Norwich Western Link

Environmental Statement

Chapter 12: Road Drainage and the Water Environment

Appendix 12.2: Flood Risk Assessment

Sub Appendix E: Foxburrow Stream Hydraulic Modelling Report

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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.
Climate Change Allowance	An uplift applied to peak flow or rainfall estimates, which are based on data available today, to account for predicted increases in rainfall in the future.
Culvert	Arched, enclosed, or piped structure constructed to carry water under roads, railways, and buildings
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.
Drainage Strategy	Demonstrates how surface water will be managed within a scheme so it does not increase flood risk elsewhere, how the scheme is compliant with the relevant legislation and manages risks to water quality.
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.

Term	Definition
Flood Map for Surface Water	A nationally available dataset showing areas that are susceptible to surface water (or pluvial i.e. from rainfall) flooding produced by the Environment Agency.
Flood Modeller Pro	A hydraulic modelling software package
Flood Risk Assessment	As assessment that identifies and assesses the risk of flooding to and from a proposed development for all sources. It is a requirement under the national planning policy framework for all new developments that are in flood zone 2 or 3 and are more than 1 hectare.
Flood Zone	The classification of an area based on its risk of flooding from fluvial or tidal sources.
Floodplain	Valley floor adjacent to a river that is (or was historically) inundated periodically by flood waters and is formed of sediments deposited by the river
Fluvial Flood Risk	Flooding resulting from flows within a watercourse exceeding the capacity of that watercourse.
Foxburrow Stream (a tributary of the River Tud)	In reference to the river. ‘Foxburrow Stream can be used in subsequent uses.
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.
Hydrology	The study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks.

Term	Definition
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 roughness 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.
NMU (non-motorised users)	A specific group of road users including walkers, cyclists, or horse riders.
Norwich Western Link Highway	The highway section of Proposed Scheme which encompasses 6 Kilometre (Km) of long dual-carriageway road connecting the A1067 Fakenham Road and the A47 and a dualled section of the A1067 to the existing A1270 roundabout.
Pre-Earthwork Ditch	An earth ditch that will run along the outer edge on the Norwich Western Link Highway to collect and convey surface water runoff

Term	Definition
Proposed Scheme	The proposed Norwich Western Link scheme.
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.
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
River Gauge	A location within a watercourse where the flow and depth relationship is understood so that accurate data on river flows can be collected.
Surface Water Drainage Strategy	Demonstrates how surface water will be managed within a scheme so it does not increase flood risk elsewhere, how the scheme is compliant with the relevant legislation and manages risks to water quality.
Tud tributary culvert / Bat underpass	(CU2). Drawing Structure Reference. Drawing Structure Reference to be reflected in chapter text
TUFLOW	A hydraulic modelling software package

1 Introduction

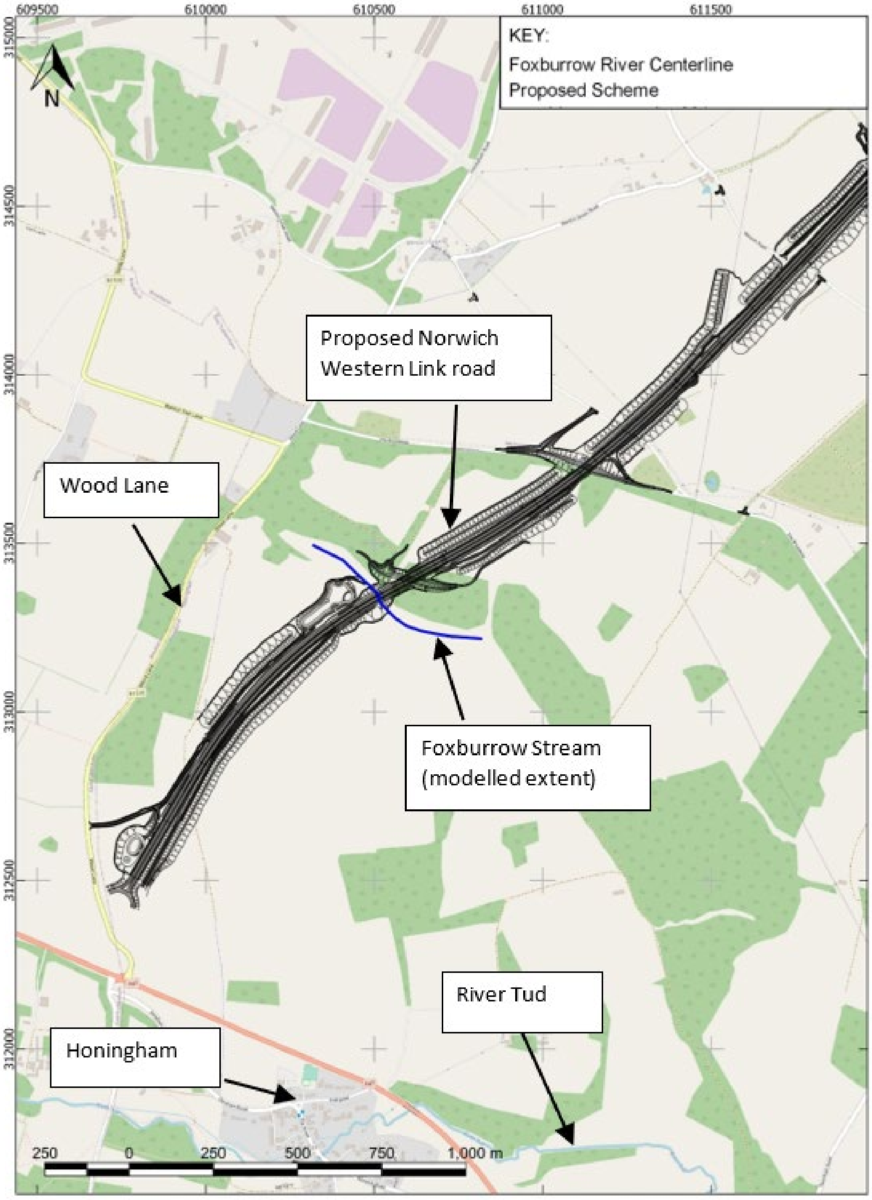
1.1 Project requirements

1.1.1 This modelling report forms an Appendix of the **Flood Risk Assessment** (Document Reference 3.12.02) and should be read in conjunction with the **Foxburrow Stream Technical Modelling Log** (Document Reference 3.12.02f) and **Foxburrow Stream FEH Calculation Record** (Document Reference 3.12.02g).

1.2 Site overview

1.2.1 The Proposed Scheme passes over a small unnamed tributary of the River Tud, hereafter referred to as ‘Foxburrow Stream.’ In order to assess the impacts of the Proposed Scheme on the existing flood risk and geomorphology of this watercourse, a hydraulic model has been developed. The extent of the hydraulic model, shown in **Figure 1-1**, incorporates the existing channel geometry and structures of this watercourse.

Figure 1-1 Site overview



1.3 Background data

Hydraulic modelling studies

1.3.1 There are no previous modelling studies of Foxburrow Stream.

Topographic data

WSP Cross Section Survey 2021

1.3.2 Cross section and structure survey of Foxburrow Stream was collected in April 2021. The survey consisted of 23 cross sections and dimensions of associated structures where present at the cross-section locations.

LIDAR data

1.3.3 LIDAR data for the study was downloaded from the UK Government's website in 2021. The data was flown in November 2017 and downloaded as a composite 1m resolution grid.

1.4 Gauge data

1.4.1 There are no flow gauges on the Foxburrow Stream watercourse.

Historical data

1.4.2 There is no historical flooding data for the study.

1.5 Approach to the study

1.5.1 Assessment of the available Environment Agency flood mapping and LIDAR data indicates that the floodplain of the Foxburrow Stream is narrow and well constrained. Therefore, it was considered that a 1D only model schematisation is appropriate as water on the floodplain is likely to remain in proximity to the channel and flow parallel to it. Flood Modeller Pro (FMP) software has been used for the model simulations.

