using the Environment Agency's flood zone 2 and map contours as a guide to ensure that the full area of each potential breach was covered. This also ensured that both the z-point and code layers were defined so as not to use unnecessarily large amounts of memory and hence unnecessarily reduce run times.

	Description and comments
What cell size(s) was used (m)?	Different cell sizes were used in order to maintain maximum details for model outputs and efficient model run time and memory requirements. Manningtree 4 m Two breach locations at Walton-on-Naze, Brightlingsea and Pointclear 5 m Holland Haven at Clacton 10 m

2.2.3 Floodplain roughness zones and coefficients

Roughness coefficients can vary spatially over the floodplain and are defined using a 2d_mat layer and TUFLOW Material File (.tmf) (see Appendix B). Each land cover parcel is digitised as a polygon object and assigned an integer "Material "code and then each integer material value is linked to Manning's n value using the .tmf file.

TUFLOW runs can be very sensitive to Manning's 'n' so it is important to allocate Manning's values with care especially in models where the timing of flows is critical. However, the more Manning's values used in a model, the more difficult it is to perform meaningful sensitivity runs.

The Manning's 'n' values used for this model are listed below:

	Description and comments
What material value(s) was used?	File names used: *2d_mat_xxx(breach location).tab* or *2d_mat_xxx(breach location)_urban.tab* or *2d_mat_xxx(breach location)_buildings.tab* Material code = 1, where the entire model is set to the value of 1 where the dominate of area is rural/grassland Material code = 3, where the entire model is set to the value of 3 where the dominate of area is floodplain meadows Material code = 6, the entire model or urban areas were set to the value of 6 where the dominate area is hard surface or work yards Material code = 9, all the buildings (extracted from OS Master Map) and within the model are set to the value of 9
List all Manning's 'n' values used in the 2D domain and the type of terrain they represent.	The breach locations comprise of a combination of urban and rural areas. In order to present the land use correctly in the model, various Manning's 'n' values were used as listed below: • The rural grassland area was given a value of 0.04 • The floodplain meadow area was given a value of 0.05 • The urban area was given a value of 0.05 • The buildings were given a value of 0.30 to specify the permeability of the buildings. The increased roughness for buildings used rather than raising levels as this thought to give

	better representation of hazard for mapping.

2.2.4 Hydraulic boundaries

The choice of hydraulic boundary is critical to the accuracy of the TUFLOW model and is often the most important consideration in the construction of a 2D hydraulic model.

TUFLOW has a wide variety of boundary types (QT, HT, QH etc) which are available to the user. Consequently, the same boundary can often be modelled in a variety of different ways. In this case a HT-level boundary was selected as the preferred boundary option to represent the breach as this allows for return flows across the breach as the tide level recedes.

The hydraulic boundary information used in the TUFLOW models is as follows:

Model	Boundary Name	Type	Data File (.csv)	Brief Description
Manningtree	Q200	HT	Q200.csv	Hydrograph shape adopted from the downstream tidal boundary in the River Gipping hydraulic model (Orwell estuary), fitted to a 1 in 200 year peak tidal level based on the extreme tidal level at Manningtree base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007).
	Q200CC	HT	Q200CC.csv	Hydrograph shape borrowed from the downstream tidal boundary in the River Gipping hydraulic model (Orwell estuary), fitted to a 1 in 200 year peak tidal level based on the extreme tidal level at Manningtree base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007)., assuming a 980mm sea level rise (based on increase tide levels as defined in PPS25).
	Q1000	HT	Q1000.csv	Hydrograph shape borrowed from the downstream tidal boundary in the River Gipping hydraulic model (Orwell estuary), fitted to a 1 in 1000 year peak tidal level based on the extreme tidal level at Manningtree base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007).
Walton 1	Q200	HT	Q200.csv	Hydrograph shape was generated as Tidal boundary in ISIS using 1 in 200 year peak tidal level at Walton-on-Naze base on the Environment Agency, Anglian Region Eastern

