Norwich Western Link

Environmental Statement

Chapter 12: Road Drainage and the Water Environment

Appendix 12.2: Flood Risk Assessment

Sub Appendix I: Ringland Lane Technical Modelling Log

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Glossary of Abbreviations and Defined Terms

The definition of key terms used in this report are provided below. These definitions have been developed by reference to the definitions used in EU and UK legislation and guidance relevant to the water environment as well as professional judgement based on knowledge and experience of similar schemes in the context of the Proposed Scheme.

Term	Definition
1D model	A hydraulic model used for watercourses that calculates flow in the direction of the channel only. It does not calculate movement vertically or horizontally in the channel.
2D model	A hydraulic model used for watercourses and floodplains that calculates flow along a plane in two directions, often at 90 degrees to each other. It does not calculate movement in the vertical direction.
Digital Terrain Model	A surface produced from LIDAR data where surface features such as buildings and vegetation have been removed so that is represents ground level.
Flood Estimation Handbook	A manual consisting 5 volumes that sets out the techniques to be used within the UK to derive flood flows, which are used to support Flood Risk Assessments.
Flood Modeller Pro	A hydraulic modelling software package
Fluvial Flood Risk	Flooding resulting from a flows within a watercourse exceeding the capacity of that watercourse.
Hydraulic Model	A software tool used to estimate water levels during a flood event based on topographical data of watercourse channels and the floodplain and flood event flows or rainfall data.

Term	Definition
Hydrology	The study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks.
Left Bank	Left bank is defined by the direction of flow of the watercourse, looking downstream in the direction of flow. For the purposes of this FRA both the River Wensum and Foxburrow Stream run in a south-easterly direction in the vicinity of the Proposed Scheme. The left bank is therefore on the north-east side of these watercourses.
LIDAR	Light Detection and Ranging, a method used to collect ground level data from an aircraft allowing large areas to be collected. The data in its unfiltered form will pick up vegetation and properties. A filtered form is generated to represent the ground surface and is used in assessments.
Manning's Roughness Value or Coefficient	A coefficient to represent different surface roughnesses and used in the Manning equation to understand the relationship between flow and water depth.
Model cell size	The resolution that LIDAR data is sampled at for use in the model. Smaller cell sizes increase the length of time it takes for a model to run.
QMED	The median flow extracted from an AMAX series. This is considered to represent the 1 in 2 annual probability event flood.
ReFH	The Revitalised Flood Hydrograph rainfall runoff method. One of the Flood Estimation Handbook methods for determining peak flows and hydrographs.

Term	Definition
Right Bank	Right bank is defined by the direction of flow of the watercourse, looking downstream in the direction of flow. For the purposes of this FRA both the River Wensum and Foxburrow Stream run in a south-easterly direction in the vicinity of the Proposed Scheme. The right bank is therefore on the south-west side of these watercourses
TUFLOW	A hydraulic modelling software package

1 Overview

1.1.1 This model log forms a sub-appendix of **Chapter 12: Road Drainage and the Water Environment Appendix 2: Flood Risk Assessment** (Document Reference: 3.12.02) and should be read in conjunction with **Appendix 12.2h Ringland Lane Hydraulic Modelling Report** (Document Reference: 3.12.02h).

1.1.2 The topographic survey data used for the modelling is summarised in **Table 1-1**.

Table 1-1 Topographic survey data

Data	Details
Cross Section Survey data	No cross-section survey was done as the flow is not confined to any channel in the existing scenario. Therefore, the baseline model does not consist of a 1D network. The proposed scenario consists of designed PEDs which have defined cross-sections.
Topographic Survey data	Spot level survey completed by Survey Solutions in 2021. The survey covers the floodplain for a length of approximately 650m adjacent to Ringland Lane. This is the central reach of the model. The data has been supplemented with LIDAR data for the upstream and downstream reaches of the floodplain.
LIDAR data	LIDAR data for the study was downloaded from the UK Government's website in 2022. The data was flown in November 2017 and downloaded as a composite 1m resolution grid.

1.1.3 The LIDAR was compared to the spot level survey completed by Survey Solutions and agreed well. It has been used with no adjustment other than some minor smoothing at the boundary between the LIDAR and the topographic survey.

2 Model Schematisation

2.1 Modelling approach and choice of software

2.1.1 The overland flow path to be modelled does not consist of any defined watercourse. The area is predominantly rural, and therefore the floodplain of the watercourse is not complex and there are limited features, such as roads or buildings, that are likely to influence flow paths.