1.5.2 Foxburrow Stream discharges to the River Tud approximately 1.5 kilometres downstream of the model extent. Based on the LIDAR information, which shows the River Tud floodplain at 21.4mAOD compared to the downstream cross section channel at 32.8mAOD, it has been concluded that the water level on the River Tud would not impact water levels in the area of interest.

2 Hydrological assessment

2.1 Overview

2.1.1 Full details of the hydrological assessment are provided in the **Foxburrow Stream FEH Calculation Record** (Document Reference 3.12.02g).

2.1.2 **Figure 2-1** shows the catchment for which design flows have been derived and **Table 2-1** and **Table 2-2** the design flows each inflow for the baseline and proposed scenario, respectively.

2.1.3 The statistical approach was the preferred method to derive the design flows up to the 1 in 100 year event. A risk based approach has been adopted for the larger events, the 1 in 100yr, 1 in 1000yr and climate change runs, to reflect the potential for the catchment response to change with significant rainfall.

2.1.4 As shown in **Figure 2-1** there is an existing overland flow path that joins the Foxburrow Stream immediately downstream of the Proposed Scheme (hereafter referred to as the Foxburrow Stream Tributary). The Foxburrow Stream Tributary accounts for approximately 21% of the overall catchment and this proportion of the flows shown in **Table 2-1** are applied in the location where this flow path joins Foxburrow Stream. Following the implementation of the Proposed Scheme runoff from the upper reaches of the Foxburrow Stream Tributary (Catchments 1a and 1b) will be diverted along the western face of the Proposed Scheme to be discharged into Foxburrow Stream upstream of the proposed culvert. This will be joined by some small additional catchments to the east of Foxburrow Stream (Catchments 3 and 4) which are part of a catchment that joins Foxburrow Stream just downstream of the model extent. For this reason, flows in the model in the proposed scenario are slightly larger than in the baseline scenario. In the proposed scenario the runoff from the Foxburrow Stream Tributary where it joins downstream of the Proposed Scheme are reduced to reflect the diversion of the upstream half of the catchment.

Figure 2-1 Overview of contributing catchment

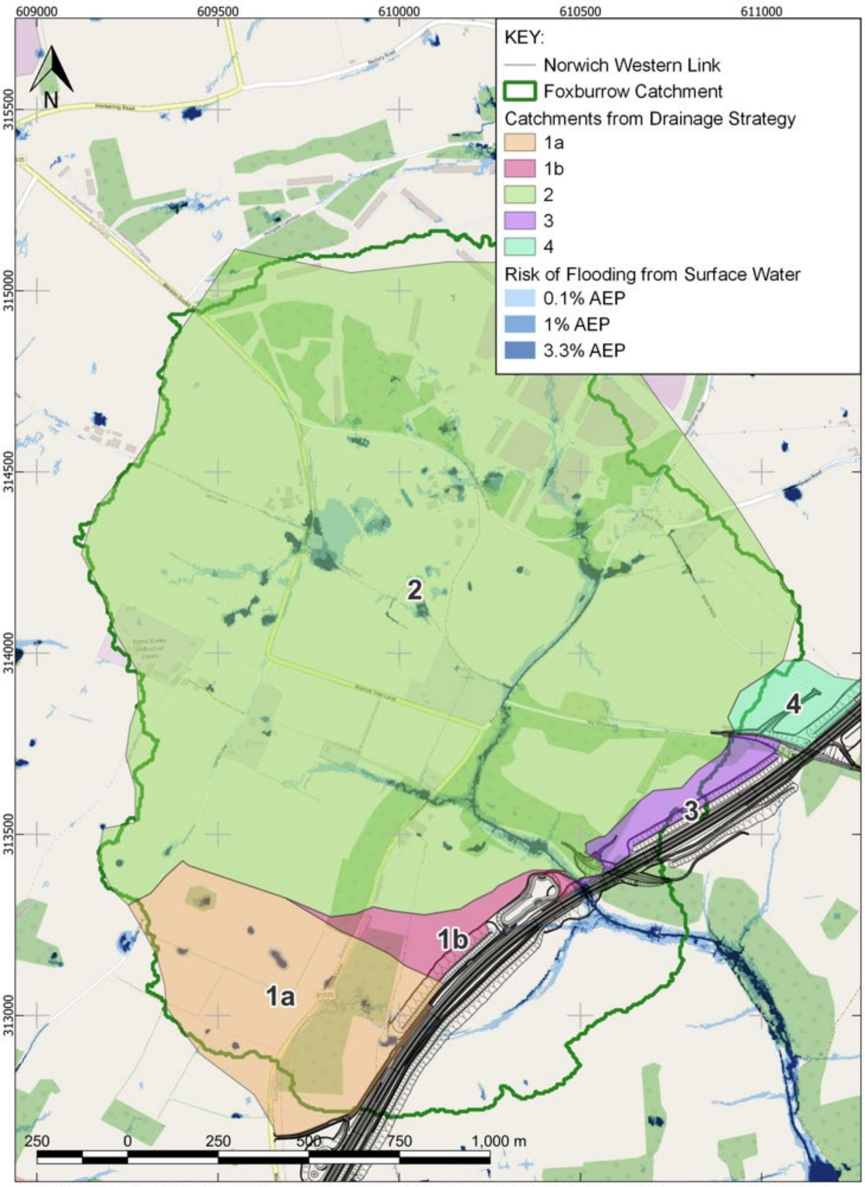


Table 2-1 Design flows for each catchment in the baseline scenario

Return Period (in years)	Original from FEH Calculation (m^3/s)	Upstream Catchment (m^3/s)	Central PED Catchment (m^3/s)	Foxburrow Stream Tributary Catchment (m^3/s)
2	0.24	0.19	0.00	0.05
5	0.24	0.19	0.00	0.05
10	0.34	0.26	0.01	0.07
20	0.42	0.33	0.01	0.09
30	0.51	0.40	0.01	0.11
50	0.57	0.44	0.01	0.12
75	0.66	0.51	0.01	0.14
100	1.02	0.79	0.02	0.21
200	1.23	0.96	0.02	0.25
1000	1.9	1.48	0.04	0.39
100+45%	1.48	1.15	0.03	0.30

Table 2-2 Design flows for each catchment in the proposed scenario

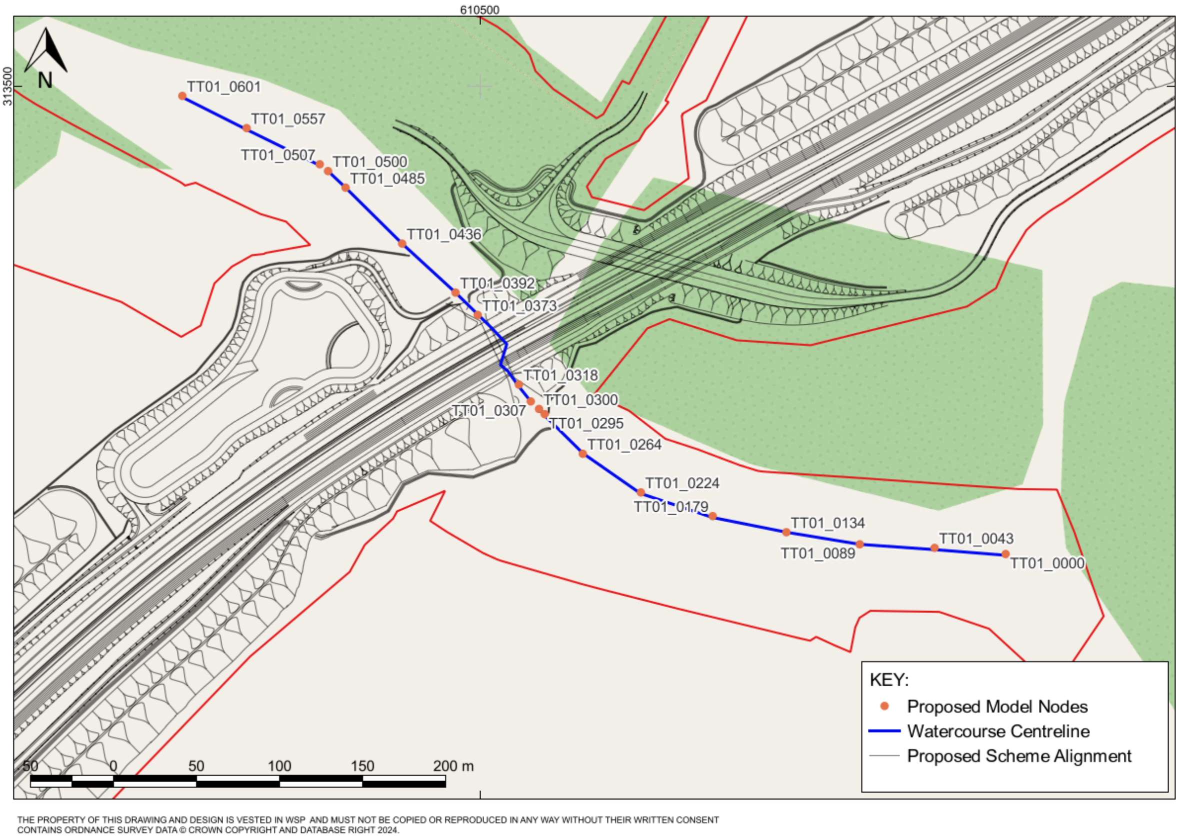
Return Period (in years)	Original from FEH Calculation (m^3/s)	Upstream Catchment (m^3/s)	Central PED Catchment (m^3/s)	Foxburrow Stream Tributary Catchment (m^3/s)
2	0.24	0.19	0.02	0.06
5	0.24	0.19	0.02	0.06
10	0.34	0.26	0.02	0.16
20	0.42	0.33	0.03	0.24
30	0.51	0.40	0.03	0.33
50	0.57	0.44	0.04	0.39
75	0.66	0.51	0.04	0.48