Model	Boundary Name	Type	Data File (.csv)	Brief Description
				and Central Areas of Extreme Tide Level Report (2007).
	Q200CC	HT	Q200CC.csv	Hydrograph shape was generated as Tidal boundary in ISIS using 1 in 200 year peak tidal level at Walton-on-Naze base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007), assuming a 980mm sea level rise (based on increase tide levels as defined in PPS25).
	Q1000	HT	Q1000.csv	Hydrograph shape was generated as Tidal boundary in ISIS using 1 in 1000 year peak tidal level at Walton-on-Naze base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007).
Walton 2	Q200	HT	Q200.csv	Hydrograph shape was generated as Tidal boundary in ISIS using 1 in 200 year peak tidal level at Walton-on-Naze base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007).
	Q200CC	HT	Q200CC.csv	Hydrograph shape was generated as Tidal boundary in ISIS using 1 in 200 year peak tidal level at Walton-on-Naze base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007), assuming a 980mm sea level rise (based on increase tide levels as defined in PPS25).
	Q1000	HT	Q1000.csv	Hydrograph shape was generated as Tidal boundary in ISIS using 1 in 1000 year peak tidal level at Walton-on-Naze base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007).
Holland Haven (Clacton)	Q200	HT	Q200.csv	Hydrograph shape was adopted from Jaywick SFRS breach models to keep consistence of all model works within Tendring DC, fitted to a 1 in 200 year peak tidal level at Clacton-on-sea base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007).
	Q200CC	HT	Q200CC.csv	Hydrograph shape was adopted from Jaywick SFRS breach models to keep consistence of

Model	Boundary Name	Type	Data File (.csv)	Brief Description
				all model works within Tendring DC, fitted to a 1 in 200 year peak tidal level at Clacton-on-sea base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007), assuming a 980mm sea level rise (based on increase tide levels as defined in PPS25).
	Q1000	HT	Q1000.csv	Hydrograph shape was adopted from Jaywick SFRS breach models to keep consistence of all model works within Tendring DC, fitted to a 1 in 1000 year peak tidal level at Clacton-on-sea base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007).
Brightlingsea	Q200	HT	Q200.csv	Hydrograph shape was adopted from Jaywick SFRS breach models to keep consistence of all model works within Tendring DC, fitted to a 1 in 200 year peak tidal level at Brightlingsea base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007).
	Q200CC	HT	Q200CC.csv	Hydrograph shape was adopted from Jaywick SFRS breach models to keep consistence of all model works within Tendring DC, fitted to a 1 in 200 year peak tidal level at Brightlingsea base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007), assuming a 980mm sea level rise (based on increase tide levels as defined in PPS25).
	Q1000	HT	Q1000.csv	Hydrograph shape was adopted from Jaywick SFRS breach models to keep consistence of all model works within Tendring DC, fitted to a 1 in 1000 year peak tidal level at Brightlingsea base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007).
Point Clear	Q200	HT	Q200.csv	Hydrograph shape was adopted from Jaywick SFRS breach models to keep consistence of all model works within Tendring DC, fitted to a 1 in 200 year peak tidal level at Brightlingsea base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007).
	Q200CC	HT	Q200CC.csv	Hydrograph shape was adopted from Jaywick SFRS breach models to keep consistence of

Model	Boundary Name	Type	Data File (.csv)	Brief Description
				all model works within Tendring DC, fitted to a 1 in 200 year peak tidal level at Brightlingsea base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007), assuming a 980mm sea level rise (based on increase tide levels as defined in PPS25).
	Q1000	HT	Q1000.csv	Hydrograph shape was adopted from Jaywick SFRS breach models to keep consistence of all model works within Tendring DC, fitted to a 1 in 1000 year peak tidal level at Brightlingsea base on the Environment Agency, Anglian Region Eastern and Central Areas of Extreme Tide Level Report (2007).

3 MODEL RUNS

Each of the breach scenarios was modelled using the TUFLOW data as describe above, but each used its own unique 2D domain. Details of the runs are provided below.

Table 3-1: Manningtree – 1 in 200 year breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Manningtree		
Purpose of run	Scenario modelling of a breach at a location south of the industrial estate at Manningtree during a 1 in 200 year event.		
Changes made to the final TUFLOW grid described in Section 2.2	Uses z file for filling null values in LiDAR: mi\2d_z_Manningtree_LidarHoles.MIF Use mat file for buildings: mi\2d_mat_Manningtree_buildings.mif		
Changes made to the boundary conditions	None		
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	**Model End Time (hrs)**	9.5
Map Save Interval	700 seconds	**Time Series Save Interval**	10 seconds
Time Step (seconds)	2		
Comments			
Approximate run time	2 hours		
Comments on results. Are there any areas in which future runs might be improved?	None		

