

Fenstanton, Cambridgeshire
Flood Risk Investigation

14/11/2022
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RESILIENCE & FLOOD RISK

Fenstanton
14/11/2022
Version 2.0

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1.0 Introduction

Fenstanton is a village located in Cambridgeshire approximately 2 miles south of St Ives. The River Ouse is to the north with the main river West Brook/Hall Green Brook located to the west of the village. The newly built A14 is to the south of Fenstanton. The A14 work started in November 2016 with the project officially opening in May 2020.

In response to a flooding event that occurred in December 2020, we were engaged by Fenstanton Parish Council to undertake a Flood Risk Investigation to assess the potential flooding mechanisms.

The aim of this report is to assess potential sources of flooding, investigate historical flooding relevant to the site area, identify the flooding mechanism and whether the new A14 could have contributed to the flooding.

The report is structured based on the following objectives, set out to meet the aim:

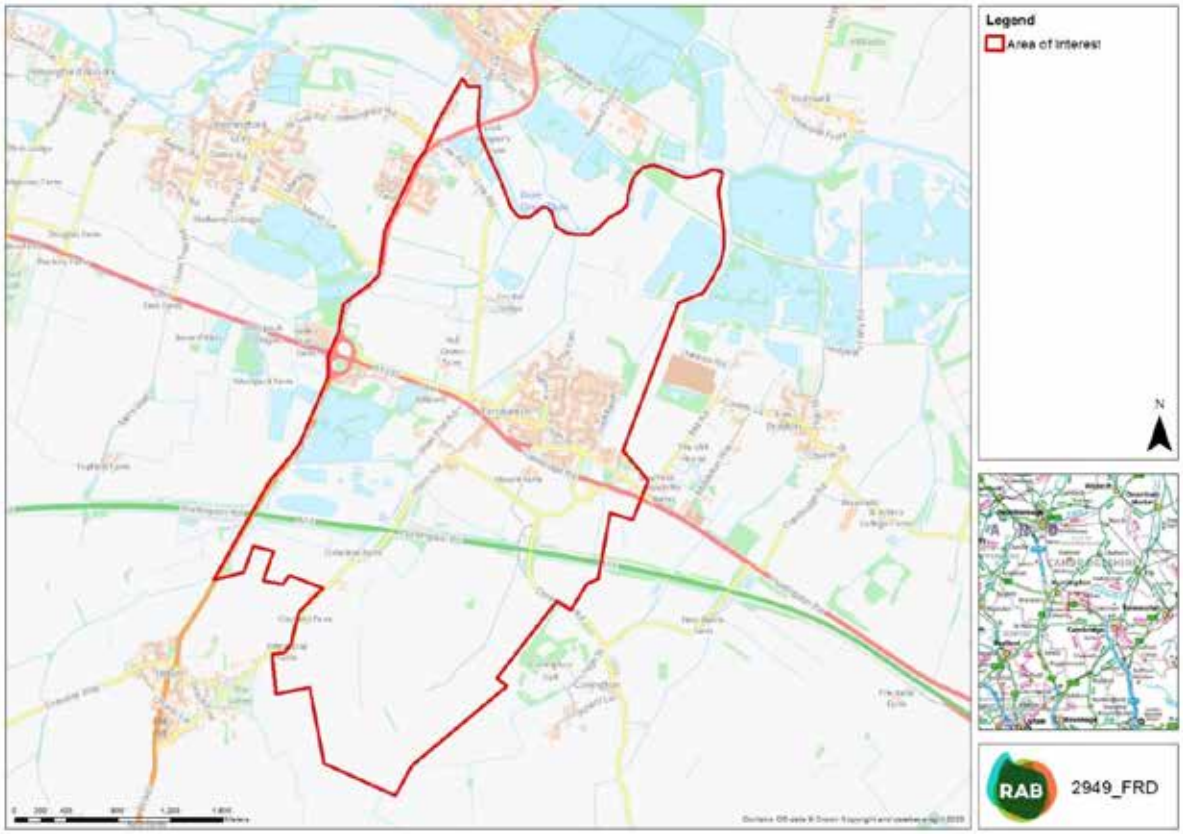
- Identification of the local area and site characteristics based on findings from a photographic survey and visual inspection.
- Assessment of all sources of flooding to the site.
- Investigation of December 2020 weather patterns and how they might explain the flooding occurrences at site level.
- Analysis of all data and assessment of the flooding mechanism at site level.
- Discussion on A14 impact on the flooding.

2.0 Site details

2.1 Site location

TABLE 1: SITE LOCATION

Site address:	Fenstanton, Cambridgeshire
Site area:	Approximately 1040 ha
Local Planning Authority:	Huntingdonshire District Council



2.2 Site visit

We undertook a site visit on the 14th of June 2022 which included a photographic survey.

Different areas of Fenstanton were visited where flooding had reportedly occurred during the December 2020 flood event. West Brook runs along the east of the B1040 under the A14 before it heads around the new balancing ponds towards West End Road. West Brook then runs along the east of West End Road before going into a culvert under the A1307 and Huntingdon Road.

Firstly, the new A14 and balancing ponds were observed (Figure 1 & Figure 2) from the B1040. This area is surrounded by farmland with West Brook adjacent to the bridge. A section of West Brook was walked which showed the realigned section to the north of the A14 (Figure 4). It was noted that this section appears to be narrower compared to the original section (upstream) of West Brook, as shown in Figure 3.

Hilton Road was then visited, which is surrounded by greenfield land to the south of the road with residential to the north. West Brook is located approximately 170m west of Hilton Road and we were informed that Hilton Road flooded in the December 2020 event, with water nearly reaching Pear Tree Close.

Lastly, West End Road was visited, which was surrounded by greenfield land with West Brook to the east side of the road. Fenstanton Bowls Club was located to the north of the road (Figure 5) and reportedly flooded during the December 2020 event although, as shown in Figure 7, it is located within Flood Zone 3. West Brook runs adjacent to the Bowls Club before going into a culvert under the A1307 and Huntingdon Road. According to the Parish Council several properties received internal flooding including the property in Figure 6, which have now constructed a bund to protect it.



FIGURE 1: ON BRIDGE OVER A14 LOOKING NORTH



FIGURE 2: ON BRIDGE OVER A14 LOOKING EAST



FIGURE 3: ORIGINAL SECTION OF WEST BROOK (UPSTREAM)



FIGURE 4: REALIGNED WEST BROOK



FIGURE 5: AREA OF FENSTANTON BOWLS CLUB



FIGURE 6: INTERNAL FLOODING IN THE PICTURE PROPERTY

3.0 Sources

3.1 Fluvial (Rivers)

According to the Environment Agency's Flood Map for Planning, Fenstanton lies in Flood Zone 3, which is described in the NPPF as land having a 1 in 100 or greater annual probability of river flooding (1% or greater Annual Exceedance Probability, AEP); or land having a 1 in 200 or greater annual probability of sea flooding (0.5% AEP or greater).

Modelled data was obtained from the Environment Agency to better understand the potential flood extents for the area of interest (Appendix A). The modelled fluvial extent (Figure 8) shows some of the area is at risk during the 5% AEP. The 2017 Huntingdonshire District Council Strategic Flood Risk Assessment (SFRA) states Flood Zone 3b '*Comprised of land where water has to flow or be stored in times of flood (the functional floodplain).* The SFRA identified this Flood Zone as *'land which would flood with an annual probability of 5%, where detailed hydraulic modelling exists*.'

On the basis of the modelled flood extents, the area of the new ponds seems to be within a high flood risk location with areas of Fenstanton also shown to be at risk of flooding during the 5% AEP and the 2% AEP. However, it should be noted that the modelled extents refer to the old hydraulic model which does not take into account the new A14 layout and associated mitigation works. In theory, the flood risk should not have been made worse as a result of the highway works and the areas shown to flood on the map, would be expected to still flood.

It is our understanding that a new hydraulic model is being developed based on the as-built details of the scheme and will be published accordingly, while the flood map will also be updated accordingly. As such, the modelled flood extents do not likely reflect reality in this instance but provide an indication of baseline conditions, pre-development. As mentioned above, it would be expected that the works do not have an adverse impact.

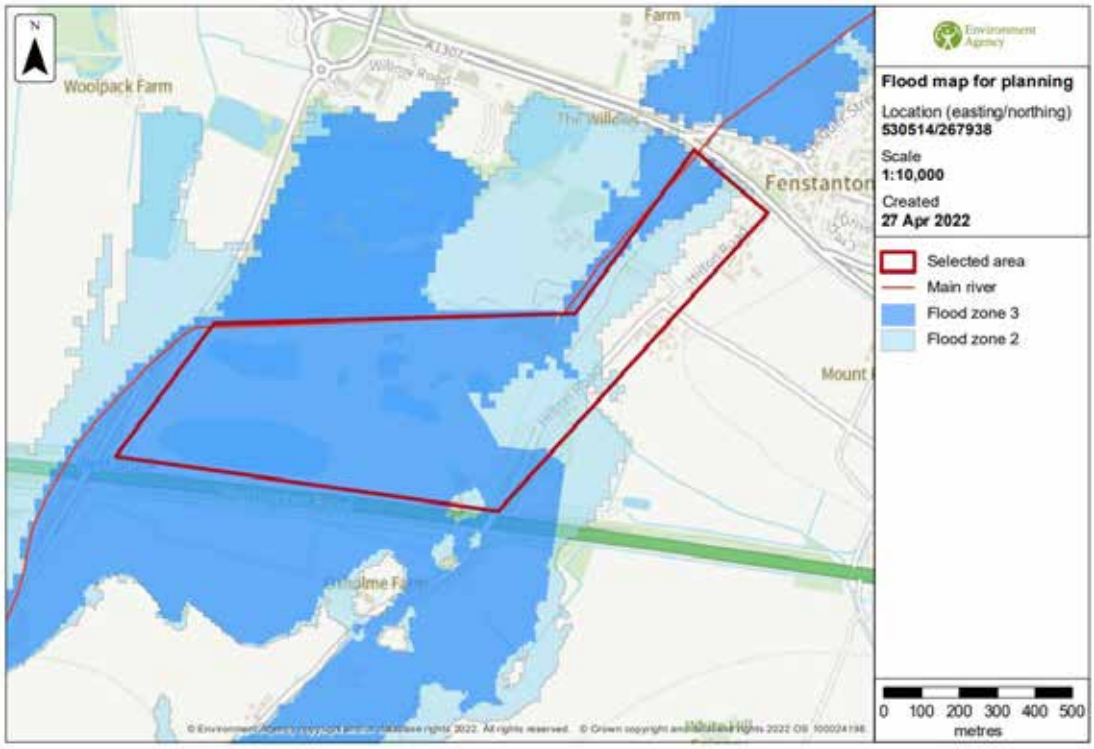


FIGURE 7: ENVIRONMENT AGENCY FLOOD MAP FOR PLANNING

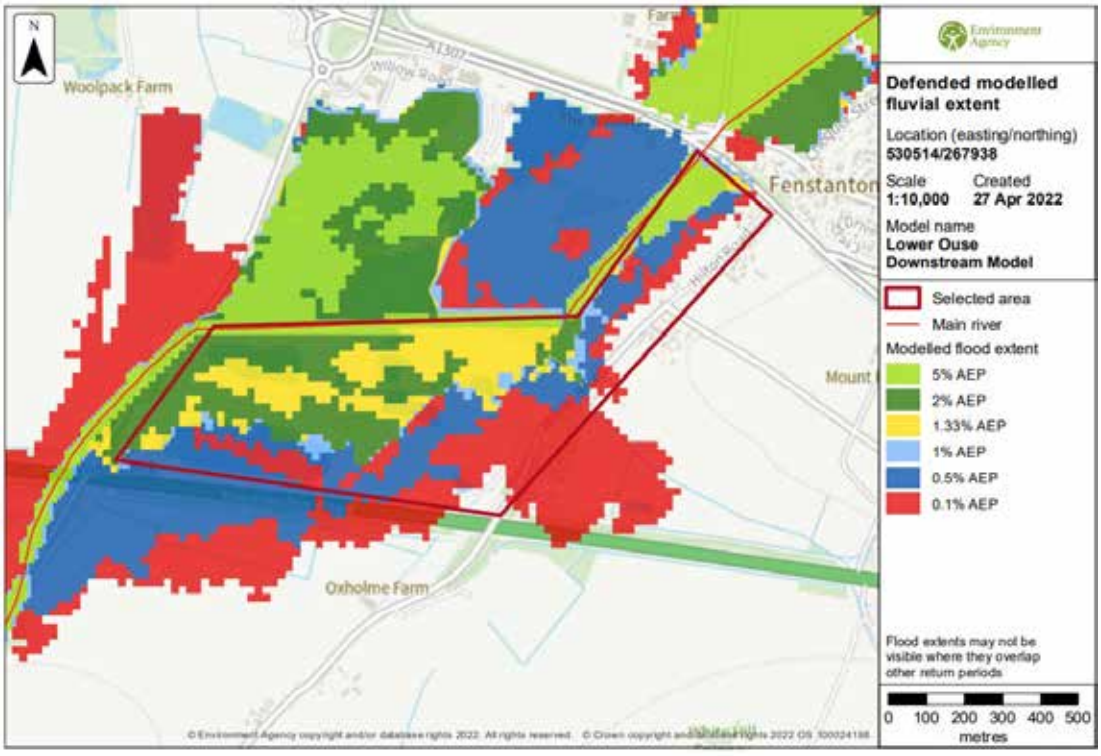


FIGURE 8: ENVIRONMENT AGENCY DEFENDED MODELLED FLUVIAL EXTENT

3.2 Flood defence breach and overtopping

The asset located along West End Road is shown to be an embankment in 'fair' (3) condition. The target condition of the asset is 'fair' (3). A fair condition includes defects that could reduce the performance of the asset. The downstream crest level is 6.78mAOD and the upstream crest level is 7.04mAOD.

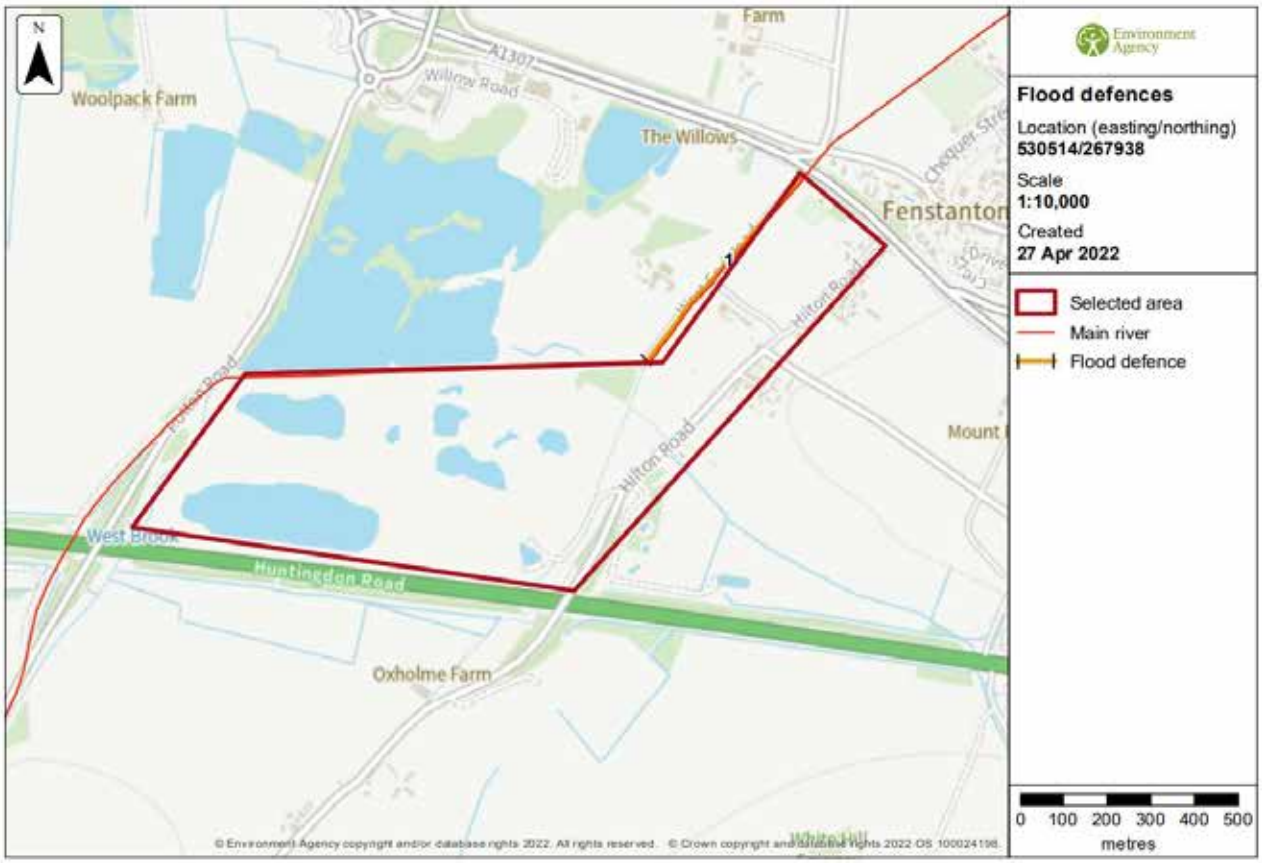


FIGURE 9: ENVIRONMENT AGENCY FLOOD DEFENCES MAP

3.2.1 Breach risk

The standard protection of the embankment is not available however, a breach analysis is out of scope at this stage.