Return Period (in years)	Original from FEH Calculation (m^3/s)	Upstream Catchment (m^3/s)	Central PED Catchment (m^3/s)	Foxburrow Stream Tributary Catchment (m^3/s)
100	1.02	0.79	0.07	0.84
200	1.23	0.96	0.08	1.05
1000	1.9	1.48	0.13	1.72
100+45%	1.48	1.15	0.10	1.22

3 Hydraulic modelling

3.1.1 A 1D only model of the Foxburrow Stream has been constructed. The extent of the modelled area and the proposed model nodes are shown in **Figure 3-1**. The nodes at the upstream and downstream face of the proposed culvert are TT_0373 and TT01_0318.

Figure 3-1 Overview of model extent and node locations



3.1.2 Full details of the hydraulic model construction and associated parameters are provided in the **Foxburrow Stream Technical Modelling Log** (Document Reference 3.12.02f).

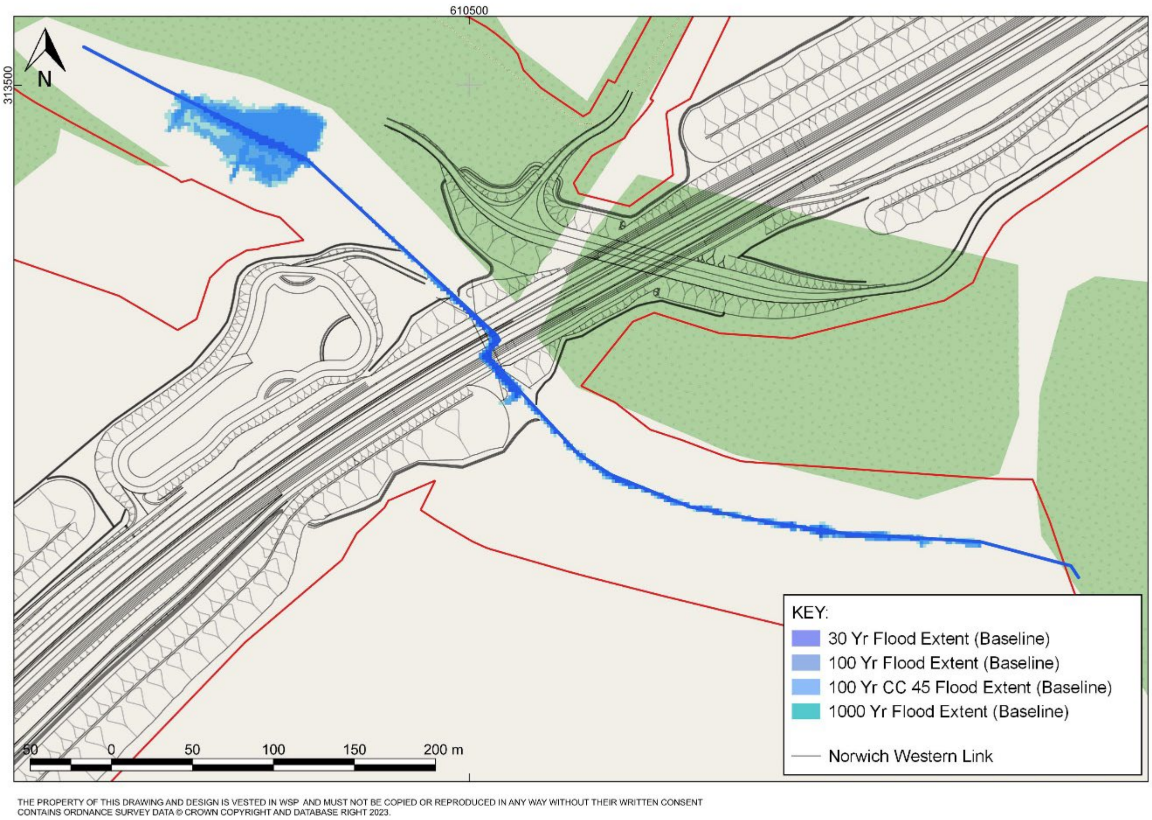
3.2 Model calibration

3.2.1 There is no calibration data available for the study.

3.3 Baseline flood risk and extents

3.3.1 Baseline flood levels, representative of the existing condition, have been derived for the 1 in 30, 1 in 100, 1 in 1000 and 100yr plus 45% climate change annual probability events and are presented in **Figure 3-2**.

Figure 3-2 Baseline flood extent for Foxburrow Stream for the 1 in 30, 1 in 100, 1 in 1000 and 1 in 100 plus 45% annual probability events



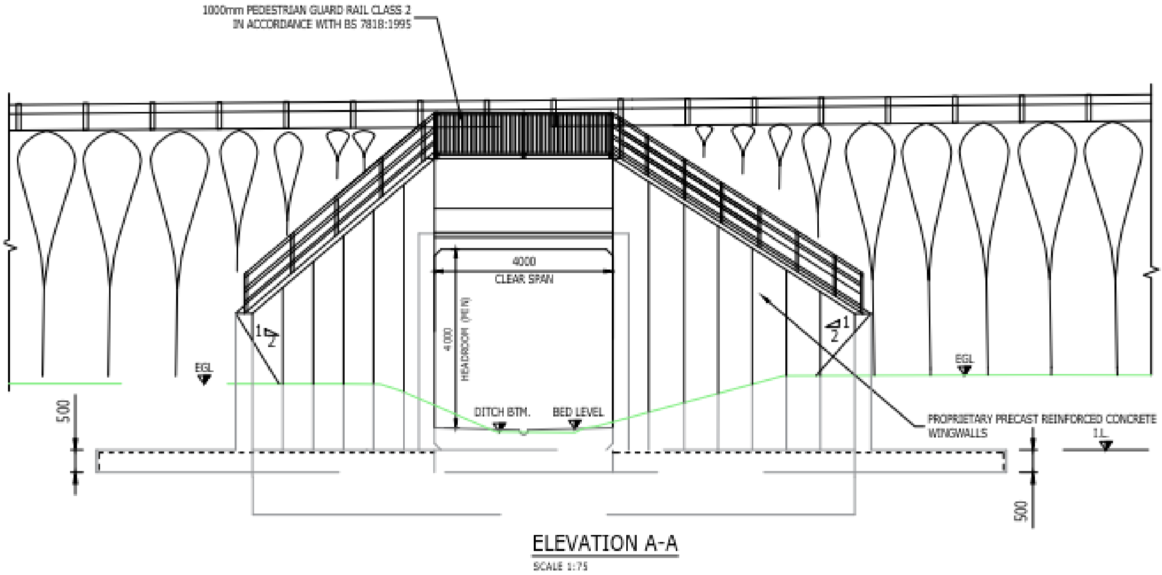
3.4 Scheme proposals

3.4.1 A design drawing of the proposed Scheme in the vicinity of Foxburrow Stream is provided in **Figure 3-3**. The Scheme in this area consists of the following elements:

- A 4m wide by 4.5m high rectangular concrete culvert with a length of 50m to convey the Foxburrow Stream beneath the NWL road. The culvert will have 500mm bed material in the base reducing the hydraulic height to 4m.
- The NWL road and associated embankment, which has a road level of approximately 42.0mAOD.