Table 3-2: Manningtree – 1 in 200 year plus climate change breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Manningtree
Purpose of run	Scenario modelling of a breach at a location south of the industrial estate at Manningtree during a 1 in 200 year event taking into account the effects of climate change.
Changes made to the final TUFLOW grid described in Section	Uses z file for filling null values in LiDAR: mi\2d_z_Manningtree_LidarHoles.MIF Use mat file for buildings: mi\2d_mat_Manningtree_buildings.mif

2.2			
Changes made to the boundary conditions	None		
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	Model End Time (hrs)	9.5
Map Save Interval	700 seconds	Time Series Save Interval	10 seconds
Time Step (seconds)	2		
Comments			
Approximate run time	2 hours		
Comments on results. Are there any areas in which future runs might be improved?	Further investigation into the likelihood of defences being overtopped during the climate change scenario.		

Table 3-3: Manningtree – 1 in 1000 year breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Manningtree		
Purpose of run	Scenario modelling of a breach at a location south of the industrial estate at Manningtree during a 1 in 1000 year event.		
Changes made to the final TUFLOW grid described in Section 2.2	Uses z file for filling null values in LiDAR: mi\2d_z_Manningtree_LidarHoles.MIF Use mat file for buildings: mi\2d_mat_Manningtree_buildings.mif		
Changes made to the boundary conditions	None		
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	Model End Time (hrs)	9.5
Map Save Interval	700 seconds	Time Series Save Interval	10 seconds
Time Step (seconds)	2		
Comments			

Approximate run time	3 hours
Comments on results. Are there any areas in which future runs might be improved?	None

Table 3-4: Walton 1 – 1 in 200 year breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Walton		
Purpose of run	Scenario modelling of a breach at a location north of Naze Marine Holiday Park at Walton-on-Naze during a 1 in 200 year event.		
Changes made to the final TUFLOW grid described in Section 2.2	Uses z polygon file for filling null values in LiDAR: 2d_z_Walton_b1_LidarHoles.MIF Uses z polygon for breach location: 2d_z_Walton_b1_Breach.MIF Use mat file for buildings: 2d_mat_Walton_buildings.mif		
Changes made to the boundary conditions	None		
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	0	8.5
Map Save Interval	300 seconds	300 seconds	10 seconds
Time Step (seconds)	2.5	2.5	
Comments			
Approximate run time	5 hours		
Comments on results. Are there any areas in which future runs might be improved?	None		

Table 3-5: Walton 1 – 1 in 200 year plus climate change breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Walton
Purpose of run	Scenario modelling of a breach at a location north of Naze Marine Holiday Park at Walton-on-Naze during a 1 in 200 year event.taking into account the effects of climate change.
Changes made to the final TUFLOW grid described in Section 2.2	Uses z polygon file for filling null values in LiDAR: 2d_z_Walton_b1_LidarHoles.MIF Uses z polygon fill for breach location: 2d_z_Walton_b1_Breach.MIF Use mat file for buildings: 2d_mat_Walton_buildings.mif

Changes made to the boundary conditions	None		
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	**Model End Time (hrs)**	19
Map Save Interval	300 seconds	**Time Series Save Interval**	10 seconds
Time Step (seconds)	2.5		
Comments			
Approximate run time	6 hours		
Comments on results. Are there any areas in which future runs might be improved?	Further investigation into the likelihood of defences being overtopped during the climate change scenario.		

Table 3-6: Walton 1 – 1 in 1000 year breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Walton		
Purpose of run	Scenario modelling of a breach at a location north of Naze Marine Holiday Park at Walton-on-Naze during a 1 in 1000 year event.		
Changes made to the final TUFLOW grid described in Section 2.2	Uses z polygon file for filling in null values in LiDAR: 2d_z_Walton_b1_LidarHoles.MIF Uses z polygon fill for breach location: 2d_z_Walton_b1_Breach.MIF Use mat file for buildings: 2d_mat_Walton_buildings.mif		
Changes made to the boundary conditions	None		
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	**Model End Time (hrs)**	19
Map Save Interval	300 seconds	**Time Series Save Interval**	10 seconds
Time Step (seconds)	2.5		
Comments			

Table 3-6: Walton 1 – 1 in 1000 year breach

Approximate run time	6 hours
Comments on results. Are there any areas in which future runs might be improved?	None