3.2.2 Overtopping risk

The standard protection of the embankment is not available however, overtopping analysis is out of scope at this stage. In addition, comparing the crest height with the modelled extents would not really offer any real value in this instance, given the outdated flood extents as mentioned above.

3.3 Coastal/tidal

The village is located at a considerable distance from the coast therefore, the risk of coastal/tidal flooding is very low.

3.4 Pluvial (Surface water)

When the infiltration capacity of land or the drainage capacity of a local sewer network is exceeded, excess rainwater flows overland. This water will collect in topographic depressions and at obstructions, which can inundate development in low lying areas. The severity of the rainfall event, the degree of saturation of the soil before the event, the permeability of soils and geology, and the gradient of the surrounding land and it's use; all contribute to and affect the severity of overland flow.

The Environment Agency Flood Map for Surface Water (Figure 10), can be used to see the approximate areas that would experience surface water flooding from a range of AEPs, which is used to categorise the risk (Table 2).

The surface water risk varies across Fenstanton with the largest high-risk area towards the south west.

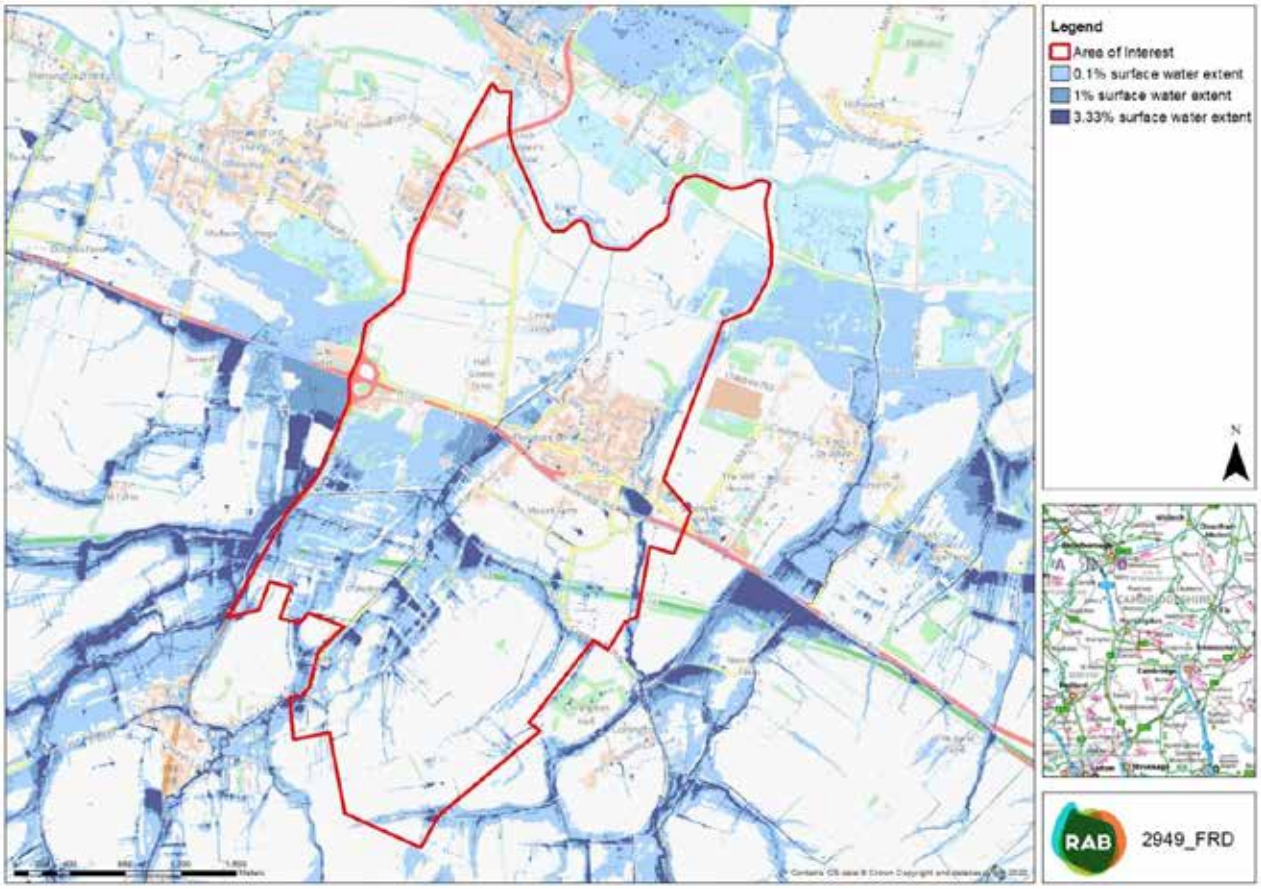


FIGURE 10: ENVIRONMENT AGENCY FLOOD RISK FROM SURFACE WATER

TABLE 2: ENVIRONMENT AGENCY SURFACE WATER RISK CATEGORIES

Surface Water Risk Category	Surface water flooding Annual Exceedance Probability
Very Low	< 0.1%
Low	Between 1% and 0.1% (1 in 100 years and 1 in 1000 years)

Surface Water Risk Category	Surface water flooding Annual Exceedance Probability
Medium	Between 1% and 3.3% (1 in 100 years and 1 in 30 years)
High	> 3.3% (1 in 30 years)

There are many overland flow paths evolving within the area of interest, where runoff ultimately finds its way into the fluvial bodies downstream. The extreme 0.1% AEP surface water depth map shows a range of depths some of which are over 1.2m. The extents suggest that the area of interest is quite prone to surface water flooding, possibly due to the flat nature of the region, encouraging water to pond and slowly move via overland flow paths. It is worth noting however, that Huntingdon Road (see Figure 11) is mostly outside the extreme 0.1% AEP, relevant to West Brook. This suggests that flood water diffuses upstream of the culvert under Cambridge Road, filling up the relevant field.

It should be noted that the Environment Agency surface water flood extents most likely reflect fluvial risk, rather than surface water risk, given the presence of multiple waterbodies within the catchment. Such risk has been assessed in section 3.1.

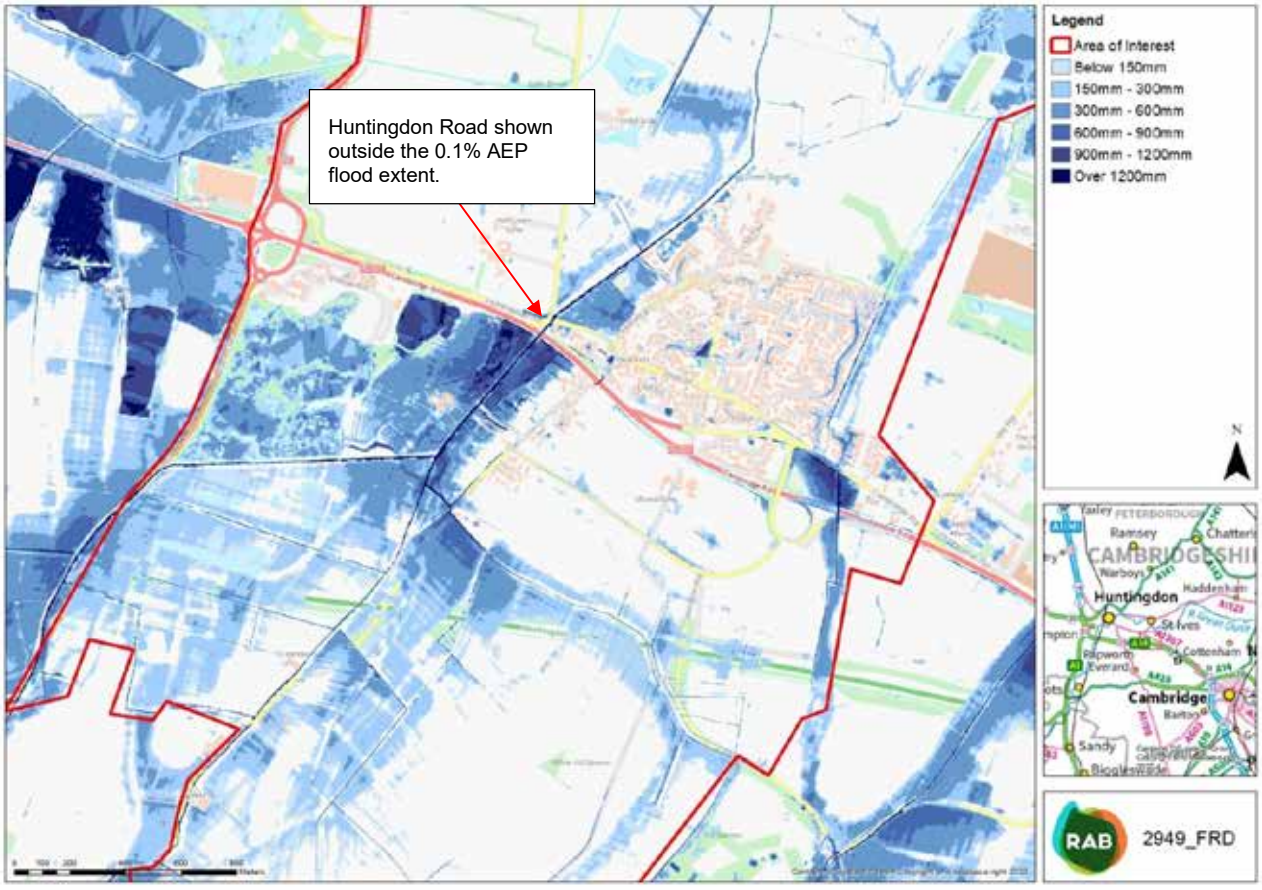


FIGURE 11: 0.1% AEP SURFACE WATER FLOOD DEPTHS

3.5 Artificial water bodies

Although flooding from reservoirs is extremely unlikely, according to the Environment Agency maximum extent of flooding from reservoirs map the south of Fenstanton is at risk from Grafham Water (grid reference TL1700067000) which is owned by Anglian Water Services Ltd.

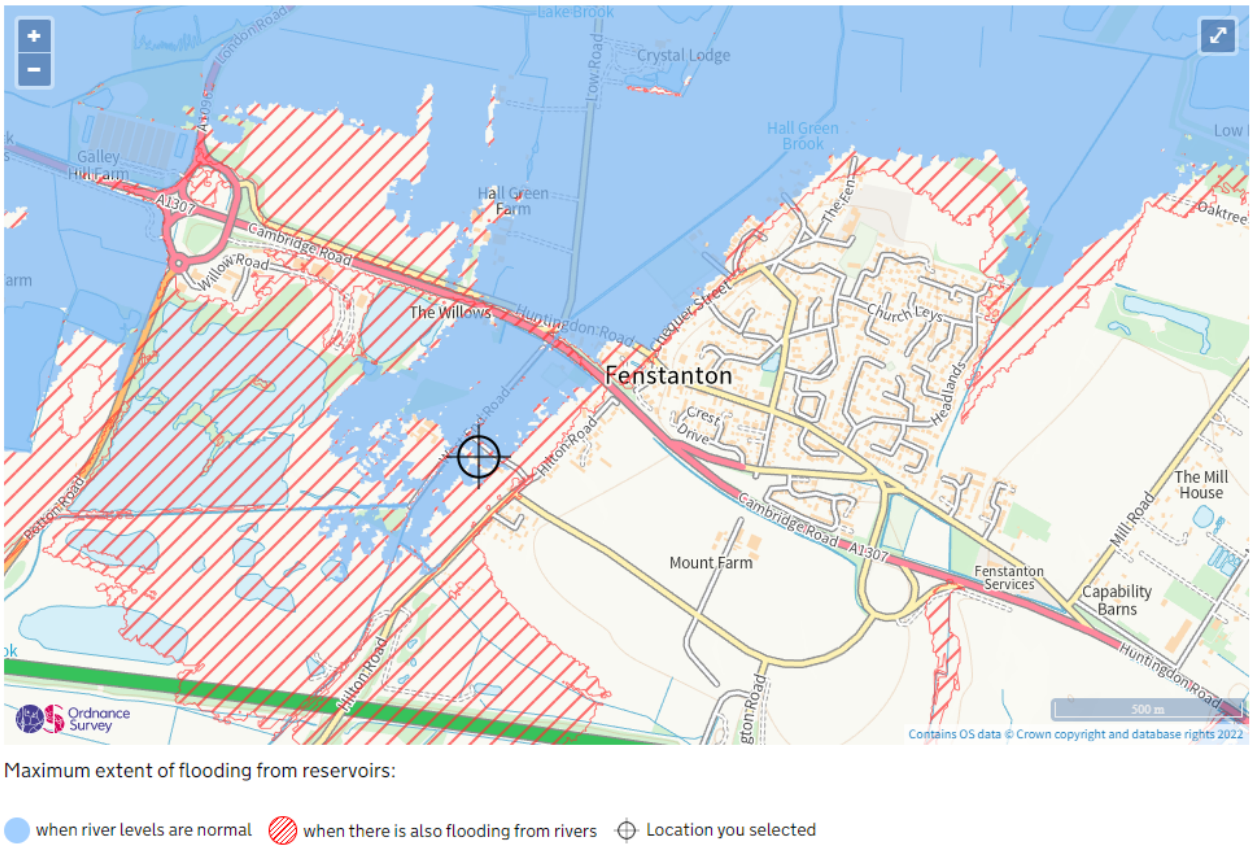


FIGURE 12: ENVIRONMENT AGENCY MAXIMUM EXTENT OF FLOODING FROM RESERVOIRS

3.6 Groundwater

Groundwater flooding is water originating from sub-surface permeable strata which emerges from the ground, either at a specific point or over a wide diffuse location and inundates low lying areas. A groundwater flood event results from a rise in groundwater level sufficient for the water table to intersect the ground surface and inundate low lying land.

British Geological Survey (BGS) records indicate that south Fenstanton overlies bedrock composed of Oxford Clay Formation - mudstone. This is overlain by various superficial deposits which include River Terrace Deposits - sand and gravel and Alluvium - clay, silt, sand and gravel. Groundwater levels usually mirror fluvial levels, therefore, should the West Brook levels be high the groundwater levels would likely reflect this. The underlying clay would most likely increase the amount of rainfall which becomes surface water runoff via its reduced infiltration potential.

According to the Magic Maps tool, Fenstanton is not located within a bedrock aquifer however, it is located within a Secondary A superficial drift aquifer. It also shows the site to be within a medium – low groundwater vulnerability area.

As there is a high degree of variability when considering groundwater flooding, using historic flooding is not a robust measure of the risk of flooding in future years.

3.7 Sewers

Anglian Water is responsible for the adopted surface and foul sewer networks within the District and maintain a DG5 register of sites affected by sewer flood incidents on a post code basis. The 2017 SFRA provided no records regarding sewer flooding.

It is important to note that previous sewer flood incidents, or the lack thereof, do not indicate the current or future risk to the site. Upgrade work could have been carried out to alleviate any issues or conversely, in areas that have not experienced sewer flooding incidents, the local drainage infrastructure could deteriorate leading to future flooding.

3.8 Flooding history

3.8.1 Environment Agency data

The Environment Agency historic flood map shows four flood events in the local area in 1947, 1993, 1998 and 2001, the source and cause of flooding for all of these events is unknown but it is likely fluvial related. The magnitude of these events is also not known at this stage.