- Environmental enhancements including riparian planting upstream and downstream of the Proposed Scheme and the remove of an existing field culvert located at the downstream face of the proposed culvert.

Figure 3-3 Proposed scheme comprising culvert to convey the Foxburrow Stream



3.5 Proposed flood risk and extents

3.5.1 Post-development flood levels, representative of the condition following construction have been derived for the 1 in 30, 1 in 100, 1 in 1000 and 100 plus 45% climate change annual probability events and are presented in **Figure 3-4**.

3.5.2 The impacts of the Proposed Scheme compared to the existing baseline are discussed in in the **Flood Risk Assessment** (Document Reference 3.12.02). A comparison of the baseline and proposed flood extents for the 1 in 30, 1 in 100, 1 in 1000 and 100yr plus 45% climate change annual probability events is presented in **Figure 3-5** to **Figure 3-8** and extracted water levels and velocities are presented in **Table 3-1** to **Table 3-4**. The nodes at the upstream and downstream face of the proposed culvert are TT_0373 and TT01_0318.

3.5.3 The existing bend in the watercourse beneath the Proposed Scheme is shown in the post development flood maps a result of the mapping process relying on LIDAR data. This bend is not in the model and water levels upstream and downstream of the Proposed Scheme reflect the presence of a culvert with reduced overall length compared to the existing watercourse in this location.

Figure 3-4 Proposed flood extent for Foxburrow Stream for the 1 in 30, 1 in 100, 1 in 1000 and 1 in 100 plus 45% annual probability events

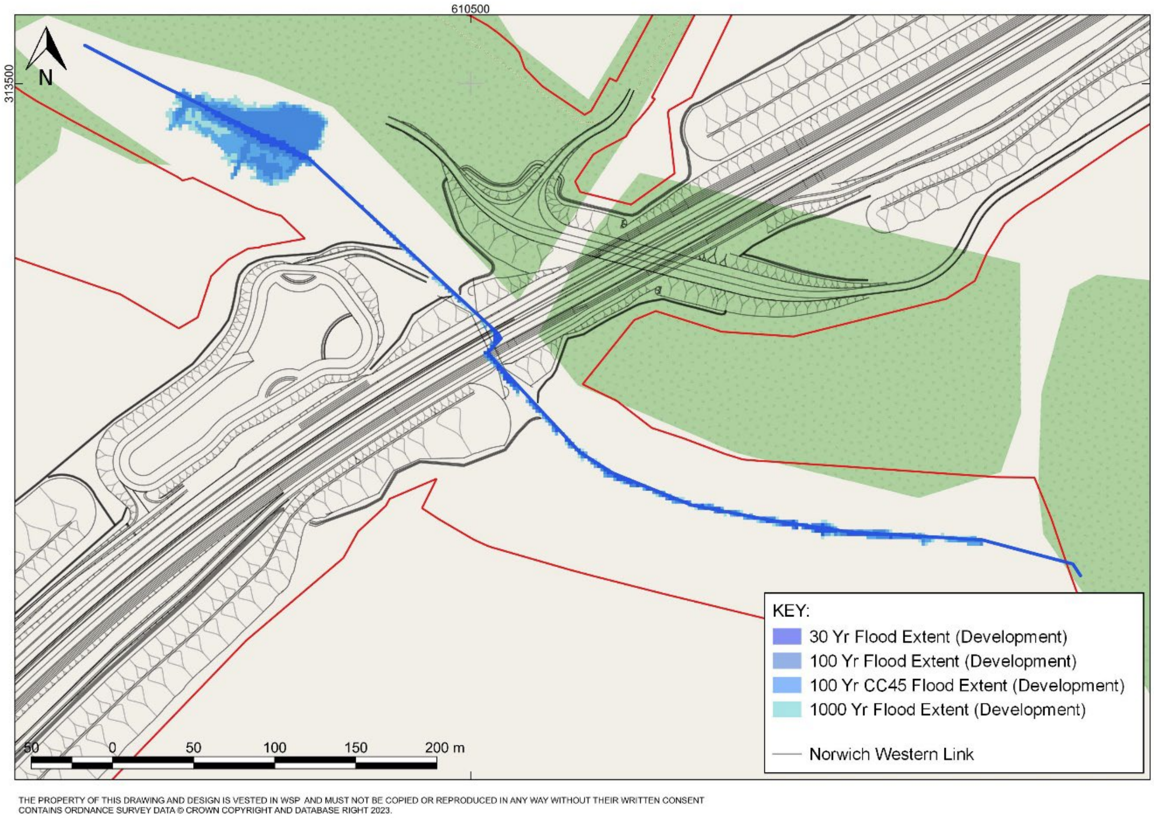


Figure 3-5 Flood extent comparison for 1 in 30 annual probability event (Baseline vs Development)

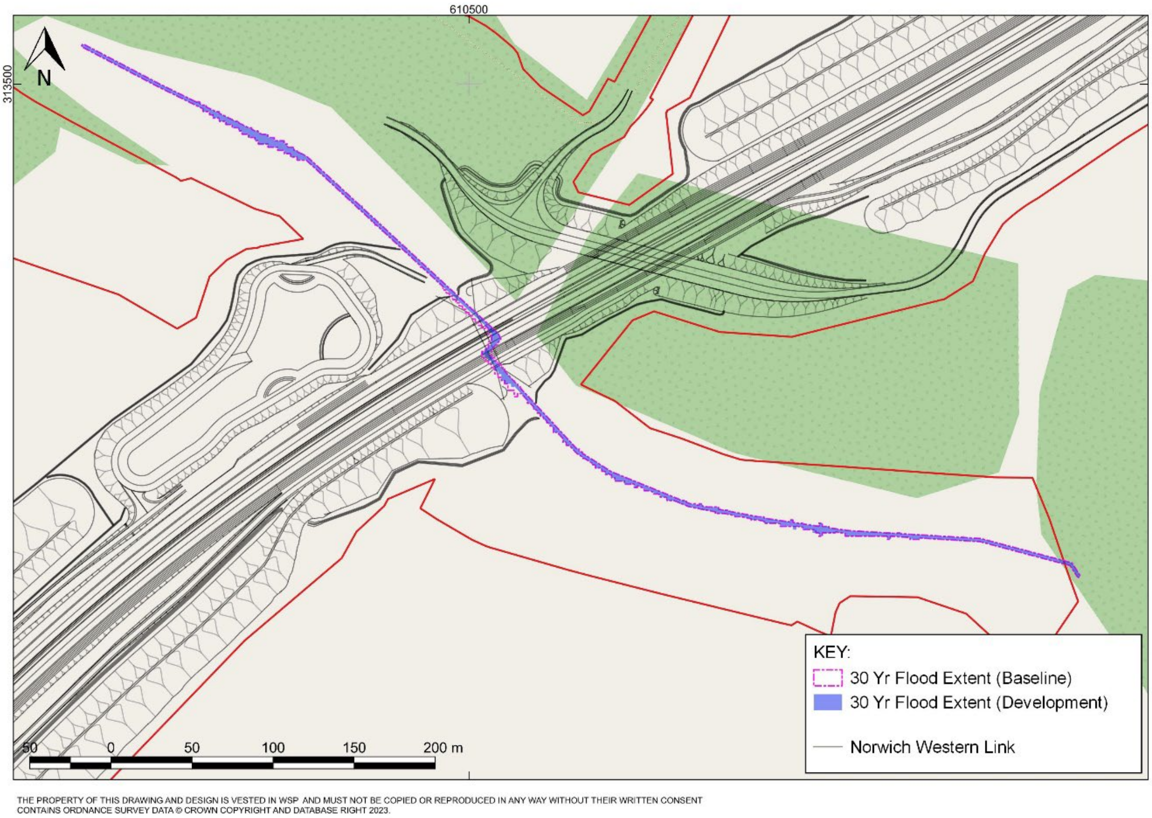


Figure 3-6 Flood extent comparison for 1 in 100 annual probability event (Baseline vs Development)