2.1.2 An ESTRY-TUFLOW model has been used for the purpose of the study. The choice of software reflects the need to investigate the overland flow pattern and industry experience in the UK in the development of fluvial models. It is also helpful to incorporate the proposed infrastructure introduced to attenuate the flood impact.

2.1.3 Further details of the representation of the proposed scheme are provided in **Section 4.**

3 2D Baseline Model Representation

3.1 Labelling Convention

3.1.1 The standard labelling convention and folder structure for TUFLOW models has been applied. Control files (.tcf, .tgc, .tbc, .tmf) have been prefixed with RLSW and suffixed with a 3 digit version number. GIS files are saved in the Model/GIS folder and prefixed with the TUFLOW ascribed codes and suffixed with a letter denoting the shapefile geometry type (point, line or region) and a 3 digit version number.

3.2 Model Grid Resolution and Modifications

3.2.1 Ground levels in the model (comprising the topographic survey and LIDAR data) has been sampled at a 2 metre grid cell size to represent the floodplain.

3.2.2 There is a single property within the floodplain and this is not located in a flow conveyance area. As such no changes to the ground model to reflect this structure has been undertaken.

3.3 Floodplain Roughness

3.3.1 OS Mastermap data has been used to determine floodplain surface types. A spatially varying roughness has been applied across the 2D domain using this data and the roughness values linked to the different surface types as shown below.

Table 3-1 Manning's n values for the 2D domain

Description / Mastermap Feature Code	Manning's 'n' value
General surface - Grass	0.04
Dense trees	0.06
Fence shrubs	0.05
Road	0.02
Footpaths and paved areas	0.025
Hard surface, standing areas, work yards	0.05
Buildings	0.3

3.4 2D Model Boundaries

3.4.1 The TUFLOW 2D domain has four upstream boundaries. Full details of the catchment areas are set out in **Appendix 12.2h Ringland Lane Hydraulic Modelling Report** (Document Reference: 3.12.02h). Details of the inflow boundaries are presented in **Table 3-2**.

Table 3-2 2D model inflows

Inflow Label	Description
US_BC_BAS	Baseline scenario only. Accounts for the large majority of the flow from upstream contributing catchment, 3.29km^2.

Inflow Label	Description
OVER_NE	Baseline and Proposed Scenario. Allows for inflow from the north east of the catchment, 0.30km^2.
US_BC_DEV	Proposed Scenario only. As for US_BC_BAS with the removal of the contributing area downstream of the attenuation feature, 3.11km^2.
PED_BC	Proposed Scenario only. Allows for the contributing inflows from the adjacent Weston Road overland flow path and the existing contributing area downstream of the attenuation feature, 0.41km^2.

3.4.2 A final boundary is located at the downstream end of the overland flow path. The downstream boundary is a ‘HQ’ type boundary which allows free flow of water depending on the downstream slope. For the downstream boundary a slope of 0.001 has been used.

4 Proposed Model Representation

4.1.1 The proposed scheme as it crosses Ringland Lane overland flow path, consists of Preliminary Earthworks Ditches (PED) and 3 locations where pipes crossings are planned. Full details of the Proposed Scheme in the vicinity of the Ringland Lane overland flow path are presented in **Appendix 12.2h Ringland Lane Hydraulic Modelling Report** (Document Reference: 3.12.02h).