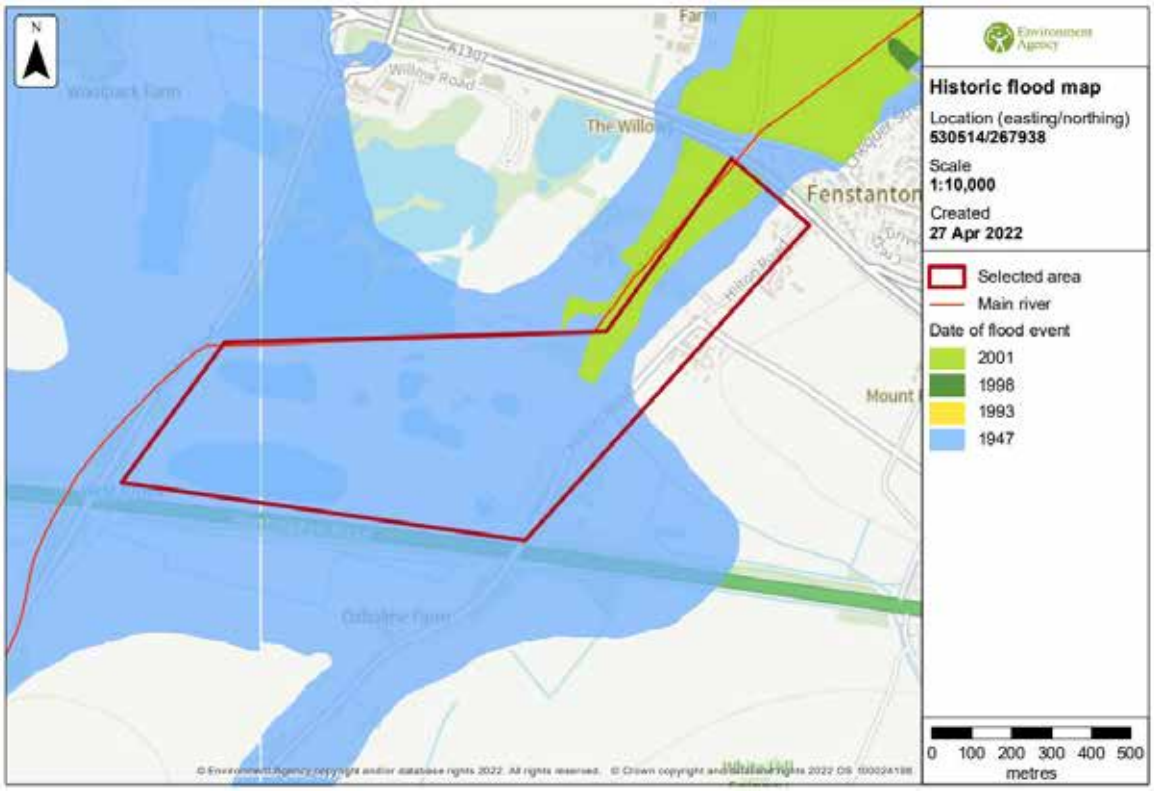


FIGURE 13: ENVIRONMENT AGENCY HISTORIC FLOOD MAP

3.8.2 Historic rainfall data

The Met Office UK actual and anomaly maps were also analysed as part of this study. The 1991 – 2020 map refers to the 30-year averaging period (Figure 15).

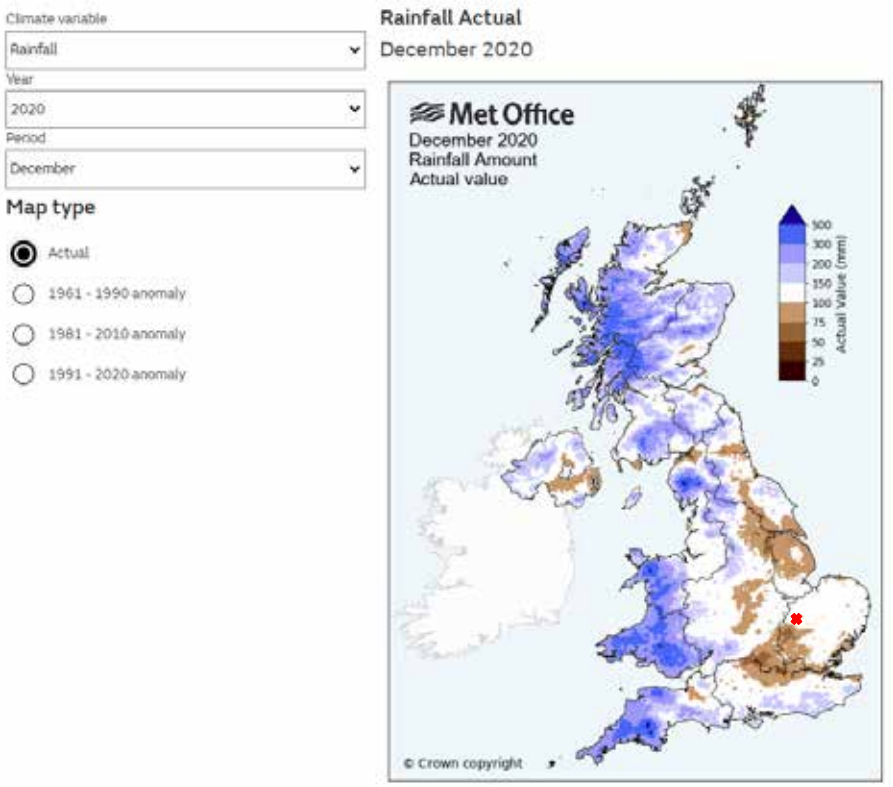


FIGURE 14: MET OFFICE ACTUAL RAINFALL DECEMBER 2020 (X INDICATES SITE LOCATION)

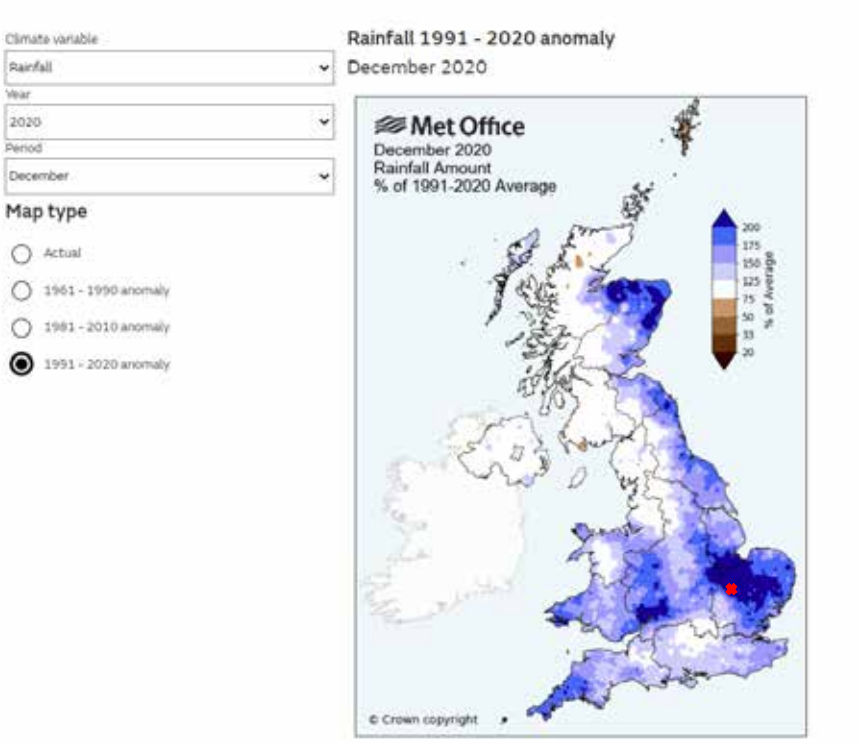


FIGURE 15: MET OFFICE RAINFALL 1991 - 2020 ANOMALY DECEMBER 2020 (X INDICATES SITE LOCATION)

The rainfall map (Figure 14) shows the East Anglia area to have between 100 -150mm of actual rainfall and when compared to the average between 1991 – 2020, parts of the East Anglia area are shown to have 200% of the average for December 2020. This shows that for December 2020, a large amount of rainfall occurred in the region compared to the average. These anomaly observations provide an insight of weather pattern severity but unfortunately, cannot be used to accurately quantify fluvial return period.

Table 3 shows noticeable rainfall events at nearby rain gauge Uttons Drove from 2014. The events of the 30/08/2017 and 06/07/2017 were during the construction of the road and the May 2020 event was just after it opened. There is also evidence from a BBC news report of flooding from the August 2014 event in Cambridgeshire, which caused power cuts and major disruption on the roads. Interestingly, all 3 gauges recorded noteworthy rainfall for the August 2014 event suggesting high rainfall throughout the region. This suggests that when rainfall is high across all three gauges, severe flooding is likely to occur, as demonstrated by the August 2014 event. High rainfall was also observed in October 2014 but without any online evidence to support the occurrence of flooding. No more information was found on flood events for the below rainfall occurrences.

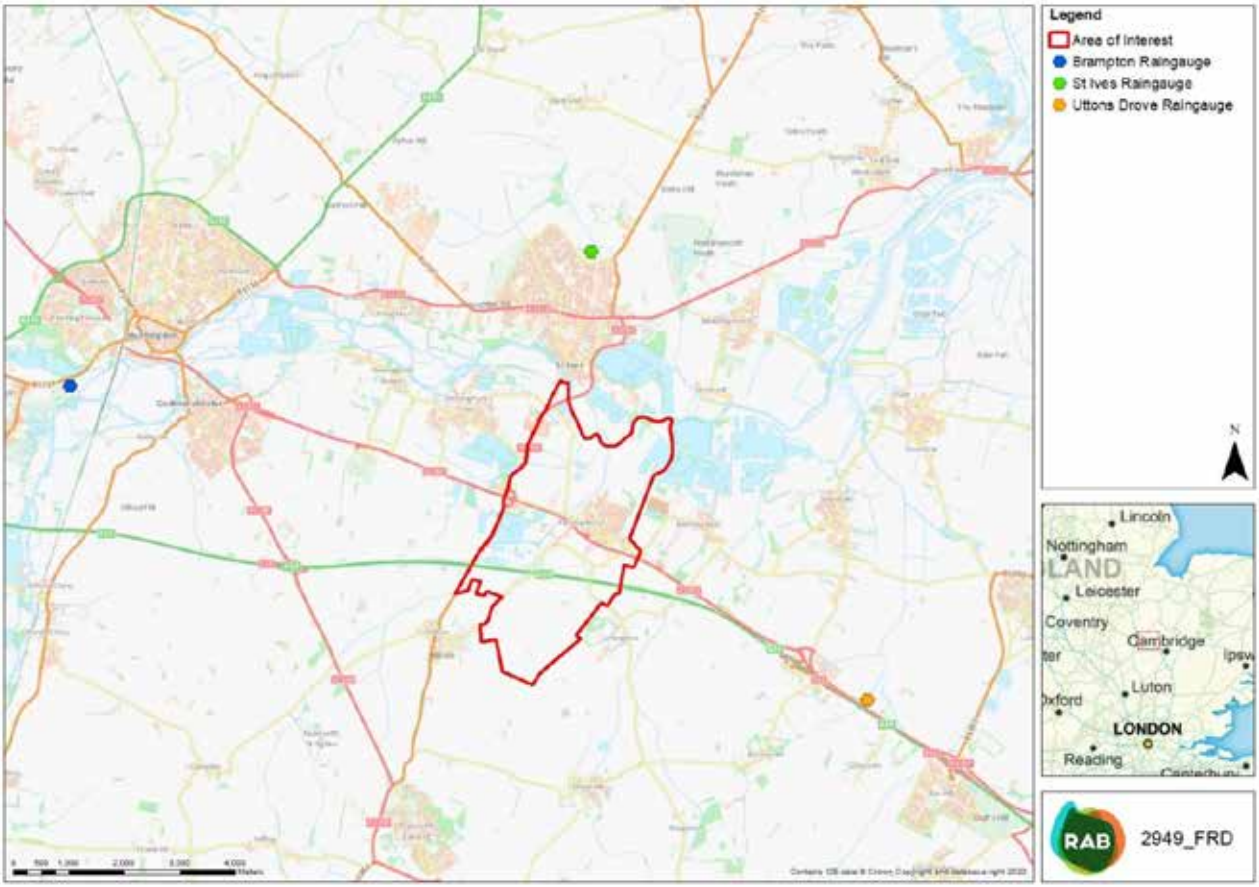


FIGURE 16: RAINGAUGE LOCATIONS

The Uttons Drove raingauge rainfall amounts were compared to the Brampton (Table 4) and St Ives (Table 5) raingauges for the same dates. There is a noteworthy difference in rainfall between the raingauges with Uttons Drove, showing higher rainfall for the noticeable events. Although the three raingauges are within close proximity to each other, it is clear that the rainfall amount greatly varied in this area (for the assessed events), demonstrating the dynamic nature of how weather patterns evolve throughout the different catchments and the challenge in quantifying storm event rarity.

What seems to be an interesting observation, however, is that when all 3 gauges record high rainfall amounts, an event which may cause significant flooding is highly likely to occur, based on historical evidence.

TABLE 3: NOTICEABLE RAINFALL AT UTTONS DROVE

Date	Rainfall (mm)
14/05/2020	120.6
30/08/2017	126.5
06/07/2017	83.4
06/08/2015	119.7

Date	Rainfall (mm)
08/08/2014	132.5
October 2014	364.2

TABLE 4: BRAMPTON RAINGAUGE RAINFALL

Date	Rainfall (mm)
14/05/2020	0
30/08/2017	1.8
06/07/2017	0
06/08/2015	0
08/08/2014	36
October 2014	69.4

TABLE 5: ST IVES RAINGAUGE RAINFALL

Date	Rainfall (mm)
14/05/2020	0
30/08/2017	3.6
06/07/2017	0
06/08/2015	0
08/08/2014	27
October 2014	79.4

3.8.3 Atkins response

Following the flooding in December 2020, Atkins provided a response, which can be found in Appendix B. Atkins stated that on the 23rd of December 2020 between 47mm – 53mm of rain fell (it is unclear which gauge was used to identify the rainfall amount) and that the design hydrology in the model was 52mm, which equated to a 1 in 100-year event. Atkins also suggests that since the ground was saturated, the event would be considered more than the A14 design modelled scenario. However, they do state that the scheme was designed to manage the 1 in 100-year plus 40% climate change and due to the saturated soil, it was at maximum capacity. They also stated, without however providing further details, that the system may have been overwhelmed. Further discussion on the Atkins response can be found in section 5.0.

3.8.4 Local media report: December 2020

Local media reports were analysed to assess the severity of flooding and how widespread the flooding was during December 2020.

Local news reports show flooding in the local area with Cambridgeshire Live reporting on the 24th of December 2020 several floods had occurred, flooding parts of the A14 and affected areas such as Bourn, Alconbury, Girton, Oakington, Cambridge, St Neots, Huntingdon and parts of Peterborough.

A BBC report from a year on from the floods supports the above findings stating that residents had to evacuate in some parts of Cambridgeshire, Norfolk and Northamptonshire.

In addition, an ITV report published on the 24th of December 2020 shows that the A14 was closed between Thrapston and Ellington due to flooding and there had been extremely high rainfall in the area.

These reports show that this was most likely not a localised issue and many areas suffered flooding within the catchment on that event.

4.0 Data Analysis

4.1 Baseline conditions

It is understood that the re-aligned West Brook and the associated works were tested as part of an appropriate Flood Risk Assessment (November 2015, Highways England, Cambridge to Huntingdon improvement scheme). A new hydraulic model was created which included West Brook, Huntingdon Award Drain, and Hilton Drain; the model was used to identify the water levels. The hydraulic modelling report was not available to review meaning, it was not possible to assess the used catchment and technical model details. Nevertheless, it is understood that the Borrow Pits were modelled as being full of groundwater, as a worst-case scenario.

The 2009 FRA (Highways Agency, 2009) referred to significant flooding problems in the village of Hilton, in particular during October 2001, when a number of properties were flooded. However, anecdotal reports in the FRA indicate that it was surface water flooding resulting from culvert and/or ordinary watercourse blockage due to insufficient maintenance rather than solely the result of exceedance of channel capacity (i.e., fluvial flooding). The Environment Agency believe that this flooding event in Hilton was not influenced by the West Brook or river Great Ouse.