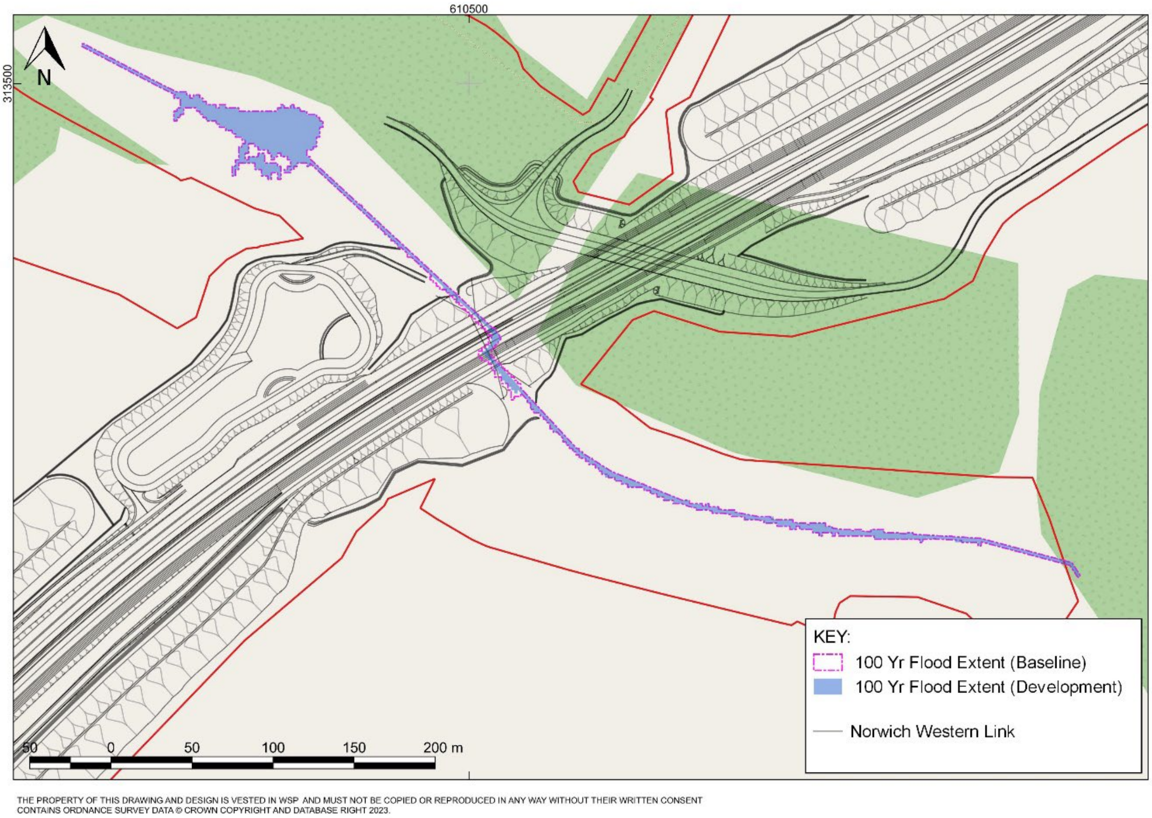


Figure 3-7 Flood extent comparison for 1 in 100 plus 45% climate change annual probability events (Baseline vs Development)

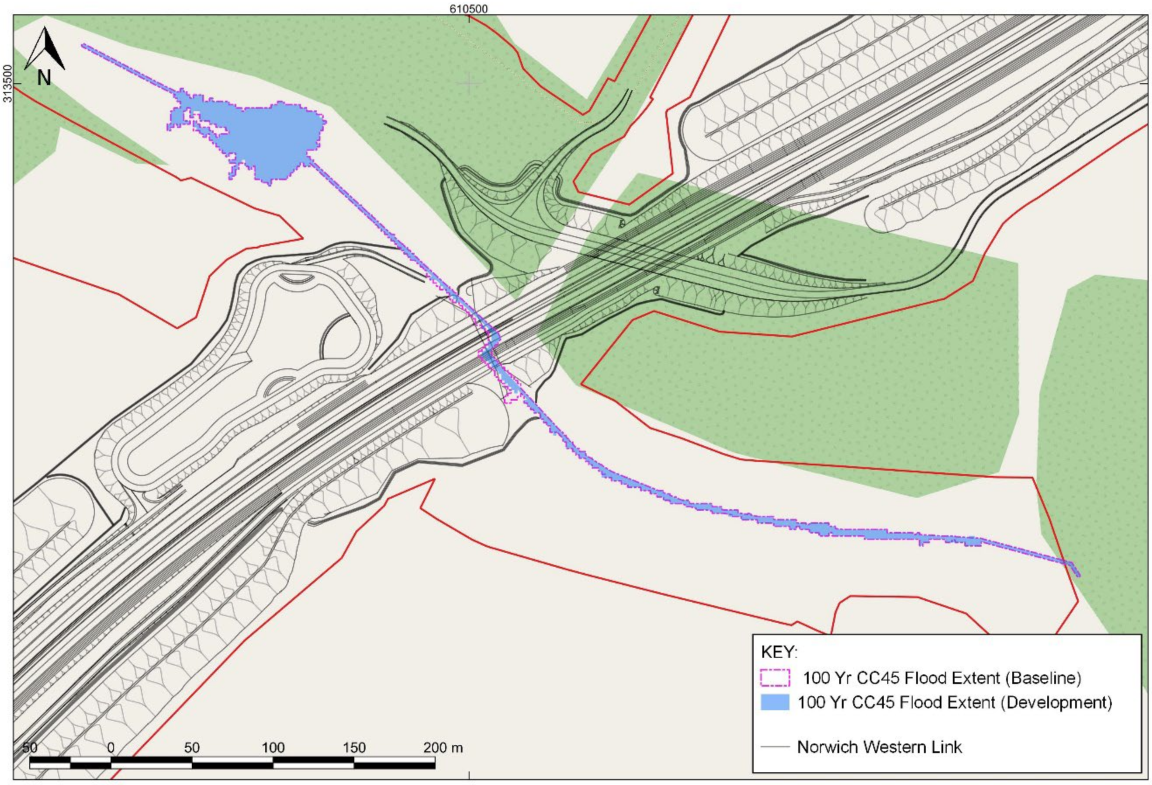


Figure 3-8 Flood extent comparison for 1 in 1000 annual probability event (Baseline vs Development)