Table 3-7: Walton2 – 1 in 200 year breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Walton		
Purpose of run	Scenario modelling of a breach at a location south of Naze Marine Holiday Park at Walton-on-Naze during a 1 in 200 year event.		
Changes made to the final TUFLOW grid described in Section 2.2	Uses z polygon file for filling null values in LiDAR: 2d_z_Walton_b1_LidarHoles.MIF Uses z polygon for breach location: 2d_z_Walton_b2_Breach.MIF Use mat file for buildings and urban area: 2d_mat_Walton_buildings.mif and 2d_mat_Walton_b2_urban.mif		
Changes made to the boundary conditions	None		
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	**Model End Time (hrs)**	19
Map Save Interval	300 seconds	**Time Series Save Interval**	10 seconds
Time Step (seconds)	2.5		
Comments			
Approximate run time	4 hours		
Comments on results. Are there any areas in which future runs might be improved?	None		

Table 3-8: Walton2– 1 in 200 year plus climate change breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Walton
Purpose of run	Scenario modelling of a breach at a location south of Naze Marine Holiday Park at Walton-on-Naze during a 1 in 200 year event, taking into account the effects of climate change.

Table 3-8: Walton2– 1 in 200 year plus climate change breach

Changes made to the final TUFLOW grid described in Section 2.2	Uses z polygon file for filling null values in LiDAR: 2d_z_Walton_b1_LidarHoles.MIF Uses z polygon for breach location: 2d_z_Walton_b2_Breach.MIF Use mat file for buildings and urban area: 2d_mat_Walton_buildings.mif and 2d_mat_Walton_b2_urban.mif		
Changes made to the boundary conditions	None		
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	**Model End Time (hrs)**	19
Map Save Interval	300 seconds	**Time Series Save Interval**	10 seconds
Time Step (seconds)	2.5		
Comments			
Approximate run time	4.5 hours		
Comments on results. Are there any areas in which future runs might be improved?	Further investigation into the likelihood of defences being overtopped during the climate change scenario.		

Table 3-9: Walton2– 1 in 1000 year breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Walton		
Purpose of run	Scenario modelling of a breach at a location south of Naze Marine Holiday Park at Walton-on-Naze during a 1 in 1000 year event.		
Changes made to the final TUFLOW grid described in Section 2.2	Uses z polygon file for filling null values in LiDAR: 2d_z_Walton_b1_LidarHoles.MIF Uses z polygon for breach location: 2d_z_Walton_b2_Breach.MIF Use mat file for buildings and urban area: 2d_mat_Walton_buildings.mif and 2d_mat_Walton_b2_urban.mif		
Changes made to the boundary conditions	None		
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	**Model End Time (hrs)**	19

Table 3-9: Walton2– 1 in 1000 year breach

Map Save Interval	300 seconds	**Time Series Save Interval**	10 seconds
Time Step (seconds)	2.5		
Comments			
Approximate run time	4.5 hours		
Comments on results. Are there any areas in which future runs might be improved?	None		

Table 3-10: Holland Haven at Clacton – 1 in 200 year breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Clacton		
Purpose of run	Scenario modelling of a breach at Holland Haven along Clacton sea front during a 1 in 200 year event		
Changes made to the final TUFLOW grid described in Section 2.2	Uses z polygon file for filling null values in LiDAR: 2d_z_Clacton_LidarHoles.MIF Uses z polygon for breach location: 2d_z_Clacton_Breach.MIF Use mat file for buildings and urban area: 2d_mat_Clacton_buildings.mif and 2d_mat_Clacton_urban.mif		
Changes made to the boundary conditions	None		
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	**Model End Time (hrs)**	36
Map Save Interval	600 seconds	**Time Series Save Interval**	10 seconds
Time Step (seconds)	5		
Comments			
Approximate run time	6 hours		
Comments on results. Are there any areas in which future runs might be improved?	None		

Table 3-11: Holland Haven at Clacton – 1 in 200 year breach plus climate change breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Clacton		
Purpose of run	Scenario modelling of a breach at Holland Haven along Clacton sea front during a 1 in 200 year event, taking into account the effects of climate change		
Changes made to the final TUFLOW grid described in Section 2.2	Uses z polygon file for filling null values in LiDAR: 2d_z_Clacton_LidarHoles.MIF Uses z polygon for breach location: 2d_z_Clacton_Breach.MIF Use mat file for buildings and urban area: 2d_mat_Clacton_buildings.mif and 2d_mat_Clacton_urban.mif		
Changes made to the boundary conditions	None		
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	**Model End Time (hrs)**	36
Map Save Interval	600 seconds	**Time Series Save Interval**	10 seconds
Time Step (seconds)	5		
Comments			
Approximate run time	6.5 hours		
Comments on results. Are there any areas in which future runs might be improved?	Further investigation into the likelihood of defences being overtopped during the climate change scenario.		