The FRA (Highways England, 2015) report states that '*the scheme would result in no increase to water levels both upstream and downstream of the new crossing for the 1% (1 in 100) AEP event*'. This suggests that the scheme should not have an influence on flood risk in the local area. Table 11.1 and 11.2 of the FRA (Highways England, 2015) identify expected water levels (for the 1 in 100-year event) along the West Brook for the existing and proposed condition, respectively. The report suggests that the water levels will be reduced along the West Brook as a result of the proposed works. In addition, the report suggests that the scheme should provide betterment along Hilton Road however, in the event of the December 2020 areas that had not flooded previously, experienced flooding.

Finally, the FRA (Highways England, 2015) report identifies the need for floodplain compensation and the relevant compensation and betterment areas are shown in the report (Box 11.4). Interestingly the area around West End Farm and the area west of The Gables are shown to be within a betterment extent, suggesting that these areas would benefit from the scheme. The compensation section of the FRA report (Highways England, 2015) concludes with the following statement "*Overall the scheme is considered to have a neutral effect on flood risk for the Huntingdon Award Drain and the Hilton Road Drain, and a slight adverse effect locally on flood risk for the West Brook. This is due to the area of West Brook floodplain with increased flood depth of greater than 100mm, resulting in a major adverse magnitude of impact, but as this occurs in an area to be permanently acquired by Highways England for the scheme and it does not affect property, the significance of this is considered to be slight*". In other words, the scheme should not have an adverse impact on the surrounding area up to the design event.

4.2 December 2020 event

Rainfall data was obtained from Shoothill Gauge Map and three different raingauge stations were analysed, St Ives (approximately 4.55km north), Uttons Drove (approximately 6.20km southeast) and Brampton raingauge (approximately 9.20km west). Across the dates between 21/12/2020 – 28/12/2020 there was a total rainfall of 46.4mm, 60.5mm and 60mm, respectively. The highest rainfall across the 8 days was on the 23rd of December 2020 with the highest reading on Brampton raingauge showing 48.8mm.

It was explained during the site visit that West Brook flooded and receded, then, the River Ouse flooded shortly after that. This suggests that flooding at the Fenstanton area occurred either due to discharge capacity issues of the West Brook (and other associated tributaries), upstream of the River Ouse, or unforeseen blockages at key control structures (or a combination of both). Atkins have also stated '*It is also considered that the Lower Ouse catchment is greatly larger in magnitude than the West Brook and therefore the response of these two catchments will be different in terms of the return period of the peak flood levels generated by any particular rainfall storm*.' suggesting that the two catchments respond hydraulically different, which is what occurred.

TABLE 6: ST IVES RAINGAUGE DATA

Date	Time	Rainfall (mm)
21/12/2020	4.00 - 7.59	1.4
	8.00 - 11.59	1.6
	16.00 - 19.59	0.4
	20.00 - 23.59	0.6
22/12/2020	12.00 - 15.59	0.6
	4.00 - 7.59	0.4
	20.00 - 23.59	0.4
23/12/2020	12.00 - 3.59	0.8
	8.00 - 11.59	2.0
	12.00 - 15.59	8.4
	16.00 - 19.59	15.6
	20.00 - 23.59	8.8
24/12/2020	12.00 - 3.59	2.4
27/12/2020	12.00 - 3.59	1.0
	4.00 - 7.59	1.8
28/12/2020	4.00 - 7.59	0.2
Total rainfall across 8 days		46.4

TABLE 7: UTTONS DROVE RAINGAUGE DATA

Date	Time	Rainfall (mm)
21/12/2020	12.00 - 15.59	0.1
	20.00 - 23.59	3.1
22/12/2020	12.00 - 3.59	0.2
	4.00 - 7.59	0.4
	16.00 - 19.59	0.2
	20.00 - 23.59	0.5
23/12/2020	12.00 - 3.59	0.7
	8.00 - 11.59	1.3
	12.00 - 15.59	10.2
	16.00 - 19.59	22.2
	20.00 - 23.59	11.5
24/12/2020	12.00 - 3.59	2.6
26/12/2020	20.00 – 23.59	0.2
27/12/2020	12.00 - 3.59	5.1
	4.00 - 7.59	1.7
28/12/2020	16.00 – 19.59	0.5
Total rainfall across 8 days		60.5

TABLE 8: BRAMPTON RAINGAUGE DATA

Date	Time	Rainfall (mm)
21/12/2020	4.00 - 7.59	1.8
	8.00 - 11.59	2.0
	16.00 - 19.59	0.6
	20.00 - 23.59	0.8
22/12/2020	12.00 - 3.59	0.4
	4.00 - 7.59	0.2
	16.00 - 19.59	0.2
	20.00 - 23.59	0.4
23/12/2020	12.00 - 3.59	0.2
	4.00 - 7.59	0.2
	8.00 - 11.59	2.2

Date	Time	Rainfall (mm)
	12.00 - 15.59	13.0
	16.00 - 19.59	24.4
	20.00 - 23.59	8.8
24/12/2020	12.00 - 3.59	4.6
	12.00 - 15.59	0.2
Total rainfall across 8 days		60.0

4.2.1 FEH Data

The Brampton raingauge data has been taken forward as the worst rainfall scenario with available data locally[1]. The rainfall at 1-hour timeframes for the 23/12/2020 has been analysed in the FEH webservice tool to assess the event rarity, the results of which are found below. Table 9 shows there was no rainfall until 19 hours suggesting there was an intense rainfall period between the 19 and 24-hours timeframe. According to the FEH webpage, the highest observed rainfall event rarity was 8.5-years, which was at 24 hours with a cumulative rainfall of 48.8mm; this is a low event rarity compared to the flood event severity that occurred in December 2020.

However, according to the St Ives Section 19 Flood Report published in 2022, the long-term average rainfall for the area over the month is 47mm which suggests that there was over a month's rainfall in 24 hours at the Brampton raingauge; assuming of course that the long-term average is numerically comparable to the Brampton gauge. It should be noted that there is no raingauge available in Fenstanton, therefore, it could be possible that a localised rainfall pattern evolved, which may have not been picked up at this raingauge; although, data suggests that a high rainfall amount fell in the area (based on the findings of the aforementioned Section 19 Flood Report).

TABLE 9: BRAMPTON FEH RAINFALL

Brampton Rainfall (mm)	Cumulative Rainfall (mm)	Duration (hour)	FEH Rainfall Return Period (years)
0	0	1	0
0	0	2	0
0.2	0.2	3	0
0	0.2	4	0
0	0.2	5	0
0	0.2	6	0
0	0.2	7	0
0.2	0.4	8	0

[1] It should be noted that this raingauge most likely falls outside the hydrological catchment of the West Brook relevant to the area of interest but has been used as a worst case scenario.

Brampton Rainfall (mm)	Cumulative Rainfall (mm)	Duration (hour)	FEH Rainfall Return Period (years)
0.2	0.6	9	0
0.8	1.4	10	0
1	2.4	11	0
0.2	2.6	12	0
3.6	6.2	13	0
1	7.2	14	0
3.6	10.8	15	0
4.8	15.6	16	0
0.8	16.4	17	0
4.8	21.2	18	0
12.6	33.8	19	2.86
6.2	40	20	4.64
1.4	41.4	21	5.05
2.6	44	22	6.08
3.4	47.4	23	7.81
1.4	48.8	24	8.5

4.2.2 Estimation of return period for the catchment

In the interest of better understanding the hydrological response of the catchment, in terms of event rarity, the ReFH2 method was utilised. ReFH is a method for estimating flows based on catchment descriptors and the process was undertaken using the latest version of the WINFAP software.

Firstly, the West Brook catchment area was identified using the FEH webservice tool, which had a total area of 49.6275ha. The catchment area includes important descriptors on key catchment features such as slope, permeability, presence of reservoirs, etc. This data set was then inputted into WINFAP, and certain return periods were assessed.

A number of different return periods were assessed, as shown in Table 10. The Brampton raingauge showed a 24-hour rainfall of 48.8mm, which when compared to Table 10, suggests that such a rainfall amount within this timeframe could potentially result in a 1 in 50-year flow within the West Brook catchment. Therefore, it is probable that the West Brook catchment, relative to the site, likely experienced a rainfall event which might have caused a 1 in 50-year return period[2].

[2] This statement assumes that the rainfall amount that fell in Brampton is similar to that that fell at the Fenstanton catchment, within the same timeframe (Figure 17), and that the ReFH2 timestep is valid in this context.

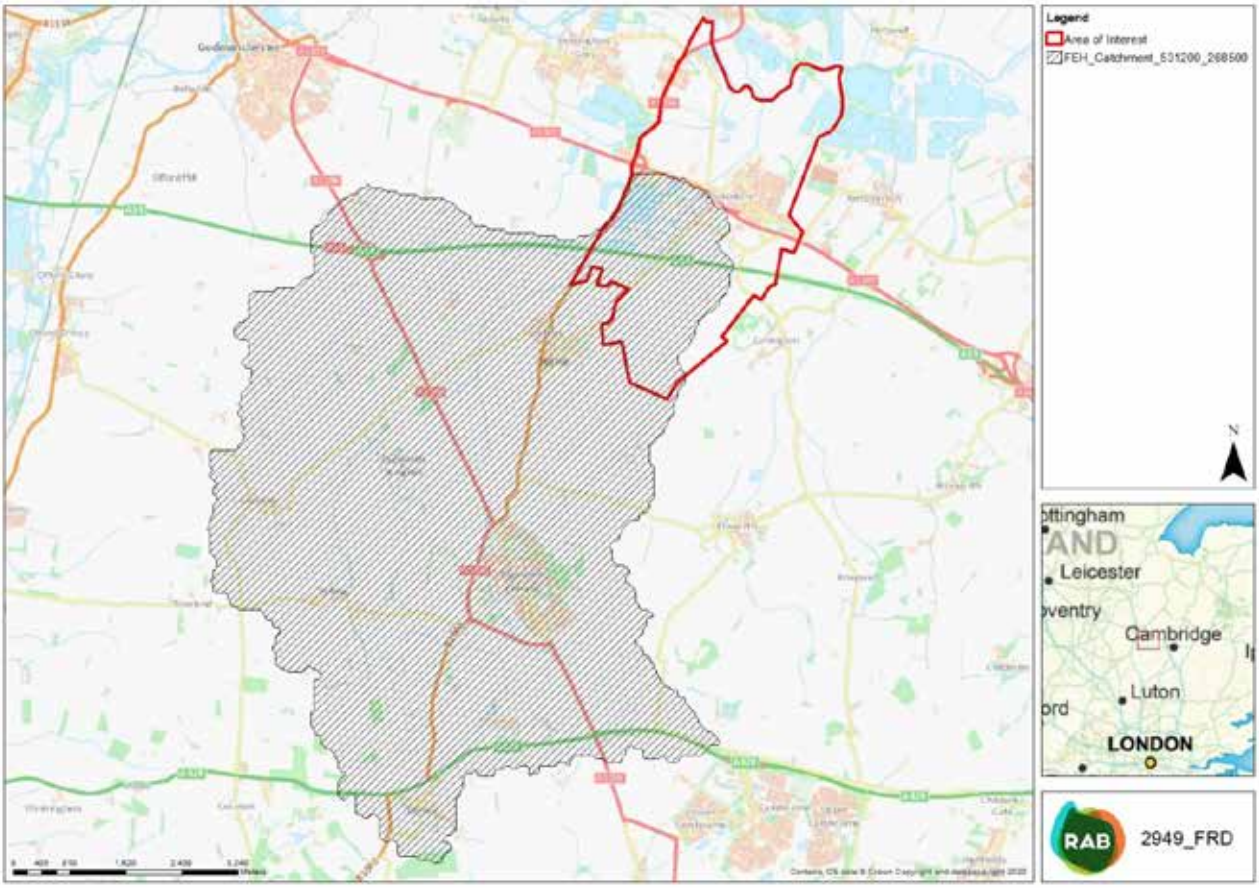


FIGURE 17: FEH CATCHMENT

TABLE 10: REEH2 RETURN PERIOD OUTPUTS FOR DIFFERENT RAINFALL AMOUNTS (REFH2 DEFAULT TIMEFRAME)

Total Rainfall (mm)	Return Period (years)
16.52	1
18.79	2
26.1	5
31.53	10
41.8	30
47.91	50
53.35	75
57.43	100
67.48	200
89.76	1000

4.3 Pathway and receptors

It is believed that flooding occurred from the West Brook, which overtopped at the B1040 and flowed east from the bottom of Hilton Road Bridge, flowing towards West End Road and Hilton Road, thereby, flooding the surrounding areas.

According to the Fenstanton Parish Council Flood Working Group report (Appendix C), the following areas suffered from flooding during the December 2020 event:

- Old Clayfield
- Hollow Farm
- Thames Laboratories
- West End Farm
- Fenstanton Bowls Club
- Hall Green Lane
- Junction of Low Road and Huntingdon Road
- Hilton Road
- 11 Hilton Road

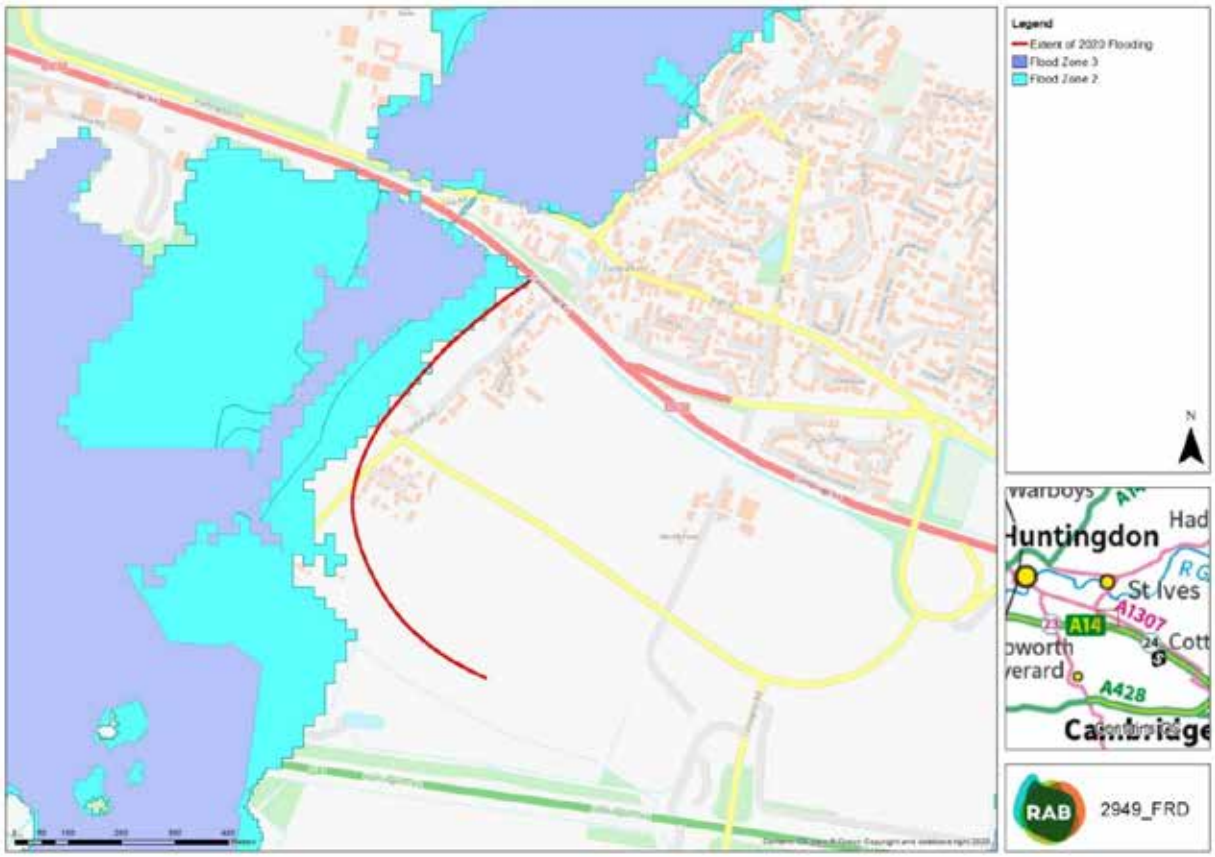


FIGURE 18: APPROXIMATE DECEMBER 2020 EXTENT OF FLOODING (FENSTANTON PARISH COUNCIL)

The report stated that 150mm of internal flooding occurred in Old Clayfields with Hollow Farm, Thames Laboratories, West End Farm and Fenstanton Bowls Club experiencing internal depths of around 600mm. Moreover, it was noted that residents saw very high-water flow rates through the culvert under the A1307, causing Hall Green Brook to be overtopped and flood the junction of Low Road and Huntingdon Road (which is very unusual according to local residents).