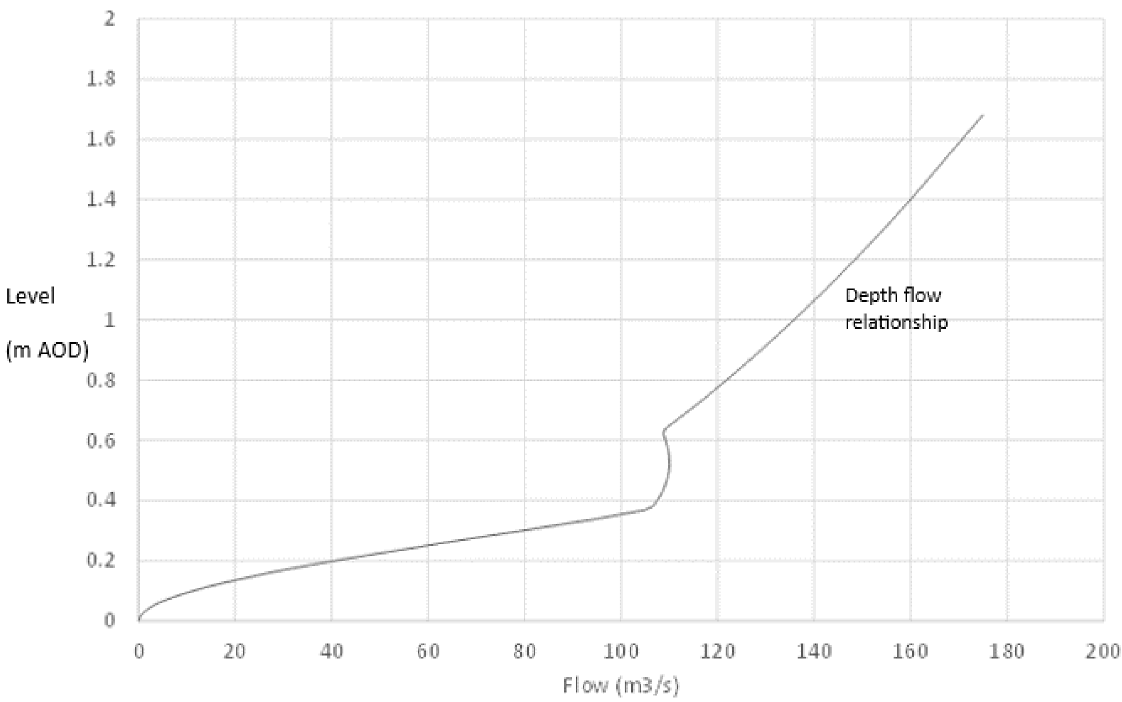
4.2 1D Model

4.2.1 The PEDs have been created with variable cross sections reflecting the scale and size of the PED. Typically, the cross sections are trapezoidal and have a base width between 0.5 metres and 1 metre. Side slopes are approximately 1 in 1.

4.2.2 The proposed culverts have been represented using circular conduit units with appropriate sizes. The roughness value assigned to all 3 culverts is 0.02.

4.2.3 Flow Control Devices were schematised to convey flow from the flood attenuation basin (behind the flood bund) into the PEDs downstream at a restricted rate. The preferred setup includes three flow control devices at 25.5 metres AOD, the lowest elevation within the attenuation basin, and an additional structure set to 27.4 metres AOD to determine the requirement for an overspill feature (e.g., weir). This latter structure has a capacity 9 times the remaining structures. The depth flow relationship for each flow control device is shown in **Figure 4-1**.

Figure 4-1 Hydrobrake depth flow relationship



4.3 2D Model

4.3.1 A flood bund is included to create a flood attenuation basin upstream of the scheme in a natural depression already present. The bund has been represented in the model using a raster to provide the overlying shape with a 2d_zsh polygon overlaid to enforce the crest level. The final crest height is set at 28 metres AOD. Ground elevations in close proximity but outside the area of the bund were represented based on site survey.

4.3.2 In addition to the design mitigation the 2D model incorporates the various road and surface water drainage ponds being constructed as part of the wider scheme. A water level equivalent to the 1 in 1000 annual probability event is applied within Drainage Basin 3 so that this is not available as capacity should the banks be overtopped.

4.3.3 A series of meanders are also proposed in the design at the outfall of the PED network to slow flows. These are currently excluded from the model as they created mass balance errors.

5 Model Run Summary

5.1 Model Run Parameters

Parameter	**Approach**
Model cell size	2m
Model run times	Start: 0 hrs End: 40 hrs
Timestep	1D ESTRY: 0.5s 2D TUFLOW: 1s
Time series output interval	1D: 300s 2D: 300s

5.1.1 1D run parameters

- Write CSV Online == ON
- Output Times Same as 2D == OFF

5.1.2 2D run parameters: Default with the following changes:

- Double precision
- Cell Wet/Dry Depth == 0.0002
- Map Output Format == XMDF

- Map Output Data Types == d v q h ZUK0 MB1 MB2
- Store Maximums and Minimums == ON MAXIMUMS ONLY

5.2 Model Scenarios

Scenario: Baseline

- This scenario represents the existing situation.
- The scenario has been run for the 2yr, 5yr, 30yr, 50yr, 75yr, 100yr, 1000yr and 100yr+45% events.

5.2.1 TUFLOW Files

- tcf: RLSW_027_~s1~_~s2~_~s3~_~e1~.tcf
- tgc: RLSW_026.tgc
- tbc: RLSW_021.tbc
- tef: RLSW_004.tef
- tmf: RLSW_001.tmf
- results: RLSW_027_BAS_xx_xx_0100C45.xmdf

5.2.2 TUFLOW Messages

- None

Figure 5-1 TUFLOW dv plot for the 1 in 100 annual probability plus 45% climate change event