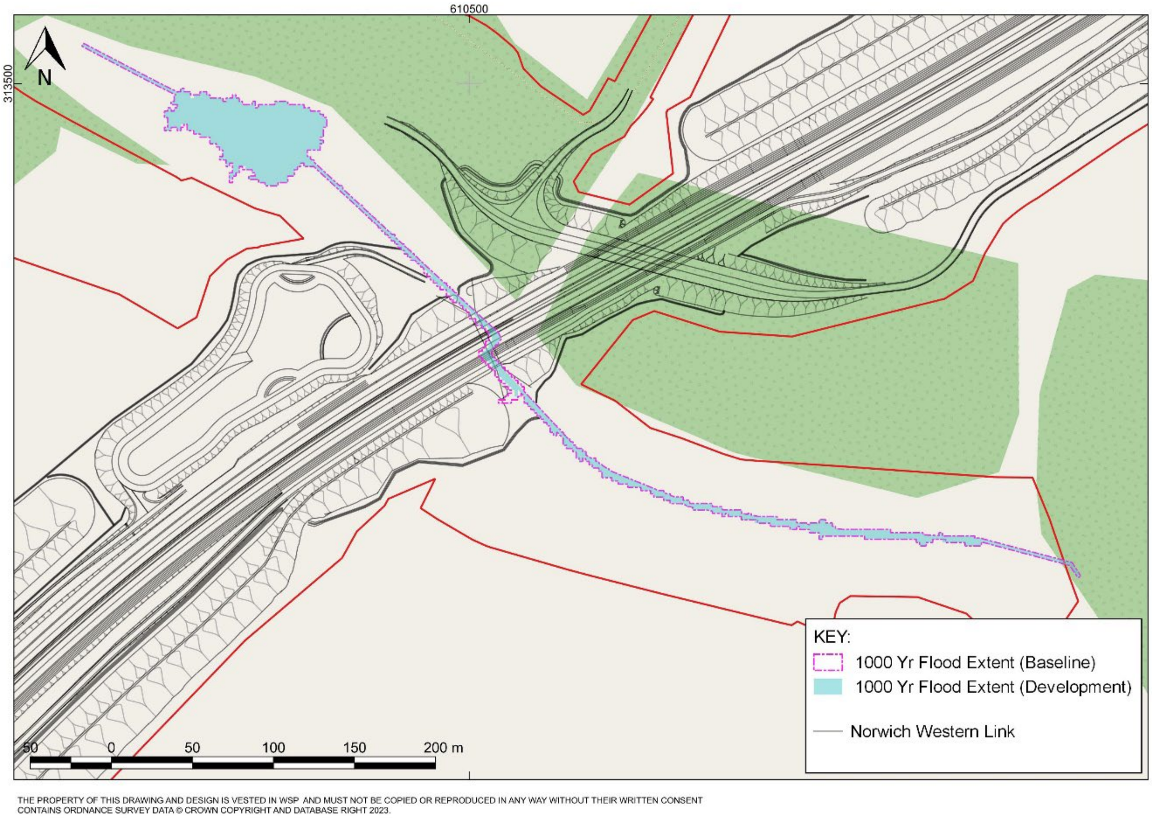


Table 3-1 – Baseline peak water levels (m AOD) for annual probability events

Cross Section	1 in 30	1 in 100	1 in 1000	1 in 30+45%	1 in 100+45%
TT01_0601	37.67	38.17	38.33	38.03	38.27
TT01_0579i	37.56	38.17	38.33	38.03	38.27
TT01_0557	37.53	38.16	38.33	38.03	38.27
TT01_0533i	37.52	38.16	38.32	38.02	38.27
TT01_0507	37.51	38.16	38.31	38.02	38.26
TT01_0507CuI	37.51	38.16	38.31	38.02	38.26
TT01_0507Cu	37.28	37.86	38.06	37.70	38.00
TT01_0507Cd	37.11	37.48	37.65	37.36	37.59
TT01_0507CdO	36.98	37.14	37.30	37.06	37.23

Cross Section	1 in 30	1 in 100	1 in 1000	1 in 30+45%	1 in 100+45%
TT01_0507Su	37.51	38.16	38.31	38.02	38.26
TT01_0507Sd	36.98	37.14	37.30	37.06	37.23
TT01_0500	36.98	37.14	37.30	37.06	37.23
TT01_0485	36.63	36.74	36.88	36.69	36.83
TT01_0436u	36.12	36.22	36.35	36.16	36.29
TT01_0436d	36.12	36.22	36.35	36.16	36.29
TT01_0402i	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0392	35.82	36.00	36.11	35.94	36.06
TT01_0373 (US Scheme)	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0373Su	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0318Sd	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0373CuI	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0373Cu	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0318Cd	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0318CdO	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0318 (DS Scheme)	35.72	35.94	36.01	35.89	35.98
TT01_0307	35.72	35.93	36.01	35.88	35.98
TT01_0300	35.12	35.23	35.35	35.17	35.29
TT01_0295	35.04	35.16	35.29	35.10	35.23
TT01_0264u	34.72	34.86	35.04	34.79	34.96

Cross Section	1 in 30	1 in 100	1 in 1000	1 in 30+45%	1 in 100+45%
TT01_0264d	34.72	34.86	35.04	34.79	34.96
TT01_0224	34.47	34.60	34.77	34.53	34.69
TT01_0179	34.20	34.34	34.52	34.27	34.44
TT01_0134	33.94	34.10	34.28	34.02	34.20
TT01_0089	33.72	33.86	34.04	33.79	33.96
TT01_0043	33.49	33.63	33.81	33.56	33.73
TT01_0000	33.22	33.38	33.56	33.30	33.48

Table 3-2 – Proposed peak water levels (m AOD) for annual probability events

Cross Section	1 in 30	1 in 100	1 in 1000	1 in 30+45%	1 in 100+45%
TT01_0601	37.67	38.17	38.33	38.03	38.27
TT01_0579i	37.56	38.17	38.33	38.03	38.27
TT01_0557	37.53	38.16	38.32	38.02	38.27
TT01_0533i	37.52	38.16	38.32	38.02	38.26
TT01_0507	37.51	38.16	38.31	38.02	38.26
TT01_0507CuI	37.51	38.16	38.31	38.02	38.26
TT01_0507Cu	37.28	37.86	38.06	37.70	38.00
TT01_0507Cd	37.11	37.48	37.65	37.36	37.59
TT01_0507CdO	36.98	37.13	37.30	37.06	37.23
TT01_0507Su	37.51	38.16	38.31	38.02	38.26
TT01_0507Sd	36.98	37.13	37.30	37.06	37.23
TT01_0500	36.98	37.13	37.30	37.06	37.23
TT01_0485	36.62	36.73	36.87	36.68	36.81
TT01_0436u	36.14	36.26	36.41	36.20	36.34
TT01_0436d	36.14	36.26	36.41	36.20	36.34
TT01_0402i	35.95	36.04	36.14	35.99	36.10

Cross Section	1 in 30	1 in 100	1 in 1000	1 in 30+45%	1 in 100+45%
TT01_0392	35.73	35.83	35.94	35.78	35.89
TT01_0373 (US Scheme)	35.44	35.53	35.68	35.51	35.61
TT01_0373Su	35.44	35.53	35.68	35.51	35.61
TT01_0318Sd	35.39	35.45	35.57	35.45	35.50
TT01_0373CuI	35.44	35.53	35.68	35.51	35.61
TT01_0373Cu	35.44	35.52	35.66	35.50	35.60
TT01_0318Cd	35.39	35.46	35.59	35.46	35.52
TT01_0318CdO	35.39	35.45	35.57	35.45	35.50
TT01_0318 (DS Scheme)	35.39	35.45	35.57	35.45	35.50
TT01_0307	35.13	35.27	35.40	35.26	35.34
TT01_0300	35.13	35.23	35.36	35.22	35.30
TT01_0295	35.05	35.16	35.30	35.14	35.24
TT01_0264u	34.72	34.87	35.05	34.82	34.97
TT01_0264d	34.72	34.87	35.05	34.82	34.97
TT01_0224	34.47	34.61	34.78	34.56	34.70
TT01_0179	34.21	34.34	34.52	34.29	34.44
TT01_0134	33.95	34.10	34.29	34.04	34.21
TT01_0089	33.73	33.87	34.04	33.81	33.97
TT01_0043	33.49	33.64	33.82	33.57	33.74
TT01_0000	33.23	33.38	33.57	33.32	33.49

Table 3-3 – Baseline peak velocities (m/s) for annual probability events

Cross Section	1 in 30	1 in 100	1 in 1000	1 in 30+45%	1 in 100+45%
TT01_0601	0.59	0.60	0.60	0.59	0.60