The below map (Figure 7) shows some of the areas in Fenstanton that were affected by the 2020 December flooding event. It is clear that a number of areas that flooded were in Flood Zone 2 with Pear Tree Close junction located in Flood Zone 1. Flood Zone 2 is defined in the NPPF as land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (between 1% AEP and 0.1% AEP); or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (between 0.5% AEP and 0.1% AEP). The junction of Low Road and Huntingdon Road is shown by the black arrow on Figure 20 and it should be noted that this junction does not normally flood, and it is shown to be located within Flood Zone 1. It should be noted however, that the flooding at the junction might have occurred due to a blockage at the culvert structure; something which we are unable to confirm at this stage.

The rear of 11 Hilton Road flooded (Figure 19) during the December 2020 event with floodwater reaching the rear of their garage; substantially higher than the extent of the March 1947 event. The rear of the site is shown to be within Flood Zone 2 however, the house and garage are shown to be within Flood Zone 1. Figure 18 shows how floodwater encroached onto Flood Zone 1 to the west of 11 Hilton Road, suggesting that there was a different hydrological response within the catchment.



FIGURE 19: 11 HILTON ROAD

On the basis of the rainfall analysis in the sections above, there is no evidence from the raingauges to suggest that such an extreme event occurred in the area which would cause flooding to areas within Flood Zones 1 & 2. Of course, there is no actual rainfall data for the Fenstanton area and the state of the control structures across the West Brook are not known to us but nevertheless, it seems unlikely (based on available evidence) that a localised flash flooding event of such significant magnitude (1% AEP – 0.1% AEP) occurred.

On the other hand, the updated flood map for planning has not been published yet and it may well indicate changes to the zoning of this area(s); this of course would contradict the findings of the FRA report (Highways England, 2015).

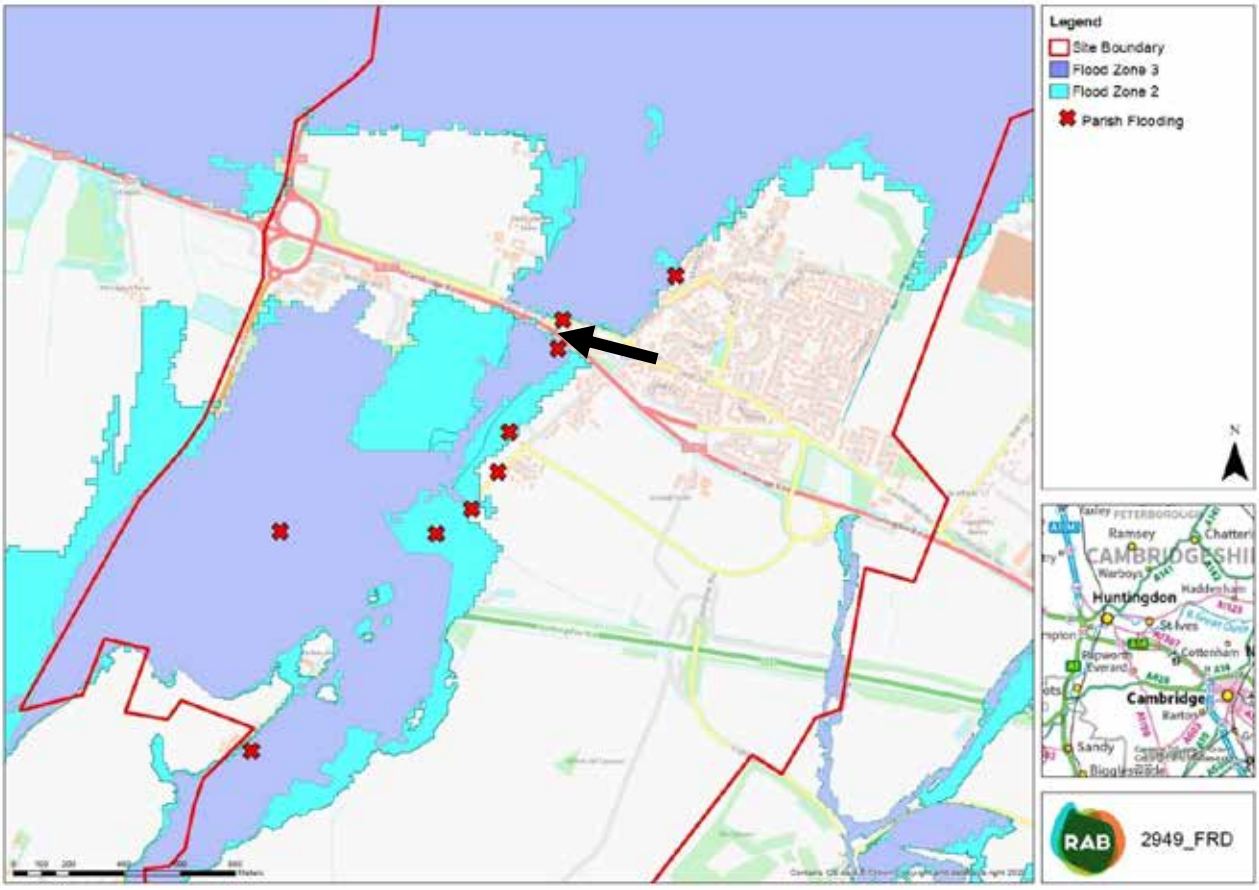


FIGURE 20: AREAS FLOODED DURING THE DECEMBER 2020 EVENT

5.0 Discussion and Concluding Remarks

According to local media reports many of the areas around Fenstanton flooded during December 2020, suggesting the local area experienced heavy rainfall around the same time. Section 19 reports were produced for local areas however, not for Fenstanton as the threshold was not met, demonstrating the severity of flooding in other areas as well (this was not a completely localised event).

The Environment Agency provided historic flood extents for events that occurred in 1947, 1993, 1998 and 2001, with the source and cause of flooding unknown. Historical raingauge data appears to greatly vary even within short distances demonstrating the dynamic nature of evolving weather patterns across the different catchments, for the assessed period. This should be taken into account when considering the rainfall data since there is no raingauge in Fenstanton therefore, it could have received less or more rainfall than nearby gauges.

It can be seen from the Met Office data in section 3.8.2 that there was a considerable amount of rainfall across December 2020 for the area, which was well above average. This heavy rainfall throughout the month likely resulted in saturated ground conditions with a large amount of rainfall falling on the 23rd of December 2020. According to the St Ives Section 19, the amount of rainfall that fell in 24 hours was shown to be higher than what usually falls within a month suggesting that flooding should have been expected.

To that extent, the ReFH2 analysis identified that the return period of the event that occurred on the 23rd of December 2020 was approximately a 1 in 50-year event at fluvial (West Brook) catchment level, based on a specific catchment boundary and using the Brampton raingauge rainfall data. There are several limitations and assumptions in this exercise but nevertheless, it provides an outline insight as to the potential return period that might have occurred. Such a return period is quite low to justify flood extents of such severity occurring in December 2020. Even if the event was of a 1 in 100 year return period, it would not explain the flooding occurrences within Flood Zones 1 & 2. As such, it seems that the risk profile has changed throughout the catchment with the installed works being a potential contributor to this change[3].

According to the Atkins response, 52mm of rain fell on the catchment resulting in a 1 in 100-year event, which was different to the findings of this report. It is also not clear how this 52mm figure was identified as there is no gauge in West Brook catchment, to the best of our knowledge. However, our ReFH2 analysis is a simplistic approach and might have used a different catchment boundary, compared to the actual hydraulic model, which might extend further upstream/downstream of the area of interest. In addition, it is possible that localised pockets of intense rainfall could have occurred, either upstream or downstream of the area of interest thereby, contributing to increased flood risk within the catchment; such localised rainfall may have not been captured by the relevant raingauges.

Interestingly, areas within Flood Zone 2 and Flood Zone 1 flooded in the December 2020 event, which is unusual as the ReFH2 analysis suggested a 1 in 50 year storm and the Flood Zone 2 extent relates to areas at risk of flooding for events between 1 in 100 year and 1 in 1000 year. However, Atkins did suggest it was a 1 in 100-year storm which would explain some flooding in Flood Zone 2, but not in Flood Zone 1. In addition, the 2015 Highways England FRA suggested that the West Brook works would not have an adverse impact on the catchment and that floodplain compensation measures would mitigate any increase in flood risk. As such, parts of the catchment that would not normally flood (Flood Zone 2 & 1), flooded during the December 2020 event, without any evidence of a storm greater than 1 in 100 year occurring at the time.

Atkins suggested that the new highway was designed to deal with the 1% AEP + 40% climate change event meaning it should have not been overwhelmed in either the 2% AEP or the 1% AEP. Although, Atkins stated '*It is also recognised that (without specific analysis) the event may have been in excess of the design event and the system may have been overwhelmed*.' They suggest that due to the fact that the catchment was already saturated, it was not unexpected that the fluvial system was operational to its maximum capacity however, the system was designed to cope with the 1% AEP + 40% climate change event and based on the outline rainfall analysis it does not seem that such an extreme event occurred at the time.

Moreover, it can be seen from Figure 21 that the realigned section of the West Brook is very overgrown therefore, leading to an increased Manning's n value, generating high water levels within the watercourse. Fenstanton Parish Council stated that the realigned channel is narrower than the previous channel, something which would reduce the discharge capacity of the West Brook causing it to burst its banks (at that location) at lower return periods, compared to the original cross section, and cause flooding. It was also noted that water was pouring out of the intersection between the old West Brook and the newly aligned West Brook suggesting reduced cross-sectional area and reduced discharge capacity at the junction. The 2015 Highways England FRA report stated, '*The newly realigned channel would be designed to provide a*

[3] This cannot be confirmed beyond any doubt without the outputs of the hydraulic model of the as-built layout.

similar cross-sectional dimension, gradient and floodplain profile to existing.' suggesting that the new realignment should theoretically match that of the original channel. They state that the realignment was added to the hydraulic model to assess the impact, however without having access to the drawing (A14-JCB-BN-14-DR-S-00001 in Annex H) it is difficult to compare the as-built cross section with the design cross section.



FIGURE 21: REALIGNED WEST BROOK (OCTOBER 2022)

Following the construction of the new road and the realignment of the West Brook, there would have been a different hydrological response from the catchment however, the updated model and flood map are required to confirm this in more detail. The Atkins response stated, '*Highway England are currently undertaking a review of the 'as built' structures in conjunction with the flood modelling to adhere to the consent conditions and to challenge the current published flood maps (to update them to reflect the scheme mitigation).*' therefore, this modelling of the 'as built' structures would be required to clearly identify areas with increased risk of flooding as a result of the works.

At this stage and based on available data, it is difficult to fully understand and translate the rainfall data behind the December 2020 flood event although, based on the current evidence it seems that an event of approximately 1 in 50-year return period might have occurred at the West Brook catchment. The flooding mechanism of the December 2020 event was most likely a combination of saturated ground, intense rainfall, discharge capacity issues of the West Brook, and possibly blockages at key structures (although this cannot be confirmed). In addition, the River Ouse contributed to flooding in the area but it is our understanding that this mechanism evolved after the initial flooding occurred, associated with the West Brook catchment. Based on the location of some of the properties that reported flooding during the December 2020 event, one could argue that an event of between 1 in 100 year and 1 in 1,000 year occurred. However, there is evidence suggesting that the local catchment did not experience such a high-return period event (based on the ReFH2 analysis and Brampton raingauge data), which would suggest that the design event was not exceeded and thereby, the West Brook scheme should have not become inundated and areas in Flood Zone 1 should have not experienced flooding.

In light of the foregoing, it is clear that there are conflicting information surrounding the performance of the West Brook realignment scheme and the resultant flood risk profile of the West Brook catchment. Based on our simplified rainfall analysis, it seems that an event of approximately 1 in 50-year return period occurred in December 2020 at the West Brook catchment. Such an event should have not inundated the West Brook and cause flooding to areas in Flood Zone 2 and Flood Zone 1. However, one could argue that localised

pockets of intense rainfall (exceeding the 1 in 100-year return period) could have occurred within the West Brook catchment. However, the system was designed to manage the 1 in 100-year plus 40% climate change and based on the nearby rainfall data, an event of such magnitude does not seem to have occurred. In addition, blockages at key structures might have contributed to the flooding regime, which evolved in December 2020, causing flooding due to blockages; though no evidence of blockages were reported to us by the Parish Council and/or local residents.

Given the potential increased flood risk at the West Brook catchment, mitigation measures should be identified and implemented by all relevant stakeholders; until the as-built scheme has been modelled in detail with the updated flood extents for different return periods clearly identified.

6.0 Recommendations

- The as built hydraulic model (especially the 1 in 50-year flood extent relevant to the area of interest) in combination with the updated flood map should be provided to all stakeholders as soon as possible to better understand the actual impact of the works and identify areas at risk.
- The principal designer along with all relevant stakeholders should develop and agree mitigation measures of potential exceedance events within the West Brook catchment, ideally informed by the as-built hydraulic model and by the December 2020 historic flood extents.

Appendix A – Environment Agency Data

Flood risk assessment data

Location of site: 530514 / 267938 (shown as easting and northing coordinates)
Document created on: 27 April 2022
This information was previously known as a product 4.
Customer reference number: BMBPFRPCP5ET

Map showing the location that flood risk assessment data has been requested for.



How to use this information

You can use this information as part of a flood risk assessment for a planning application. To do this, you should include it in the appendix of your flood risk assessment.

> **We recommend that you work with a flood risk consultant to get your flood risk assessment.**

Included in this document

In this document you'll find:

- how to find information about surface water and other sources of flooding
- information on the models used
- definitions for the terminology used throughout
- flood map for planning (rivers and the sea)
- historic flooding
- flood defences and attributes
- modelled data
- information about strategic flood risk assessments
- information about this data
- information about flood risk activity permits
- help and advice

You will need to consider the latest flood risk assessment climate change allowances and factor in the new allowances to demonstrate the development will be safe from flooding..

Surface water and other sources of flooding

Use the long term flood risk service to find out about the risk of flooding from:

- surface water
- ordinary watercourses
- reservoirs

For information about sewer flooding, contact the relevant water company for the area.

About the model(s) used

Model name: Lower Ouse Modelling Project - Downstream Model
Scenario(s): Defended fluvial
Date: 1 November 2015

This model(s) contains the most relevant data for your area of interest.

Terminology used

Annual exceedance probability (AEP)

This refers to the probability of a flood event occurring in any year. The probability is expressed as a percentage. For example, a large flood which is calculated to have a 1% chance of occuring in any one year, is described as 1% AEP.

Metres above ordnance datum (mAOD)

All flood levels are given in metres above ordnance datum which is defined as the mean sea level at Newlyn, Cornwall.

Flood map for planning (rivers and the sea)

Your development is in flood zone 3.