Table 3-12: Holland Haven at Clacton – 1 in 1000 year breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Clacton
Purpose of run	Scenario modelling of a breach at Holland Haven along Clacton sea front during a 1 in 1000 year event
Changes made to the final TUFLOW grid described in Section 2.2	Uses z polygon file for filling null values in LiDAR: 2d_z_Clacton_LidarHoles.MIF Uses z polygon for breach location: 2d_z_Clacton_Breach.MIF Use mat file for buildings and urban area: 2d_mat_Clacton_buildings.mif and 2d_mat_Clacton_urban.mif
Changes made to the boundary conditions	None
Any other changes to the model template described in Section 2.	None (same as default model)

Table 3-12: Holland Haven at Clacton – 1 in 1000 year breach

Settings			
Model Start Time (hrs)	0	Model End Time (hrs)	36
Map Save Interval	600 seconds	Time Series Save Interval	10 seconds
Time Step (seconds)	5		
Comments			
Approximate run time	6.5 hours		
Comments on results. Are there any areas in which future runs might be improved?	None		

Table 3-13: Brightlingsea – 1 in 200 year breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Brightlingsea		
Purpose of run	Scenario modelling of a breach at west of Bateman's Tower in Brightlingsea during a 1 in 200 year event		
Changes made to the final TUFLOW grid described in Section 2.2	Uses z file: 2d_z_bank.mif Uses z polygon for breach location: 2d_z_breachpoly.mif Use mat file for buildings and urban area: 2d_mat_BRI.mif and 2d_mat_buildings.mif		
Changes made to the boundary conditions	None		
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	Model End Time (hrs)	35
Map Save Interval	900 seconds	Time Series Save Interval	120 seconds
Time Step (seconds)	2.5		
Comments			
Approximate run time	3 hours		
Comments on results. Are there any areas in which future runs might be improved?	Flow comes from the marsh into the undefended part of town. Floods in the undefended area can be simulated separately though this covered in the Environment Agency Flood Zone maps. Overtopping of bank may occur but information on bank top level is poor to be able to determine this.		

Table 3-14: Brightlingsea – 1 in 200 year plus climate change breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Brightlingsea		
Purpose of run	Scenario modelling of a breach at west of Bateman's Tower in Brightlingsea during a 1 in 200 year event taking into account the effects of climate change		
Changes made to the final TUFLOW grid described in Section 2.2	Uses z file: 2d_z_bank.mif Uses z polygon for breach location: 2d_z_breachpoly.mif Use mat file for buildings and urban area: 2d_mat_BRI.mif and 2d_mat_buildings.mif		
Changes made to the boundary conditions	Continuous peak level modelled for entire model durations (peak occurred 0.5 hours after model start for stability reasons).		
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	**Model End Time (hrs)**	35
Map Save Interval	900 seconds	**Time Series Save Interval**	120 seconds
Time Step (seconds)	2.5		
Comments			
Approximate run time	3.5 hours		
Comments on results. Are there any areas in which future runs might be improved?	Further consideration of flooding mechanisms within the undefended parts of town and overtopping of defences to the north in climate change scenario. Flow comes from the marsh into the undefended part of town. Floods in the undefended area can be simulated separately though this covered in the Environment Agency Flood Zone maps. Overtopping of bank may occur but information on bank top level is poor to be able to determine this.		

Table 3-15: Brightlingsea – 1 in 1000 year breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\Brightlingsea
Purpose of run	Scenario modelling of a breach at west of Bateman's Tower in Brightlingsea during a 1 in 1000 year event
Changes made to the final TUFLOW grid described in Section 2.2	Uses z file: 2d_z_bank.mif Uses z polygon for breach location: 2d_z_breachpoly.mif Use mat file for buildings and urban area: 2d_mat_BRI.mif and 2d_mat_buildings.mif
Changes made to the boundary conditions	None

Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	**Model End Time (hrs)**	35
Map Save Interval	900 seconds	**Time Series Save Interval**	120 seconds
Time Step (seconds)	2.5		
Comments			
Approximate run time	3.5 hours		
Comments on results. Are there any areas in which future runs might be improved?	Flow comes from the marsh into the undefended part of town. Floods in the undefended area can be simulated separately though this covered in the Environment Agency Flood Zone maps. Overtopping of bank may occur but information on bank top level is poor to be able to determine this.		