Cross Section	**1 in 30**	**1 in 100**	**1 in 1000**	**1 in 30+45%**	**1 in 100+45%**
TT01_0579i	0.52	0.53	0.53	0.52	0.53
TT01_0557	0.40	0.40	0.40	0.40	0.40
TT01_0533i	0.30	0.30	0.30	0.30	0.30
TT01_0507	0.26	0.26	0.26	0.26	0.26
TT01_0507CuI	0.22	0.22	0.22	0.22	0.22
TT01_0507Cu	2.02	3.00	3.16	2.82	3.13
TT01_0507Cd	2.00	2.97	3.12	2.79	3.10
TT01_0507CdO	0.22	0.22	0.22	0.22	0.22
TT01_0507Su	0.22	0.22	0.22	0.22	0.22
TT01_0507Sd	0.22	0.22	0.22	0.22	0.22
TT01_0500	1.24	1.46	1.69	1.34	1.60
TT01_0485	0.77	1.01	1.27	0.87	1.15
TT01_0436u	0.63	0.80	0.99	0.72	0.91
TT01_0436d	0.64	0.82	1.01	0.74	0.93
TT01_0402i	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0392	0.64	0.65	0.81	0.65	0.71
TT01_0373 (US Scheme)	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0373Su	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0318Sd	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0373CuI	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0373Cu	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

Cross Section	1 in 30	1 in 100	1 in 1000	1 in 30+45%	1 in 100+45%
TT01_0318Cd	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0318CdO	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TT01_0318 (DS Scheme)	0.21	0.21	0.24	0.21	0.21
TT01_0307	0.46	0.46	0.46	0.46	0.46
TT01_0300	0.73	0.94	1.17	0.83	1.08
TT01_0295	0.74	0.89	1.06	0.82	0.99
TT01_0264u	0.56	0.68	0.80	0.62	0.75
TT01_0264d	0.70	0.86	1.00	0.78	0.94
TT01_0224	0.54	0.73	0.91	0.63	0.84
TT01_0179	0.60	0.72	0.84	0.66	0.79
TT01_0134	0.56	0.72	0.87	0.64	0.81
TT01_0089	0.58	0.76	0.93	0.67	0.86
TT01_0043	0.53	0.67	0.83	0.60	0.76
TT01_0000	0.67	0.81	0.96	0.74	0.90

Table 3-4 – Proposed peak velocities (m/s) for annual probability events

Cross Section	1 in 30	1 in 100	1 in 1000	1 in 30+45%	1 in 100+45%
TT01_0601	0.59	0.60	0.60	0.59	0.60
TT01_0579i	0.52	0.53	0.53	0.52	0.53
TT01_0557	0.40	0.40	0.40	0.40	0.40
TT01_0533i	0.30	0.30	0.30	0.30	0.30
TT01_0507	0.26	0.26	0.26	0.26	0.26
TT01_0507CuI	0.22	0.22	0.22	0.22	0.22

Cross Section	1 in 30	1 in 100	1 in 1000	1 in 30+45%	1 in 100+45%
TT01_0507Cu	2.02	3.00	3.14	2.82	3.13
TT01_0507Cd	2.00	2.97	3.11	2.79	3.09
TT01_0507CdO	0.22	0.22	0.22	0.22	0.22
TT01_0507Su	0.22	0.22	0.22	0.22	0.22
TT01_0507Sd	0.22	0.22	0.22	0.22	0.22
TT01_0500	1.22	1.45	1.68	1.33	1.58
TT01_0485	0.80	1.04	1.31	0.92	1.19
TT01_0436u	0.55	0.70	0.85	0.63	0.79
TT01_0436d	0.60	0.76	0.93	0.68	0.86
TT01_0402i	0.48	0.68	0.96	0.59	0.84
TT01_0392	0.96	1.17	1.39	1.09	1.30
TT01_0373 (US Scheme)	0.36	0.55	0.70	0.47	0.64
TT01_0373Su	0.44	0.44	0.44	0.44	0.44
TT01_0318Sd	0.44	0.44	0.44	0.44	0.44
TT01_0373CuI	0.44	0.44	0.44	0.44	0.44
TT01_0373Cu	0.44	0.65	0.84	0.56	0.76
TT01_0318Cd	0.19	0.36	0.54	0.33	0.46
TT01_0318CdO	0.44	0.44	0.44	0.44	0.44
TT01_0318 (DS Scheme)	0.25	0.46	0.62	0.43	0.56
TT01_0307	1.21	1.39	1.43	1.39	1.39
TT01_0300	0.75	0.95	1.19	0.94	1.10
TT01_0295	0.75	0.91	1.07	0.91	1.01
TT01_0264u	0.58	0.73	0.83	0.72	0.78
TT01_0264d	0.71	0.86	1.01	0.86	0.95

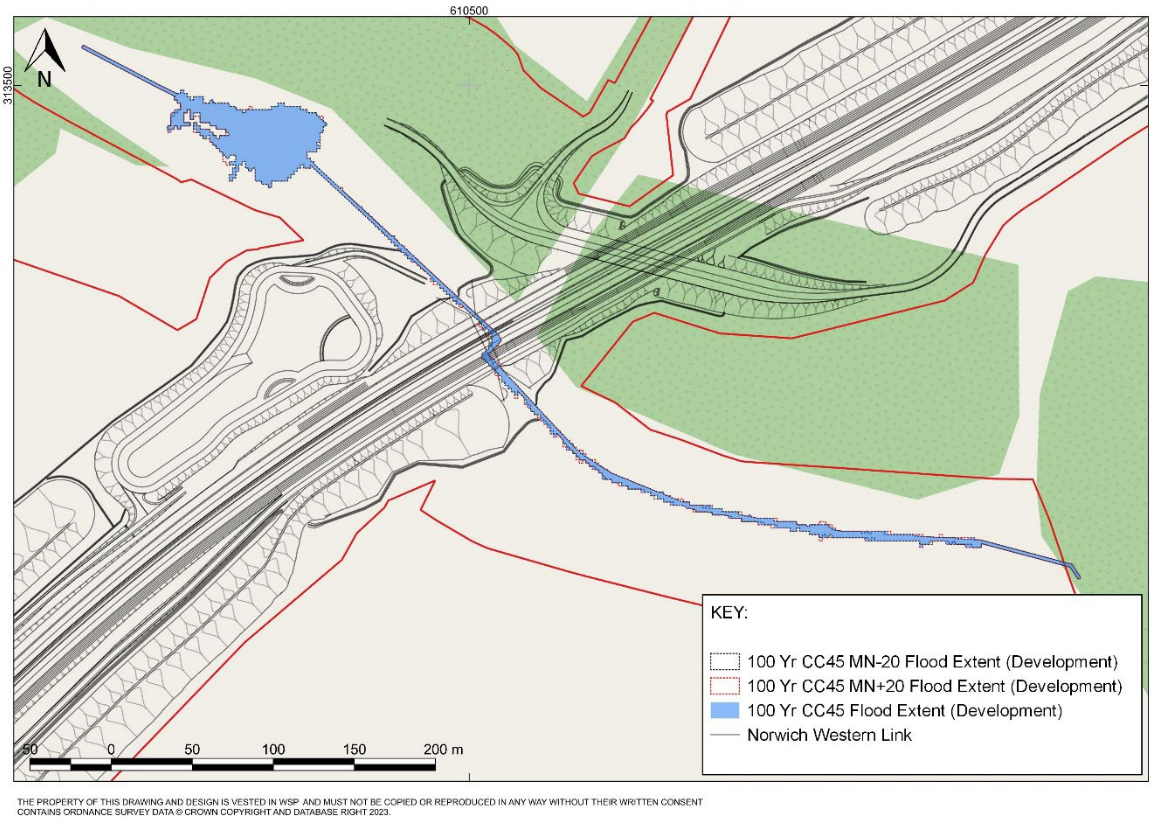
Cross Section	1 in 30	1 in 100	1 in 1000	1 in 30+45%	1 in 100+45%
TT01_0224	0.55	0.73	0.92	0.68	0.84
TT01_0179	0.61	0.72	0.85	0.70	0.79
TT01_0134	0.57	0.72	0.87	0.68	0.81
TT01_0089	0.59	0.76	0.94	0.71	0.86
TT01_0043	0.54	0.68	0.83	0.63	0.77
TT01_0000	0.68	0.81	0.97	0.76	0.90

3.6 Sensitivity analysis

3.6.1 Sensitivity analysis was carried out to test the sensitivity to Manning's roughness, flow change and downstream boundary assumptions for the proposed development for the 100 year plus 45% climate change annual probability event. No blockage sensitivity testing has been undertaken for the proposed culvert given its significant size in relation to the watercourse.