Flood zone 3 shows the area at risk of flooding for an undefended flood event with a:

- 0.5% or greater probability of occurring in any year for flooding from the sea
- 1% or greater probability of occurring in any year for fluvial (river) flooding

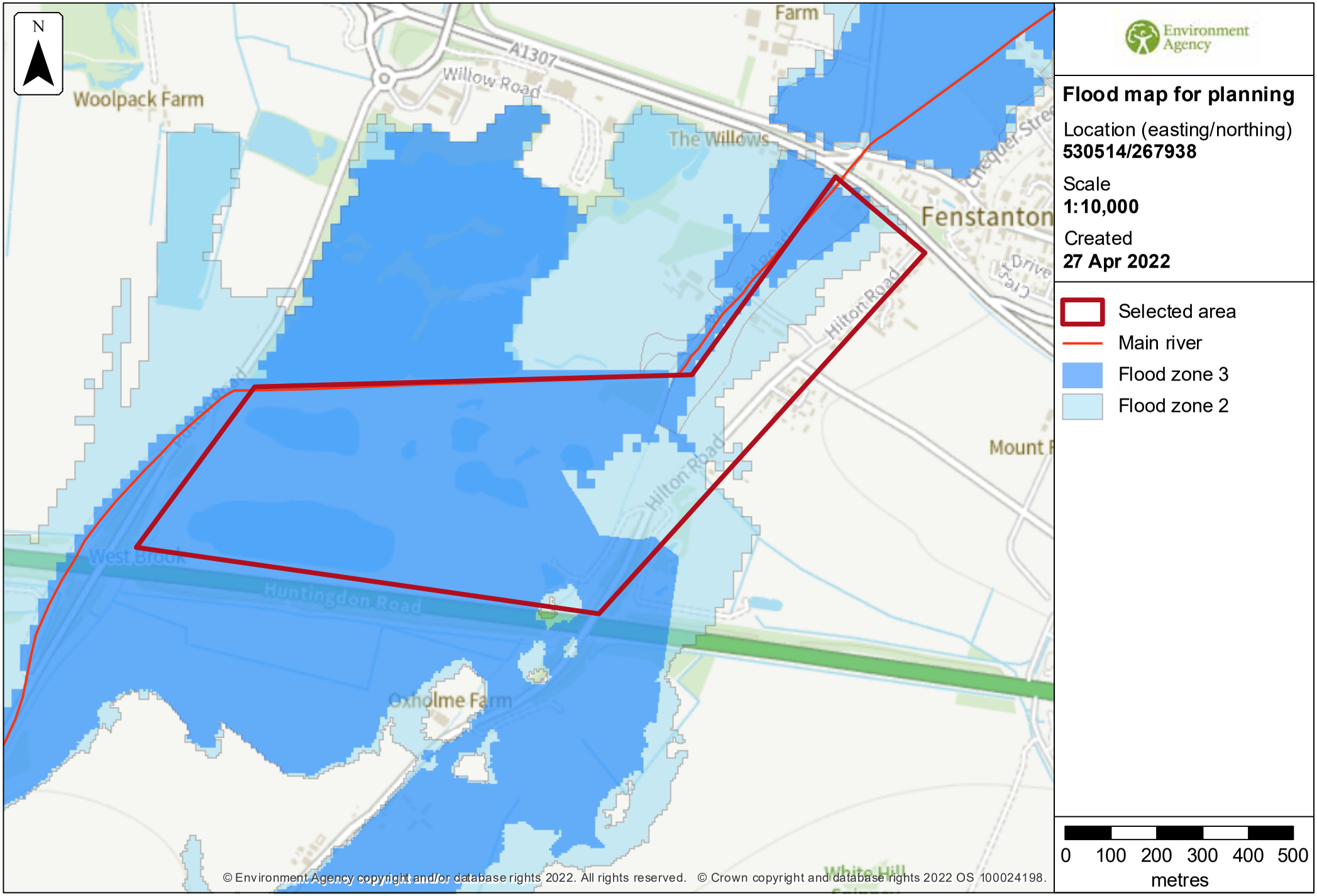
Flood zone 2 shows the area at risk of flooding for an undefended flood event with:

- between a 0.1% and 0.5% probability of occurring in any year for flooding from the sea
- between a 0.1% and 1% probability of occurring in any year for fluvial (river) flooding

It's important to remember that the flood zones on this map:

- refer to the land at risk of flooding and do not refer to individual properties
- refer to the probability of river and sea flooding, ignoring the presence of defences
- do not take into account potential impacts of climate change

This data is updated on a quarterly basis as better data becomes available.



Environment Agency

Flood map for planning

Location (easting/northing)
530514/267938

Scale
1:10,000

Created
27 Apr 2022

- Selected area
- Main river
- Flood zone 3
- Flood zone 2

0 100 200 300 400 500
metres

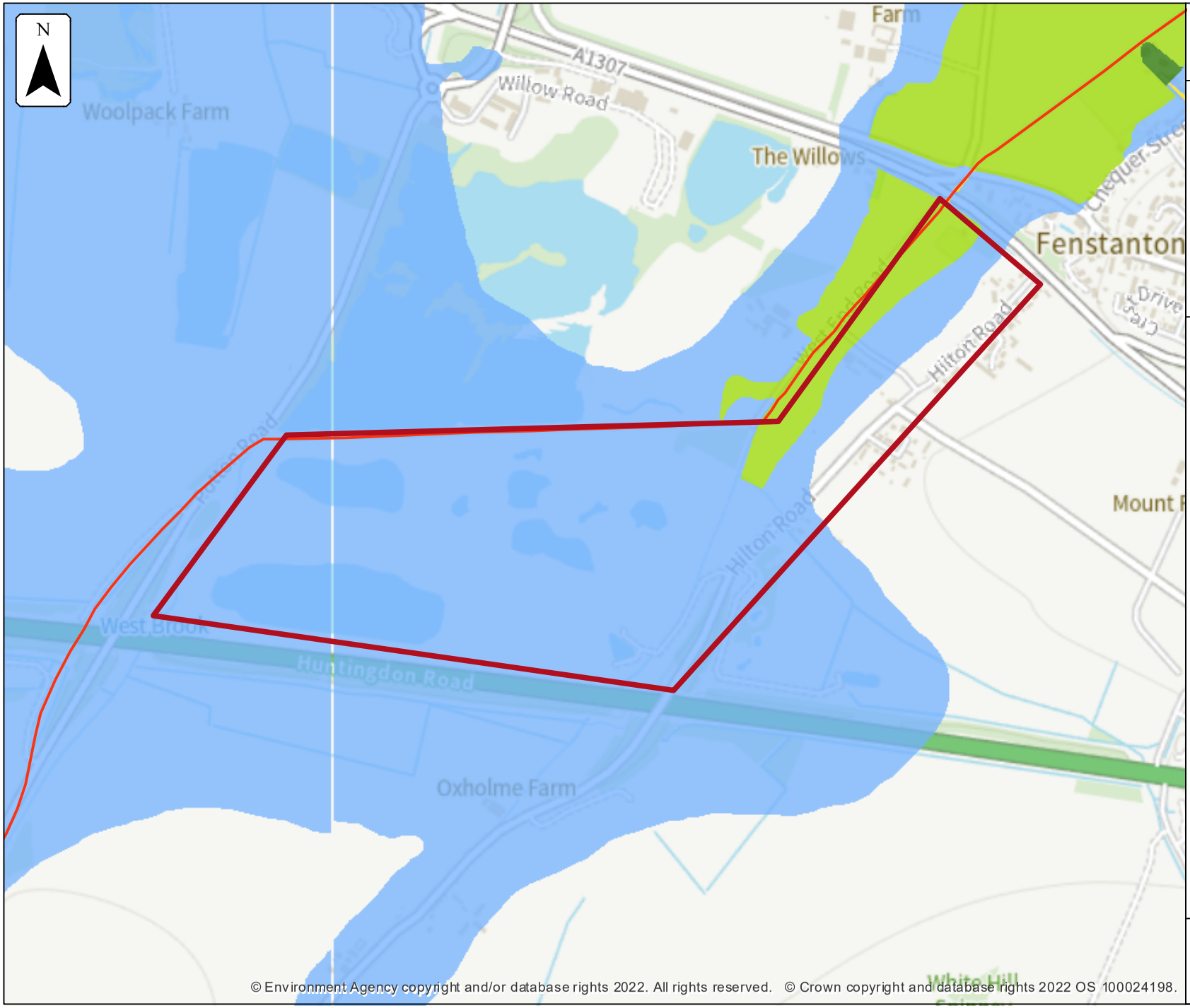
Historic flooding

This map is an indicative outline of areas that have previously flooded. Remember that:

- our records are incomplete, so the information here is based on the best available data
- it is possible not all properties within this area will have flooded
- other flooding may have occurred that we do not have records for
- flooding can come from a range of different sources - we can only supply flood risk data relating to flooding from rivers or the sea

You can also contact your Lead Local Flood Authority or Internal Drainage Board to see if they have other relevant local flood information. Please note that some areas do not have an Internal Drainage Board.

Download recorded flood outlines in GIS format



Environment Agency

Historic flood map

Location (easting/northing)
530514/267938

Scale
1:10,000

Created
27 Apr 2022

Selected area

Main river

Date of flood event

- 2001
- 1998
- 1993
- 1947

0 100 200 300 400 500
metres

Historic flood event data

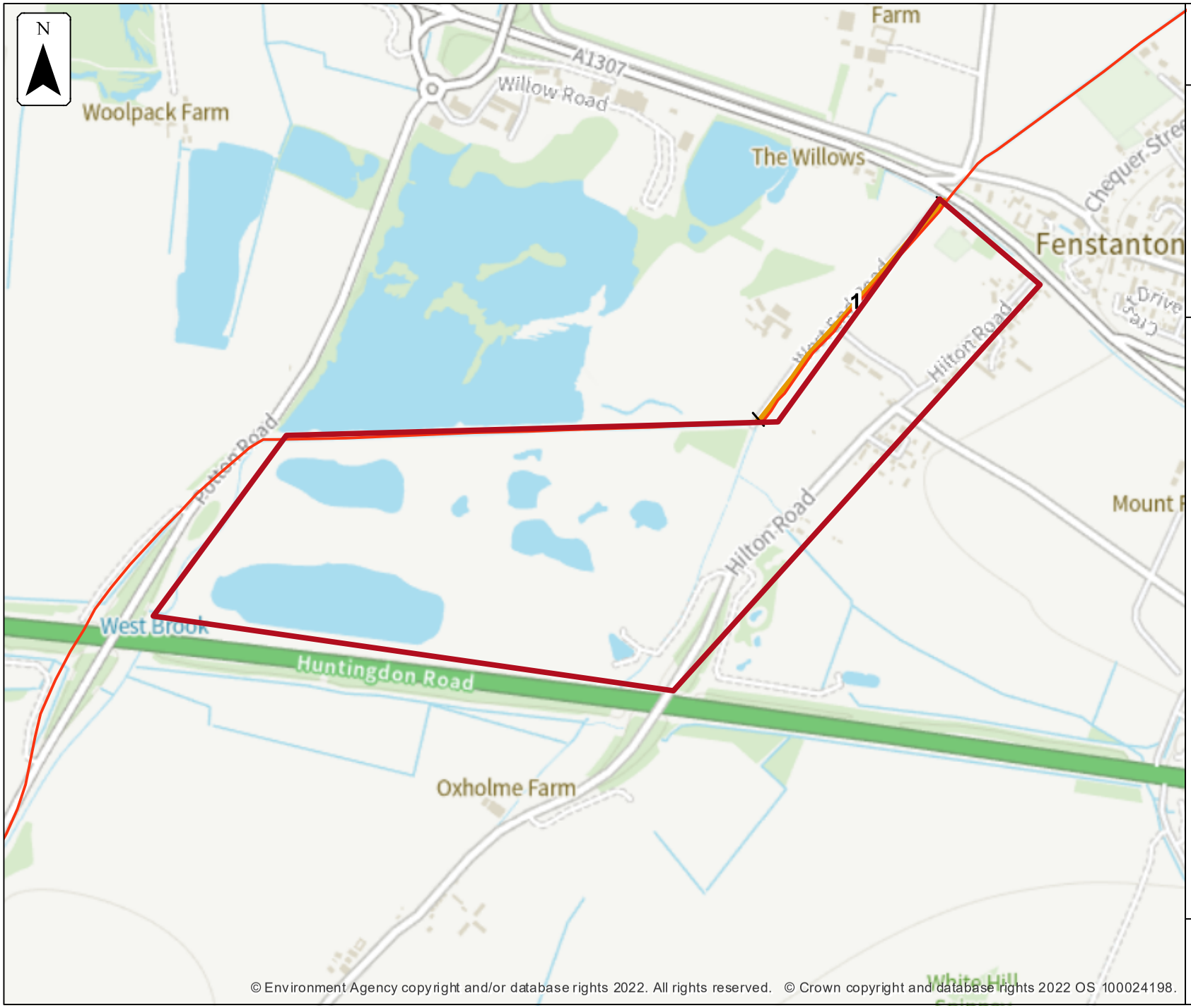
Start date	End date	Source of flood	Cause of flood	Affects location
2001	2001	unknown	unknown	Yes
1998	1998	unknown	unknown	No
1993	1993	unknown	unknown	Yes
1947	1947	unknown	unknown	Yes

Flood defences and attributes

The flood defences map shows the location of the flood defences present.

The flood defences data table shows the type of defences, their condition and the standard of protection. It shows the height above sea level of the top of the flood defence (crest level). The height is In mAOD which is the metres above the mean sea level at Newlyn, Cornwall.

It's important to remember that flood defence data may not be updated on a regular basis. The information here is based on the best available data.



Environment Agency

Flood defences

Location (easting/northing)
530514/267938

Scale
1:10,000

Created
27 Apr 2022

Selected area
Main river
Flood defence

0 100 200 300 400 500
metres

Flood defences data

Label	Asset ID	Asset Type	Standard of protection (years)	Current condition	Downstream actual crest level (mAOD)	Upstream actual crest level (mAOD)	Effective crest level (mAOD)
1	145461	Embankment		Fair	6.78	7.04	

Any blank cells show where a particular value has not been recorded for an asset.

Modelled data

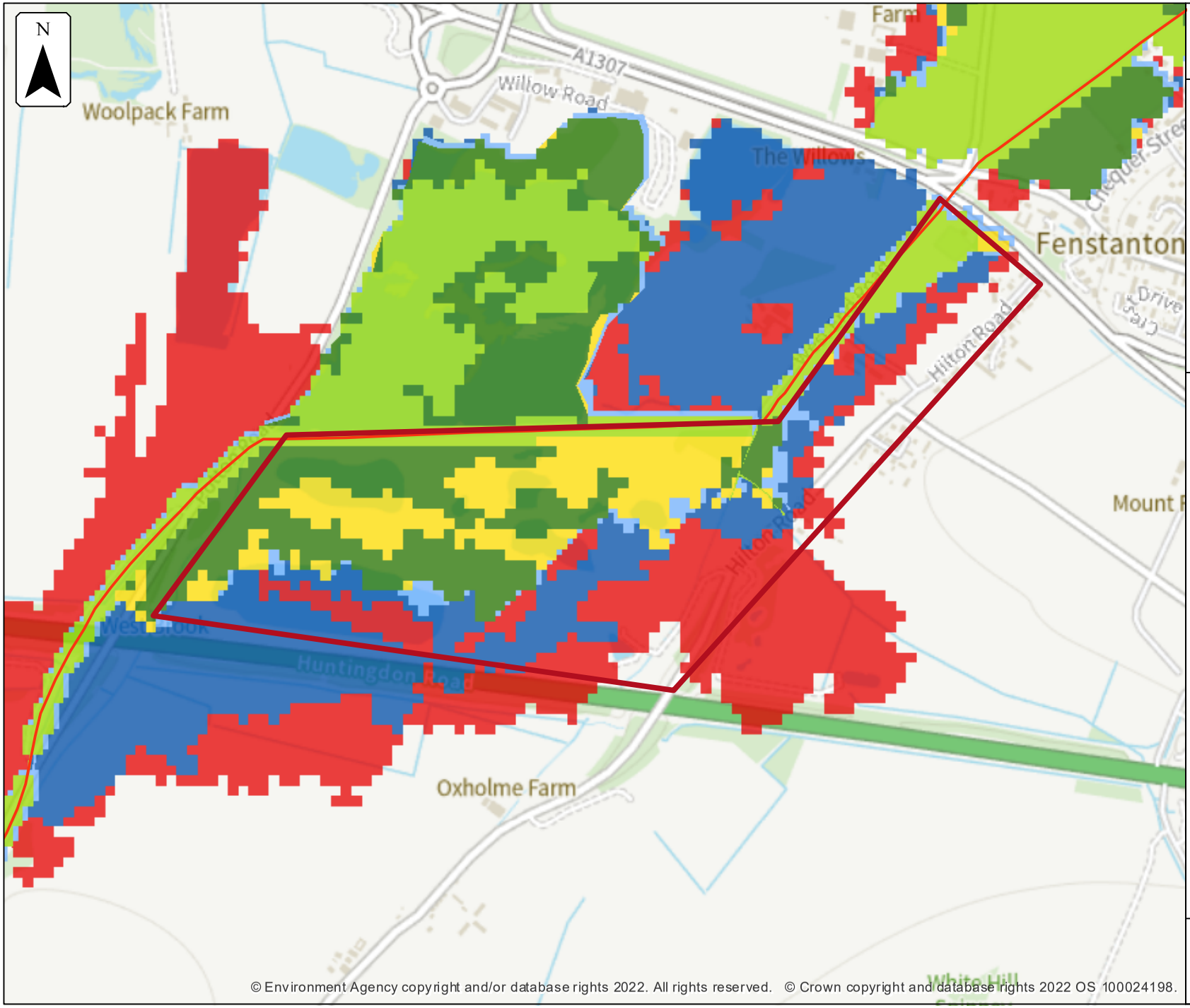
This section provides details of different scenarios we have modelled and includes the following (where available):

- outline maps showing the area at risk from flooding in different modelled scenarios
- modelled node point map(s) showing the points used to get the data to model the scenarios and table(s) providing details of the flood risk for different return periods