Table 3-16: Point Clear – 1 in 200 year breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\PointClear		
Purpose of run	Scenario modelling of a breach at east of Caravan Park in Point Clear during a 1 in 200 year event		
Changes made to the final TUFLOW grid described in Section 2.2	Uses z polygon for breach location: 2d_z_breach.mif Use mat file for buildings : 2d_mat_buildings.mif		
Changes made to the boundary conditions			
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	**Model End Time (hrs)**	33
Map Save Interval	900 seconds	**Time Series Save Interval**	120 seconds
Time Step (seconds)	2.5		
Comments			
Approximate run time	2 hours		
Comments on results. Are there any areas in which future runs	None		

Table 3-16: Point Clear – 1 in 200 year breach

might be improved?	

Table 3-17: Point Clear – 1 in 200 year plus climate change breach

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\PointClear		
Purpose of run	Scenario modelling of a breach at east of Caravan Park in Point Clear during a 1 in 200 year event taking into account the effects of climate change		
Changes made to the final TUFLOW grid described in Section 2.2	Uses z polygon for breach location: 2d_z_breach.mif Use mat file for buildings : 2d_mat_buildings.mif		
Changes made to the boundary conditions			
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	**Model End Time (hrs)**	9.5
Map Save Interval	900 seconds	**Time Series Save Interval**	10 seconds
Time Step (seconds)	2.5		
Comments			
Approximate run time	2 hours		
Comments on results. Are there any areas in which future runs might be improved?	Further investigation into the likelihood of defences being overtopped during the climate change scenario.		

Table 3-18: Point Clear – 1 in 1000 year

TUFLOW directory	2008s3779 - Babergh District Council - Babergh and Tendring District Councils Stage 2 SFRA\Calculations\Tendring\TUFLOW\PointClear
Purpose of run	Scenario modelling of a breach at east of Caravan Park in Point Clear during a 1 in 1000 year event
Changes made to the final TUFLOW grid described in Section 2.2	Uses z polygon for breach location: 2d_z_breach.mif Use mat file for buildings : 2d_mat_buildings.mif

Changes made to the boundary conditions			
Any other changes to the model template described in Section 2.	None (same as default model)		
Settings			
Model Start Time (hrs)	0	**Model End Time (hrs)**	33
Map Save Interval	900 seconds	**Time Series Save Interval**	120 seconds
Time Step (seconds)	2.5		
Comments			
Approximate run time	2 hours		
Comments on results. Are there any areas in which future runs might be improved?	None		

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4 QA CHECKS

QA checks	
Has sufficient documentation been kept?	• A record of the assumptions, limitations, and decisions made during the conceptual modelling are provided within this report and within Appendix C also provided within this report. • An internal technical review of the modelling has been undertaken; this can be provided if required.
Have the TUFLOW files been satisfactorily organised?	• The original recommended TUFLOW directory structure been maintained • Model check files have been saved to facilitate model checking • The model outputs seem appropriate for the nature of the study.
Does the 2D domain seem to be accurately represented?	• Various cell sizes of 4m, 5m and 10m were used for all breaches. These cell sizes are deemed an appropriate level of accuracy for this level of study. • The z points seem to accurately represent the topography from the DTM. • There are no significant warnings identified within the *messages.mif* file.
Do the hydraulic boundary conditions seem appropriate?	• HT boundaries were used as these are preferable where flow is likely to occur both ways across the boundary.
Are there any problems with model stability?	• The TUFLOW time step to cell size ratio is half as suggested in the TUFLOW guidance and is therefore appropriate; implying that the models are optimally configured. • The mass balance results show that the majority of results fall within +/-1% cumulative mass error after the initial breach instabilities suggesting that the models are operating stably.
Has the model been verified?	• Due to time constrains within the program and the relative simplicity of the breach scenarios, sensitivity checks were not carried out. • Verification of results against recorded levels or photographs was not possible as this information was not available. However, a site visit established the likely flow paths and extents, and the model results were checked against the Flood Zone maps for their suitability in terms of flooded extent. It must be noted that the Flood Zones do not represent the breach of defences (but do present the undefended situation) and this check was undertaken for suitability purposes only.
Are the model results realistic?	• Checks of the SMS results do not display any obvious for anomalies which are indicative of emerging instability. • Checks of the realism of depths and velocities over calculation area appear satisfactory.