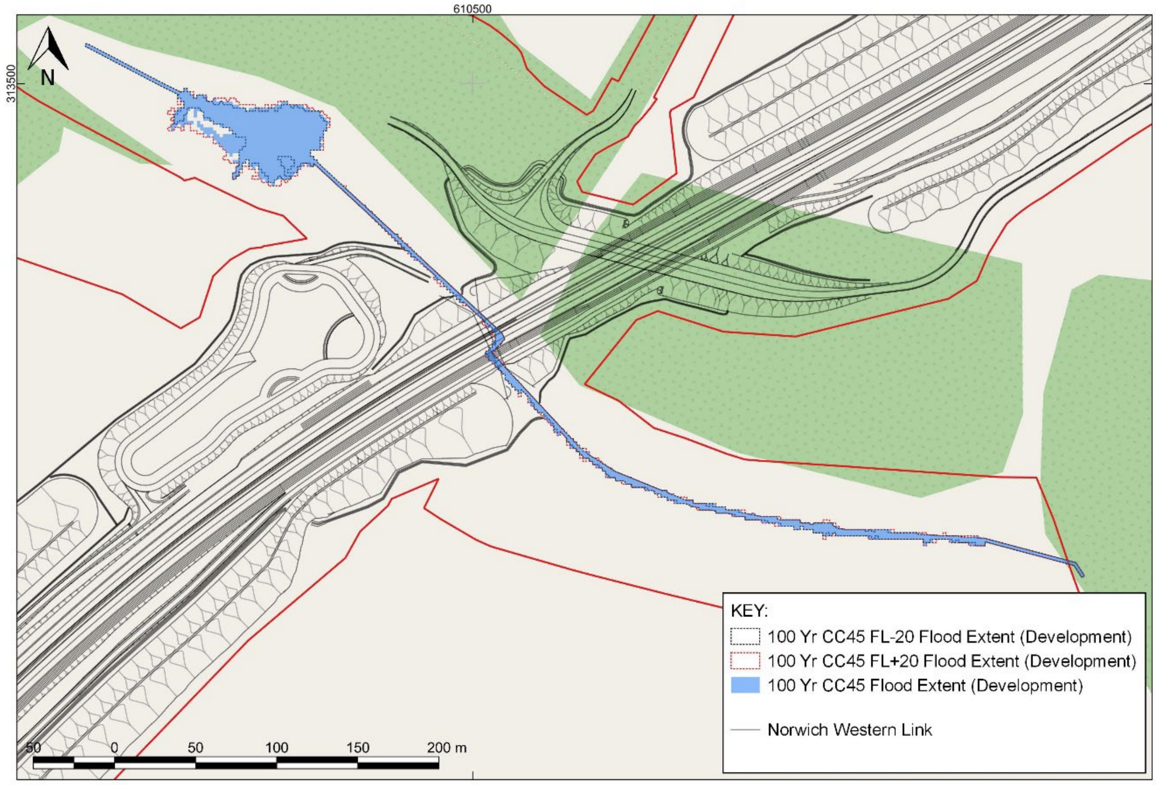
3.6.2 **Figure 3-9** presented the changes in flood extents associated with increases and decreases in Manning's n roughness values of 20%. The results remain consistent with the baseline for the two sensitivity test results.

Figure 3-9 Proposed flood extent sensitive to manning's roughness for 1 in 100 year plus 45% climate change annual probability event



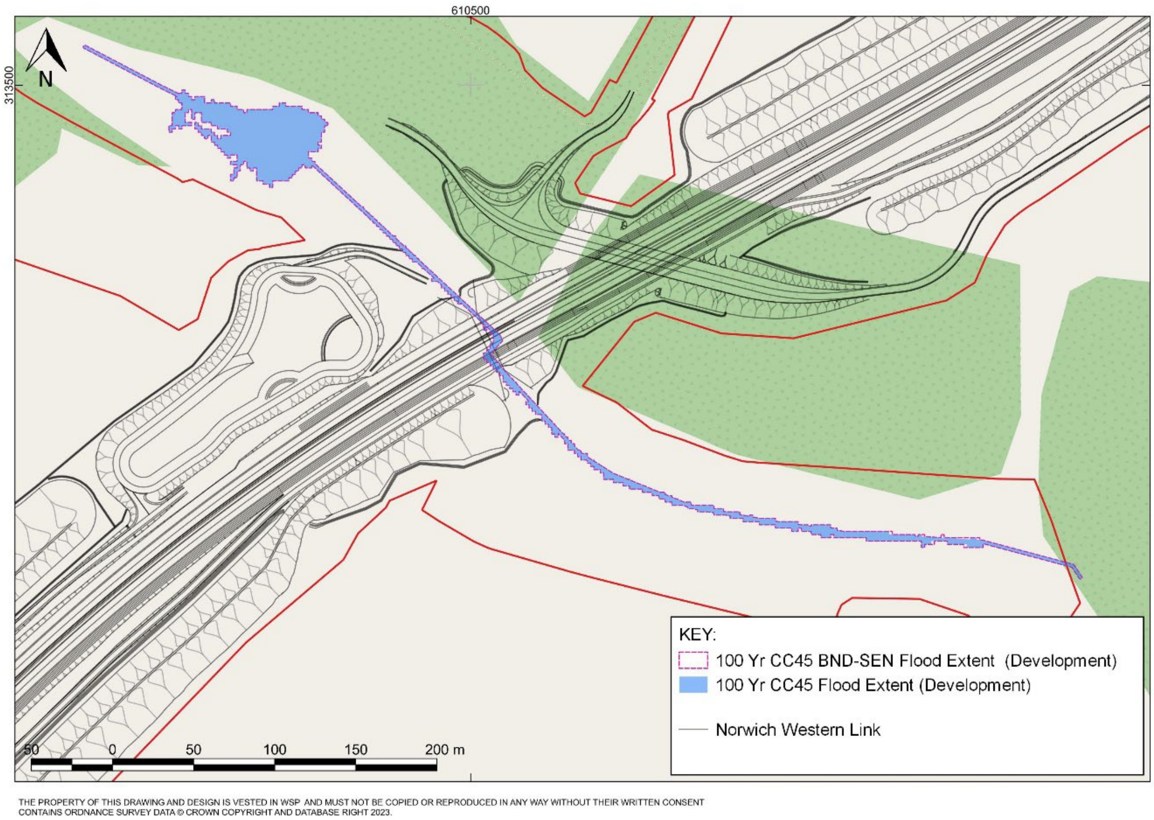
3.6.3 **Figure 3-10** presents the changes in flood risk extents associated with increases and decreases in flows of 20%. The result shows some small increases in the flood extent in the upstream areas of floodplain, but these are not of note given that there is an increase in flows. Of more relevance is the fact that even with a 20% increase in flows, there is little change in flood extent in the vicinity of the scheme.

Figure 3-10 Proposed flood extent sensitive to Flow for 1 in 100 year plus 45% climate change annual probability event



3.6.4 **Figure 3-11** presents the changes in flood risk extents associated with a reduction in the downstream channel gradient of 50%. The result shows some small increases in the flood extent within 130m of the downstream limit of the model.

Figure 3-11 Proposed flood extent sensitive to boundary at 50% slope for 1 in 100 year plus 45% climate change annual probability event



3.6.5 The findings of the sensitivity assessment suggest there is little uncertainty in the assessment of water levels and in particular the impacts of the Proposed Scheme on water levels along Foxburrow Stream.