Modelled scenarios

The following scenarios are included:

- Defended modelled fluvial: risk of flooding from rivers where there are flood defences



Environment Agency

Defended modelled fluvial extent

Location (easting/northing)
530514/267938

Scale
1:10,000

Created
27 Apr 2022

Model name
Lower Ouse Downstream Model

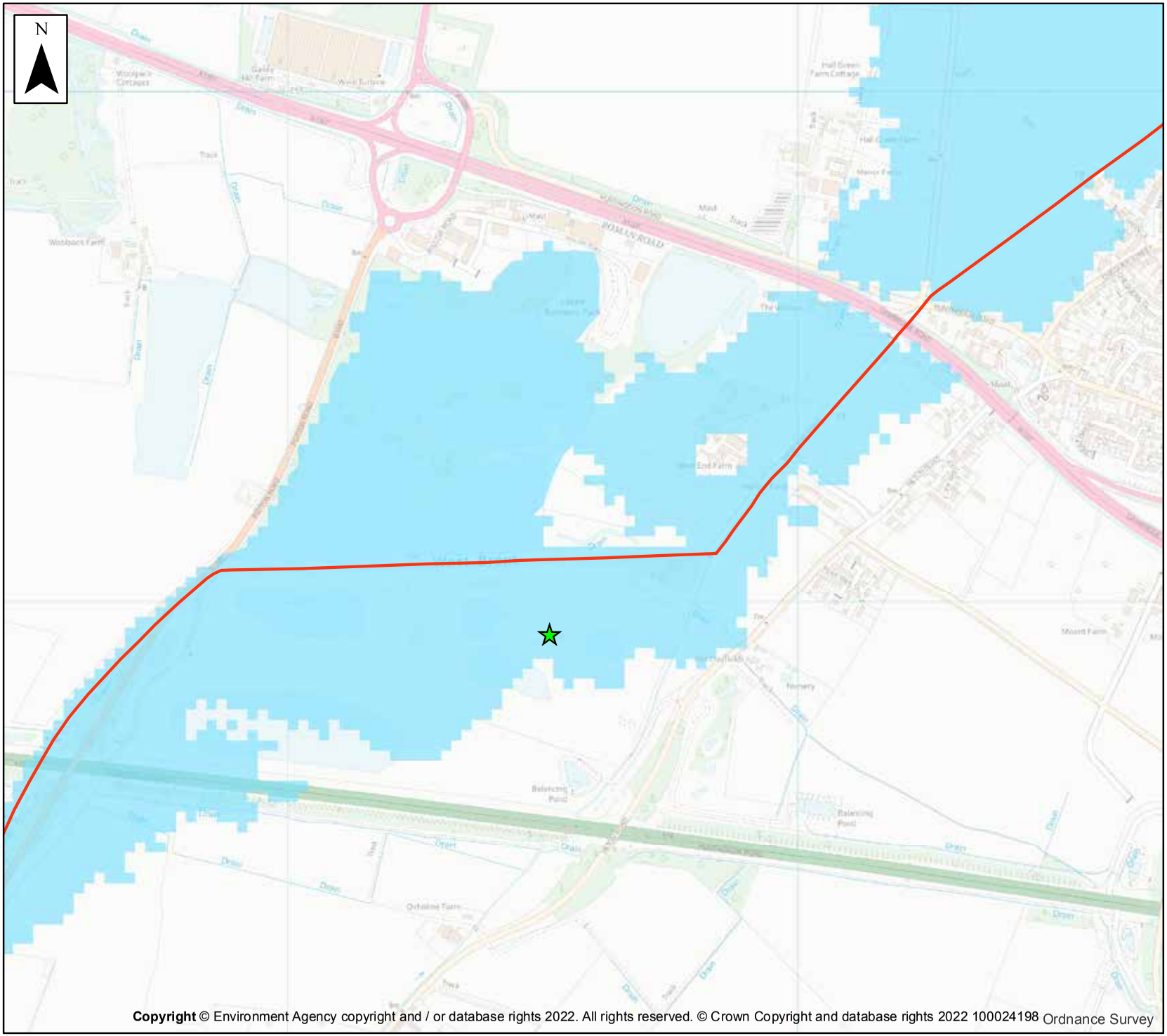
- Selected area
- Main river

Modelled flood extent

- 5% AEP
- 2% AEP
- 1.33% AEP
- 1% AEP
- 0.5% AEP
- 0.1% AEP

Flood extents may not be visible where they overlap other return periods

0 100 200 300 400 500
metres



Environment Agency

Defended climate change modelled fluvial extent

Location (easting/northing)
530514/267938

Scale
1:10,000

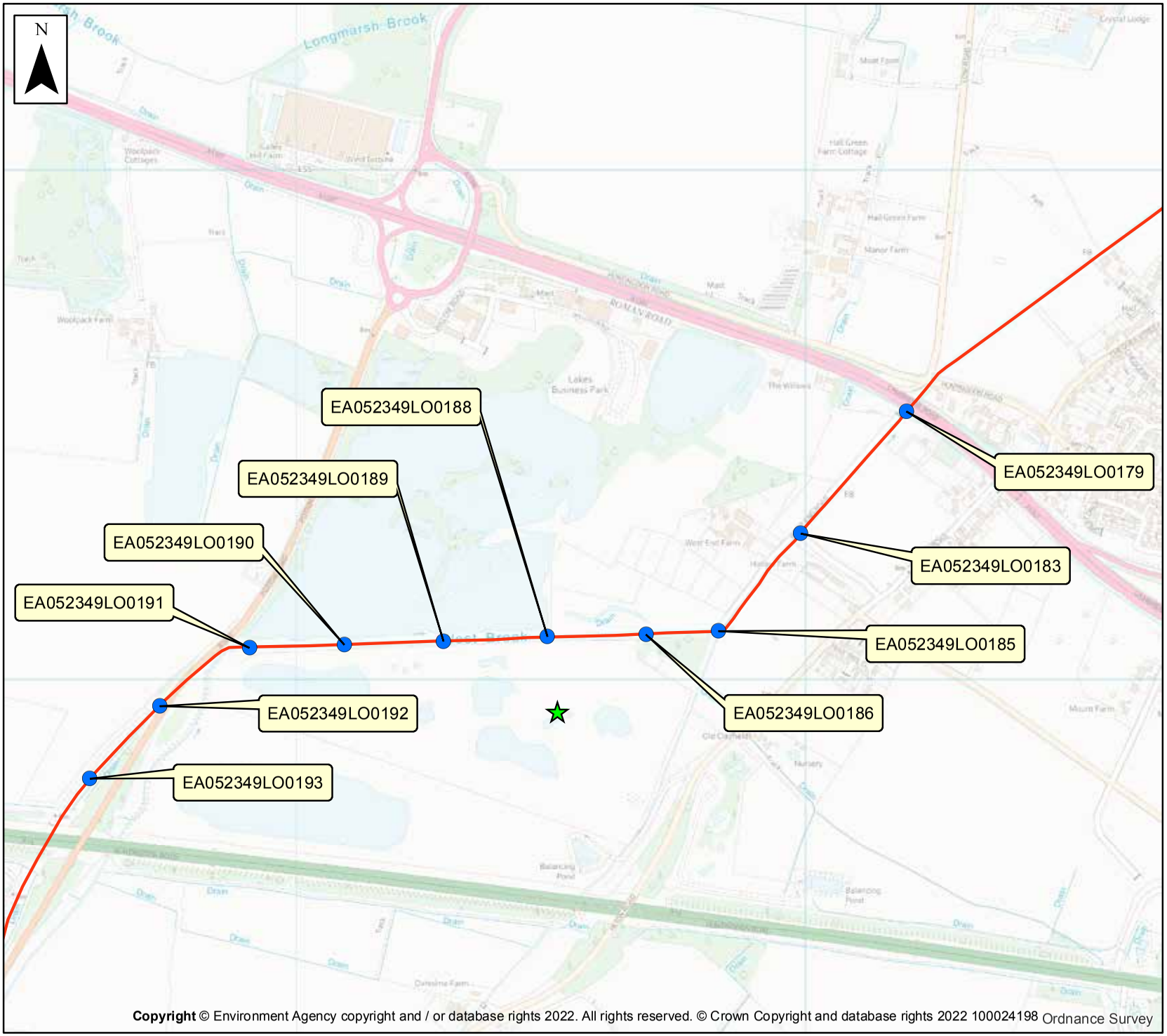
Model name:
Lower Ouse - Downstream Model

Created 18/05/2022

Legend

- Site
- Main river
- 1% AEP +20% CC

0 110 220 330 440 550
Meters



Environment Agency

Defended modelled fluvial node locations

Location (easting/northing)
530514/267938

Scale
1:10,000

Model name:
Lower Ouse - Downstream Model

Created 18/05/2022

Legend

- Site
- Modelled Node Point
- Main river

0 110 220 330 440 550
Meters

Modelled Water Levels and Flows

The following tables provide modelled in channel water level and flow values. Values are provided for Annual Exceedence Probability (AEP) events, which is the probability of a given event occurring in any one year. This is not a return period.

The fluvial models used to produce these results are intended for strategic scale use only.

If the tables show a value of -9999, this indicates that we have no level or flow data for that particular AEP or node point.

Level Data

Level values are measured in metres above Ordnance Datum (m aOD).

All level data included are subject to standard modelling tolerance of +/-150 millimetres.

Present Day Levels

Node	Model	Easting	Northing	20%	10%	5%	4%	2%	1.33%	1%	0.5%	0.1%
EA052349LO0179	EA052349	531198	268527	5.94	6.07	6.161	6.21	6.27	6.31	6.32	6.51	6.9
EA052349LO0183	EA052349	530991	268287	6.08	6.21	6.278	6.35	6.41	6.45	6.47	6.68	7.11
EA052349LO0185	EA052349	530829	268096	6.24	6.37	6.422	6.5	6.55	6.6	6.63	6.84	7.11
EA052349LO0186	EA052349	530687	268089	6.39	6.52	6.557	6.64	6.69	6.72	6.74	6.91	7.14
EA052349LO0188	EA052349	530494	268085	6.58	6.72	6.738	6.83	6.87	6.89	6.9	7.02	7.17
EA052349LO0189	EA052349	530290	268076	6.85	6.99	7.009	7.11	7.15	7.17	7.17	7.23	7.3
EA052349LO0190	EA052349	530095	268069	7.1	7.24	7.248	7.35	7.39	7.4	7.41	7.43	7.45
EA052349LO0191	EA052349	529909	268063	7.29	7.43	7.44	7.64	7.77	7.81	7.82	7.88	7.96
EA052349LO0191	EA052349	529909	268063	7.29	7.43	7.44	7.64	7.77	7.81	7.82	7.88	7.96
EA052349LO0192	EA052349	529733	267949	7.49	7.62	7.629	7.87	8.01	8.06	8.07	8.13	8.22
EA052349LO0192	EA052349	529733	267949	7.49	7.62	7.629	7.87	8.01	8.06	8.07	8.13	8.22
EA052349LO0193	EA052349	529596	267806	7.67	7.79	7.798	8.05	8.19	8.24	8.25	8.31	8.39
EA052349LO0193	EA052349	529596	267806	7.67	7.79	7.798	8.05	8.19	8.24	8.25	8.31	8.39

Climate Change Levels

Node	Model	Easting	Northing	1%+20%cc	1%+25%cc	1%+35%cc	1%+65%cc	0.5%+20%cc	0.1%+20%cc
EA052349LO0179	EA052349	531198	268527	6.46	-9999	-9999	-9999	-9999	-9999
EA052349LO0183	EA052349	530991	268287	6.62	-9999	-9999	-9999	-9999	-9999
EA052349LO0185	EA052349	530829	268096	6.77	-9999	-9999	-9999	-9999	-9999
EA052349LO0186	EA052349	530687	268089	6.85	-9999	-9999	-9999	-9999	-9999
EA052349LO0188	EA052349	530494	268085	6.98	-9999	-9999	-9999	-9999	-9999
EA052349LO0189	EA052349	530290	268076	7.21	-9999	-9999	-9999	-9999	-9999
EA052349LO0190	EA052349	530095	268069	7.42	-9999	-9999	-9999	-9999	-9999
EA052349LO0191	EA052349	529909	268063	7.86	-9999	-9999	-9999	-9999	-9999
EA052349LO0191	EA052349	529909	268063	7.86	-9999	-9999	-9999	-9999	-9999
EA052349LO0192	EA052349	529733	267949	8.12	-9999	-9999	-9999	-9999	-9999
EA052349LO0192	EA052349	529733	267949	8.12	-9999	-9999	-9999	-9999	-9999
EA052349LO0193	EA052349	529596	267806	8.3	-9999	-9999	-9999	-9999	-9999
EA052349LO0193	EA052349	529596	267806	8.3	-9999	-9999	-9999	-9999	-9999

Flow Data

Flow values are measured in cubic metres per second (cumecs - m3/s).

Present Day Flows

Node	Model	Easting	Northing	20%	10%	5%	4%	2%	1.33%	1%	0.5%	0.1%
EA052349LO0179	EA052349	531198	268527	6.39	7.17	7.268	8.47	8.94	9.28	9.6	12.25	18.67
EA052349LO0183	EA052349	530991	268287	5.39	6.21	6.216	6.81	7.01	7.64	7.88	9.86	12.06
EA052349LO0185	EA052349	530829	268096	5.39	6.21	6.219	6.84	7.06	7.12	7.13	7.15	7.18
EA052349LO0186	EA052349	530687	268089	5.39	6.21	6.221	6.84	7.06	7.13	7.13	7.16	7.18
EA052349LO0188	EA052349	530494	268085	5.39	6.21	6.221	6.84	7.06	7.12	7.13	7.16	7.18
EA052349LO0189	EA052349	530290	268076	5.39	6.21	6.224	6.84	7.06	7.13	7.13	7.16	7.18
EA052349LO0190	EA052349	530095	268069	5.4	6.21	6.261	8.77	10.45	11.1	11.23	12.05	13.13
EA052349LO0191	EA052349	529909	268063	5.4	6.21	6.263	8.77	10.45	11.09	11.23	12.05	13.13
EA052349LO0191	EA052349	529909	268063	5.4	6.21	6.263	8.77	10.45	11.09	11.23	12.05	13.13
EA052349LO0192	EA052349	529733	267949	5.4	6.22	6.261	8.77	10.45	11.1	11.22	12.05	13.13
EA052349LO0192	EA052349	529733	267949	5.4	6.22	6.261	8.77	10.45	11.1	11.22	12.05	13.13
EA052349LO0193	EA052349	529596	267806	5.4	6.22	6.265	8.77	10.73	11.87	12.15	13.3	14.06
EA052349LO0193	EA052349	529596	267806	5.4	6.22	6.265	8.77	10.73	11.87	12.15	13.3	14.06

Climate Change Flows

Node	Model	Easting	Northing	1%+20%cc	1%+25%cc	1%+35%cc	1%+65%cc	0.5%+20%cc	0.1%+20%cc
EA052349LO0179	EA052349	531198	268527	11.29	-9999	-9999	-9999	-9999	-9999
EA052349LO0183	EA052349	530991	268287	9.34	-9999	-9999	-9999	-9999	-9999
EA052349LO0185	EA052349	530829	268096	7.15	-9999	-9999	-9999	-9999	-9999
EA052349LO0186	EA052349	530687	268089	7.15	-9999	-9999	-9999	-9999	-9999
EA052349LO0188	EA052349	530494	268085	7.15	-9999	-9999	-9999	-9999	-9999
EA052349LO0189	EA052349	530290	268076	7.15	-9999	-9999	-9999	-9999	-9999
EA052349LO0190	EA052349	530095	268069	11.83	-9999	-9999	-9999	-9999	-9999
EA052349LO0191	EA052349	529909	268063	11.83	-9999	-9999	-9999	-9999	-9999
EA052349LO0191	EA052349	529909	268063	11.83	-9999	-9999	-9999	-9999	-9999
EA052349LO0192	EA052349	529733	267949	11.83	-9999	-9999	-9999	-9999	-9999
EA052349LO0192	EA052349	529733	267949	11.83	-9999	-9999	-9999	-9999	-9999
EA052349LO0193	EA052349	529596	267806	13.15	-9999	-9999	-9999	-9999	-9999
EA052349LO0193	EA052349	529596	267806	13.15	-9999	-9999	-9999	-9999	-9999

Strategic flood risk assessments

We recommend that you check the relevant local authority's strategic flood risk assessment (SFRA) as part of your work to prepare a site specific flood risk assessment.