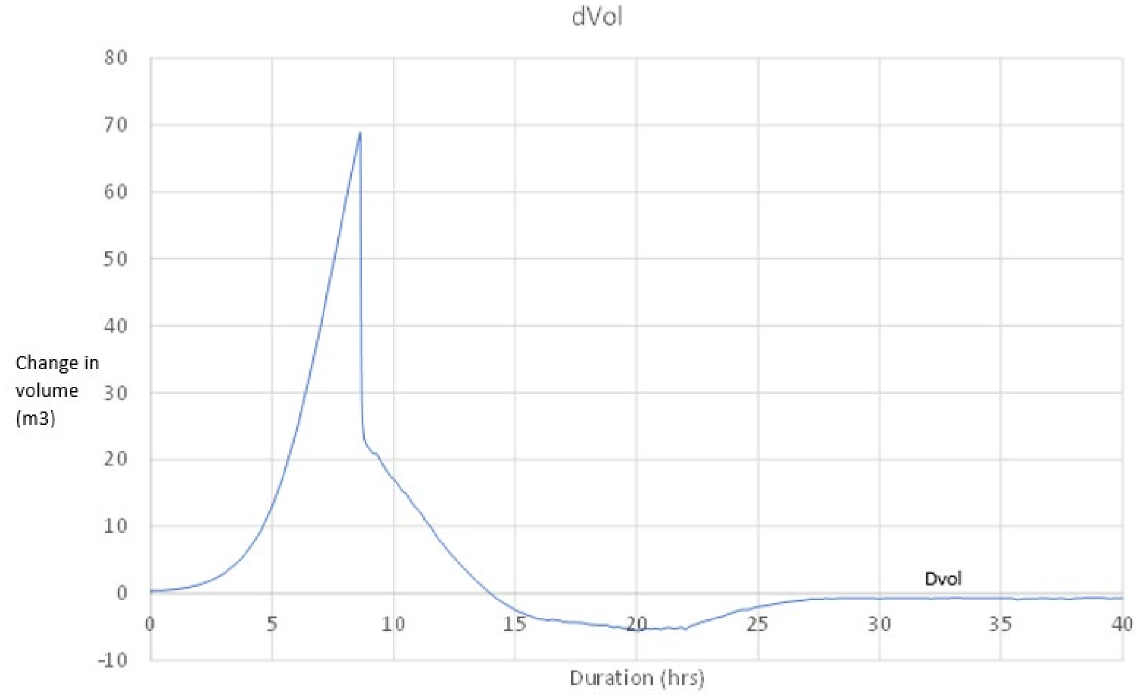
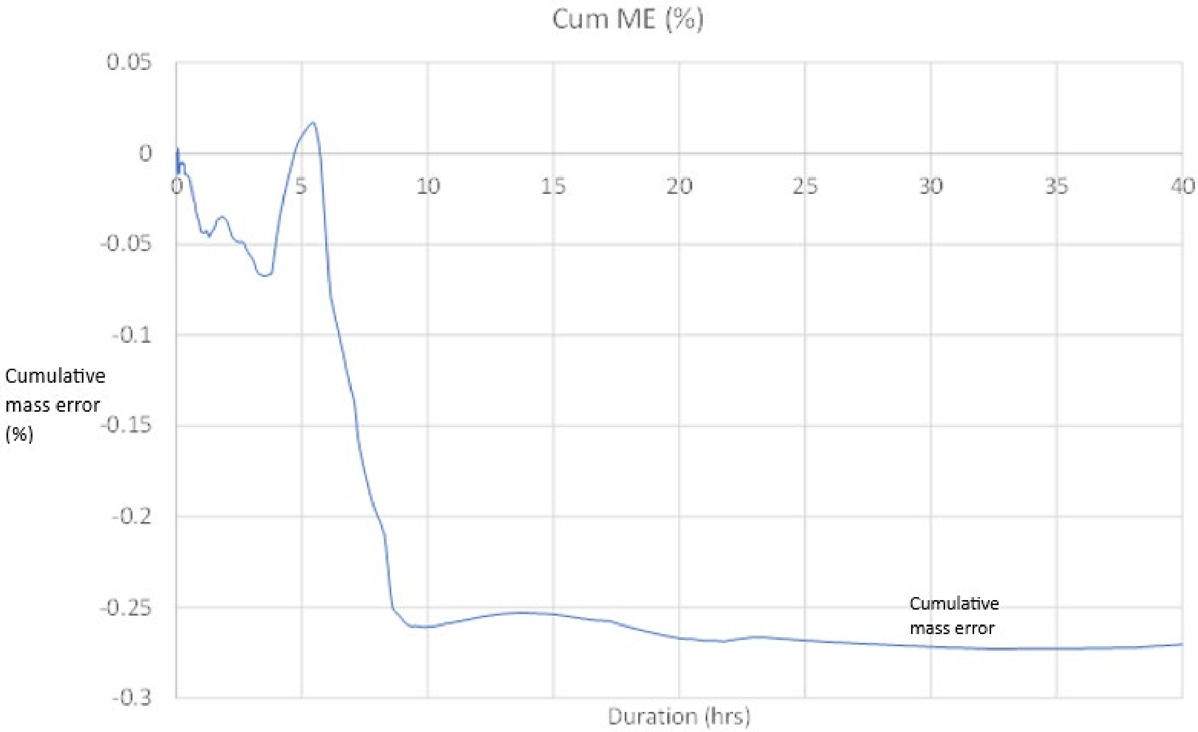