APPENDIX A: TUFLOW MODELLING LOG

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APPENDIX A: TUFLOW MODELLING LOG

Job Number: 2008s3779

Job Description: Babergh and Tendring SFRA

TUFLOW Modelling Log:

Scenario	Run by?	QA by?	.tcf	.tgc	.tbc	bc_dbase	Results
Manningtree Q200	LY	TG	Manningtree_setup_step4	Manningtree_setup_step4	Manningtree_setup_step4	Q200	Manningtree_setup_step4
Manningtree Q200CC	LY	TG	Manningtree_setup_step4_CC	Manningtree_setup_step4_CC	Manningtree_setup_step4	Q200CC	Manningtree_setup_step4_CC
Manningtree Q1000	LY	TG	Manningtree_setup_step4_1000	Manningtree_setup_step4_1000	Manningtree_setup_step4	Q1000	Manningtree_setup_step4_1000
Walton 1 Q200	LY	TG	Walton_b1_step4	Walton_b1_step4	Walton_b1_step4_rerun	Q200	Walton_b1_step4
Walton 1 Q200CC	LY	TG	Walton_b1_step4_CCrerun	Walton_b1_step4_CCrerun	Walton_b1_step4_rerun	Q200CC	Walton_b1_step4_CCrerun
Walton 1 Q1000	LY	TG	Walton_b1_step4_1000rerun	Walton_b1_step4_1000rerun	Walton_b1_step4_rerun	Q1000	Walton_b1_step4_1000rerun
Walton 2 Q200	LY	TG	Walton_b2_step4	Walton_b2_step4	Walton_b2_step4	Q200	Walton_b2_step4
Walton 2 Q200CC	LY	TG	Walton_b2_step4_cc	Walton_b2_step4_cc	Walton_b2_step4	Q200CC	Walton_b2_step4_cc
Walton 2 Q1000	LY	TG	Walton_b2_step4_1000	Walton_b2_step4_1000	Walton_b2_step4	Q1000	Walton_b2_step4_1000
Holland Haven (Clacton) Q200	LY	TG	Clacton_step4_200yr_rerun	Clacton_step4_200yr_rerun	Clacton_step4	Q200	Clacton_step4_200yr_rerun
Holland Haven (Clacton) Q200CC	LY	TG	Clacton_step4_cc	Clacton_step4_cc	Clacton_step4	Q200pluscc	Clacton_step4_cc
Holland Haven (Clacton)	LY	TG	Clacton_step4_1000yr	Clacton_step4_1000yr	Clacton_step4	Q1000	Clacton_step4_1000yr

Q1000							
Brightlingsea Q200	LY	TG	BRI_200_2007	BRI_5m	BRI_001.tbc	BRI200_2007	BRI200_2007
Brightlingsea Q200CC	LY	TG	BRI_200_2107	BRI_5m	BRI_001.tbc	BRI200_2107	BRI200_2007
Brightlingsea Q1000	LY	TG	BRI_1000_207	BRI_5m	BRI_001.tbc	BRI200_2107	BRI1000_2007
Point Clear Q200	LY	TG	PCL_200_2007	PCL_5m	PCL_001.tbc	BRI200_2007	PCL200_2007
Point Clear Q200CC	LY	TG	PCL_200_2107	PCL_5m	PCL_001.tbc	BRI200_2107	PCL200_2107
Point Clear Q1000	LY	TG	PCL_1000_2007	PCL_5m	PCL_001.tbc	BRI200_2107	PCL1000_2007

APPENDIX B: MATERIALS DEFINITION FILE FOR FINAL MODEL DEVELOPMENT

The table below shows how the material values link to Manning's n roughness values in TuFlow model.

Material Code	Manning n values	Land use
1	0.04	Grass
2	0.06	Dense trees
3	0.05	Fence shrubs
4	0.035	Gravel road
5	0.025	Footpaths and paved areas
6	0.05	Hard surface, standing areas, work yards
7	0.04	Open Carparks
8	0.20	Multi-storey carparks
9	0.30	Buildings