Figure 5-2 - TUFLOW ME plot for the 1 in 100 annual probability plus 45% climate change event



Scenario: Proposed

- This scenario represents the Proposed Scheme.
- The scenario has been run for the 2yr, 5yr, 30yr, 50yr, 75yr, 100yr, 1000yr and 100yr+45% events.

5.2.3 TUFLOW Files

- tcf: RLSW_028_~s1~_~s2~_~s3~_~e1~.tcf
- tgc: RLSW_027.tgc
- tbc: RLSW_021.tbc
- tef: RLSW_004.tef
- tmf: RLSW_001.tmf
- results: RLSW_027_DEV2_Bund_Option_23_xx_0100C45.xmdf

TUFLOW Messages. As per baseline scenario and:

- CHECK 1200 - Node at start of connector can only be used for setting up channel inverts and pit channels.
- CHECK 2118 - Lowered SX ZC Zpt by (various) m to 1D node bed level.
- WARNING 1100 - Structure C-06-Y-4.000 crest/invert (21.130) is below bed (21.147) of primary upstream channel CH4.

Figure 5-3 - TUFLOW dv plot for the 1 in 100 annual probability plus 45% climate change event

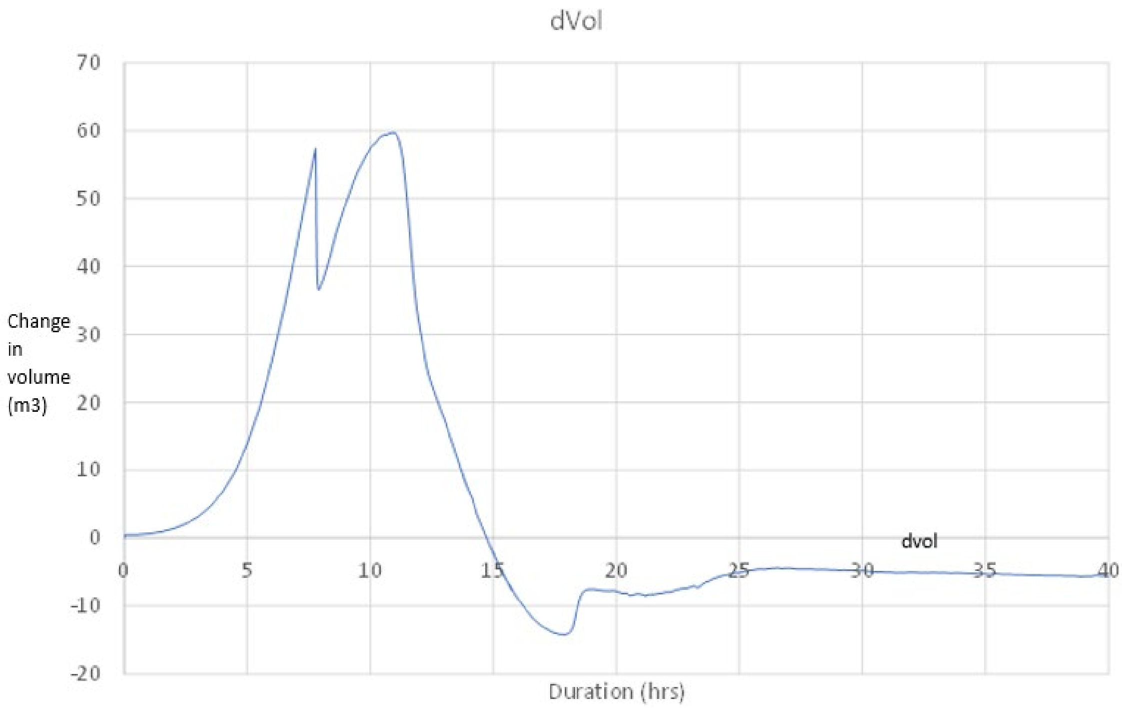


Figure 5-4 - TUFLOW ME plot for the 1 in 100 annual probability plus 45% climate change event