This should give you information about:

- the potential impacts of climate change in this catchment
- areas defined as functional floodplain
- flooding from other sources, such as surface water, ground water and reservoirs

About this data

This data has been generated by strategic scale flood models and is not intended for use at the individual property scale. If you're intending to use this data as part of a flood risk assessment, please include an appropriate modelling tolerance as part of your assessment. The Environment Agency regularly updates its modelling. We recommend that you check the data provided is the most recent, before submitting your flood risk assessment.

Flood risk activity permits

Under the Environmental Permitting (England and Wales) Regulations 2016 some developments may require an environmental permit for flood risk activities from the Environment Agency. This includes any permanent or temporary works that are in, over, under, or nearby a designated main river or flood defence structure.

Find out more about flood risk activity permits

Help and advice

Contact the East Anglia Environment Agency team at enquiries_eastanglia@environment-agency.gov.uk for:

- more information about getting a product 5, 6, 7 or 8
- general help and advice about the site you're requesting data for

Appendix B – Atkins Response

Technical Note[i]

Date	---
Document Title	RESPONSE TO FENSTATON PARISH COUNCIL observations 'Analysis of Fenstanton Flood 23/24 December 2020'
Prepared By:	---
Checked By:	---
Reviewed By:	---
Authorised By:	---
Document reference	HA528983-ACJV-EWE-S3B_FENST-RP-C-0001 Revision P01.1
Purpose of Issue	Work in Progress

1. Introduction

1.1. This document outlines Highways England's review of 'Analysis of Fenstanton Flood 23/24 December 2020' ('the report') provided by Fenstanton Parish Council in light of the flood event of December 2020, in respect of the A14 Cambridge to Huntingdon Scheme.

1.2. The flooding in December was perhaps not unexpected given the hydrological characteristics of the event and in view of the historic flooding on the West Brook in March 1947, October 1993, Easter 1998 and October 2001 to name a few. The area is prone to flooding and the assessment which was undertaken as part of the design of the scheme utilised the best available information, utilising the Environment Agency baseline model of West Brook and updating to include better quality topographic information and surveyed levels.

2. River Flooding

River flows (Hydrology)

2.1. Flows across East Anglia for the duration of the flooding were exceptionally high[1] , which lead to 'On the 23 December 2020 between 47mm and 53mm of rain fell onto the already saturated local catchments of the Alconbury and Ellington Brooks, River Kym and Lower Ouse'. Design hydrology within the modelling was 52mm which equates to a 1 in 100 year rainfall storm event. As the report has highlighted the catchment was saturated. The design parameters for the design scheme does not account for a saturated catchment and therefore the December event would be considered in excess of the A14 design modelled scenario.

2.2. It is also considered that the Lower Ouse catchment is greatly larger in magnitude than the West Brook and therefore the response of these two catchment will be different in terms of the return period of the peak flood levels generated by any particular rainfall storm.

2.3. With a more saturated catchment in reality compared to the modelled scenario, the run-off would have been quicker and therefore the hydrograph peaked quicker

[1] HS_202012.pdf (nerc.ac.uk)

2.4. The depth of rainfall that fell is equivalent to the 1 in 100 year rainfall storm used in the design modelling for the A14 scheme, but because this rainfall fell on a saturated catchment, the resulted flood levels are expected to be higher than the design flood levels used (and mitigated) for the scheme.

2.5. The scheme is designed to maintain the status quo up to the 1 in 100 year plus climate change and in light of the rainfall which fell on the catchment in conjunction with a saturated catchment it is not unexpected that the fluvial system was operational to its maximum capacity. It is also recognised that (without specific analysis) that the event may have been in excess of the design event and they system may have been overwhelmed.

Flood Compensation Areas

2.6. The area of flood compensation (land lowered to allow flood water to enter) for loss of floodplain to West Brook is located to the West of West Brook (within an area shown as Flood Zone 1 on the current EA flood map) and was included in the scheme modelling. This is the formal flood mitigation for the scheme. It is neither required nor intended to reduce the existing flooding which would occur from the surrounding watercourses. The borrow pits are not designed to mitigate the flooding, however it is recognised that their presence could act as informal attenuation to rainfall.

'The Bank'

2.7. Highways England have previously proposed to reconstruct 'The Bank' along the realigned section of West Brook and had extensive discussions with the Environment Agency. The Environment Agency concluded that they would not consent a replacement bund.

3. Surface Water Flooding

Drainage of the road

3.1. In order to not increase the flooding as a result of the additional paved/impermeable areas, it was designed to attenuate, within the balancing ponds, the rainfall falling on the new paved road surface so that the water entering the watercourses in both volume and rate was mimicked. This was designed up to the 1 in 100 year plus climate change event, it is neither required nor intended to reduce the existing flooding which would occur from the surrounding watercourses. However, many of the ponds across the scheme have a greater capacity than is required, providing more storage for rainfall prior to entering the receiving watercourses.

3.2. In this location, as new road, this was the greenfield run-off rate and the design and rates of discharge to the surrounding ditches, watercourses and rivers was designed in line with the required Design Manual for Roads and Bridges (DMRB) and National Planning Policy guidance for surface water run-off.

3.3. The design of the attenuation ponds including the volume of storage, volumes and discharge rates was agreed with Cambridgeshire County Council (as Lead Local Flood Authority) and the Environment Agency during the Development Consent Order phase. This was a legal requirement of the legal Development Consent Order itself.

4. Flooding photographic evidence and commentary

4.1. The photographic evidence shows various flooded land and it is our opinion that it generally concurs with the Environment Agency published flood mapping for planning and the modelling undertaken from this scheme.

4.2. It is worth noting that Photo 3 shows that the flooded farmland is separate from the balancing pond, as intended for the surface water drainage design and clearly showing it wasn't overwhelmed.

4.3. The Environment Agency should be able to provide further records of any historic flooding to properties in the area and accompanying mapping, however from the 2009 FRA it was noted that the *SCDC/CCC SFRA* (WSP, 2010) makes reference to historic flooding on the West Brook in March 1947, October 1993, Easter 1998 and October 2001.

5. Conclusion

5.1. In summary to conclude the following;

- 47mm-53mm of rainfall during the December event fell on a fully saturated catchment,
- The A14 fluvial (river) flood model simulates a 52mm rainfall for a 1 in 100 year event on an unsaturated catchment,
- Therefore, it is considered that the December event was in excess of a 1 in 100 year event and beyond the design event,
- It was not unexpected that the extent of flooding during the December event was in excess of any of the flooding shown in the design assessment.
- Based on the photographic evidence, it broadly supports the Environment Agency published flood zone mapping for Flood Zone 2 (1 in 1000 year event).
- The scheme modelling and design was undertaken using industry standard software, approaches, policy and guidance and was approved by the Environment Agency and Cambridgeshire County Council (as Lead Local Flood Authority).
- Highway England are currently undertaking a review of the 'as built' structures in conjunction with the flood modelling to adhere to the consent conditions and to challenge the current published flood maps (to update them to reflect the scheme mitigation).

[i] Notice

This technical note was produced by ACJV for Highways England for the specific purpose of the A14 Cambridge to Huntingdon Improvements Scheme.

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Appendix C – Fenstanton Parish Council Flood Working Group Report

Analysis of Fenstanton Flood 23/24 December 2020

Martyn Crawshaw
Member of Fenstanton Parish Council Flood Working Group



Background

December 2020 was an unsettled and very wet month, a fitting end to the third wettest year (after 2000 and 2012) for the UK in a series from 1910. Rainfall was above average across the majority of the UK, exceptionally so across East Anglia and north-east Scotland (recording their wettest and second wettest December since 1929, respectively). River flows generally far exceeded December averages across England and Wales, notably so in South Wales and eastern and southwestern England, and exceptionally so in East Anglia where flows were two to three times the average. Soil moisture deficits were near-zero across the whole of the UK, the wettest soils for late December at a national scale since 2012 and comparable with 2000. Groundwater levels rose and were in the normal range or above, with some exceptionally high levels. Reservoir stocks in December were above average at a national scale, notably so in Yorkshire, southwest England and

Northern Ireland. Saturated soils across the country and high river flows and groundwater levels imply an elevated risk that rainfall will bring fluvial and groundwater flooding episodes through the remainder of the winter. (ref: Hydrological summary for the UK - Dec 2020)

On the 23 December 2020 between 47mm and 53mm of rain fell onto the already saturated local catchments of the Alconbury and Ellington Brooks, River Kym and Lower Ouse resulting in a first flood level (peak) at Hemingford Grey of 7.45m AOD which was the same as the Easter 1998 flood level. The Easter 1998 flood, assessed by the Environment Agency (EA) at the time, was a one in 25-year event.

The main urbanised village of Fenstanton is built on higher ground than the surrounding area and therefore has a low probability of flooding. Defined as Flood Zone 1. This is in contrast to adjacent areas to the north of the village along the line of the Great Ouse and south west between Hilton and Fenstanton as shown on the Environment Agency Flood map (Fig 1 & 2 below) which has a high probability of flooding. Defined as Flood Zone 3 and is functional flood plain liable to flood with up to a 1 in 20-yr flood event (1 in 20-yr annual exceedance probability – 5 % AEP).



Fig 1. Environment Agency Flood Zone Map showing area benefiting from flood defences

A small part of north west Fenstanton situated to the south of London Road is within Zone 3 but does benefit from flood defences constructed by the EA in 2006 following the Easter 1998 floods. No other part of the village has the same benefits. Properties to the west and south west that are situated close to West Brook and Hall Green Brook are affected when river levels rise to those experienced in April 1998 and even higher in March 1947. These properties are within Zone 2 as shown in the light blue areas on the flood map below.

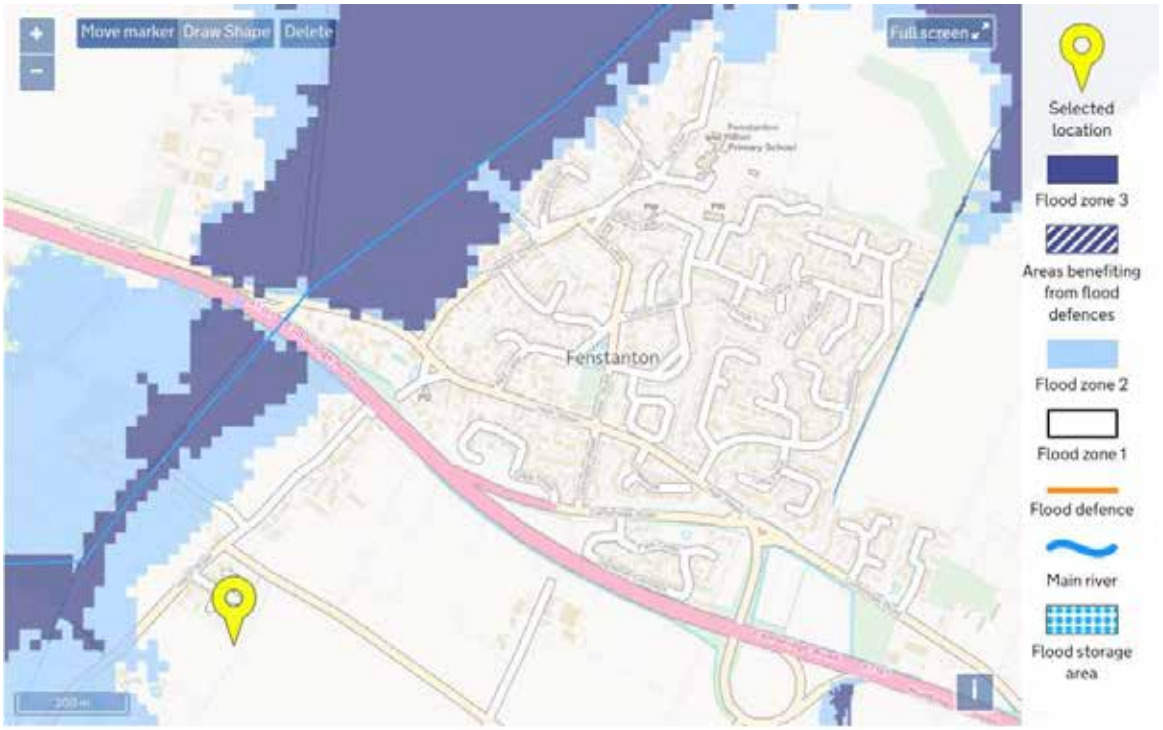


Fig 2. EA flood zones

Fenstanton residents have few experiences of property being inundated through flooding in living memory. It is therefore not surprising the events of 23/24 December came as something of a shock when Old Clayfields was inundated by an uncharacteristic rapid rise in fast flowing water. The house was cut off by 450mm of water on the road and 150mm in the property.

The owner of Hollow Farm Hilton Road reported a wall of water 30mtrs wide and 600mm high rapidly progressing across the field to the south at approximately 05.00 am on 24 Dec 2020. The water hit the farm gates forcing them open and inundating the property to a depth of 600mm. The adjacent buildings used by Thames Laboratories were also inundated to a similar level as were the stables on West End Farm and Fenstanton Bowls Club.

At the same time residents witnessed exceptional and not seen before water flow rates through the culvert under the A1307. Water levels rapidly increased over the banks of Hall Green Brook, up Hall Green Lane, in gardens in Honey Hill and flooded the road at the junction of Low Road and Huntingdon Road. This water receded over the next day and only increased three days later in line with levels in the Great Ouse in St Ives. However, this rising river level water it did not affect Old Clayfields or the road at the junction of Low Road and Huntingdon Road.

Residents also witnessed water flooding over the recently realigned sections of West Brook in the areas north and south of the A14 between B1040 Potton Road bridge and Hilton Road Bridge. This resulted in flood water being diverted across the lower ground into and over the Borrow Pits and inundating Hilton Road and Old Clayfields then north across flood zone 2 (land having

between a 1 in 100 and 1 in 1000 annual exceedance probability of flooding) land inundating Hollow Farm, Thames Laboratories and West End Farm stables.

This section of the A14, including the flood mitigation scheme, had formed an effective reservoir which is completed on the north edge by the raised banks of West Brook which runs west to east. The only escape route, other than the reduced capacity of original West Brook, was onto the road at the bottom of Hilton Road Bridge.

The annotated maps below (Fig 3 and 3a) show the flow of flood water derived from realigned section of West Brook.



Fig 3. Highways England A14 improvement scheme map showing flood water flows from realigned West Brook



Fig 3a. High level of flow of flood water from realigned West Brook

The Fenstanton A14 flood mitigation scheme was designed and modeled to achieve a neutral impact on flooding for a 1 in 100 year event including a 20% margin for climate change. However, the implementation of the scheme has been shown that during a 1 in 25-year event the scheme was overwhelmed.

Photographic Evidence

The following A14 map and pictures show some of the flood zones 1 and 2 areas affected during the 23/24 December flooding, i.e., the flood mitigation scheme and surrounding areas between Hilton Road Bridge and Potton Road bridge. Pictures showing flooded land were taken some time during 24 December 2020. At the time they were taken levels had already dropped by at least 300mm. They were taken and kindly provided by Mr P Cooper of Oxholm Farm, Hilton Road, Fenstanton. Pictures not showing flooded areas are for comparison of the same areas taken from as close to the original spot and angle as possible.



Fig 4. Highways England A14 improvement scheme map showing location and direction for pictures taken 24 December 2020 and similar pictures taken recently



1. Hilton Road looking north towards Old Clayfields. Taken 24 December 20 from cycle path at bottom of bridge



1a. Hilton Road looking north towards Old Clayfields. Taken 04 March 21 from cycle path at bottom of bridge.



2. Looking east from south side of Hilton Road bridge. Taken 24 December 20.



2a. Looking east from south side of Hilton Road bridge. Taken 04 March 21.



3. Looking west across A14 towards B1040. Taken 24 December 20 from south side of Hilton Road bridge. The balance pond can be seen is at a higher elevation to flood area around Borrow Pits.



3a. Looking west across A14 towards B1040. Taken 04 March 21 from south side of Hilton Road bridge.



4. Looking north from Clayfields Farm along Hilton Ditch towards Alpha Farm. Taken 24 December 20. N: This area has not previously been flooded.



4a. Looking north from Clayfields Farm along Hilton Ditch towards Alpha Farm. Taken 04 March 21.



5. Looking south down Hilton Road from last bungalow in Fenstanton Village. Taken 24 December 20.



5a. Looking south down Hilton Road from last bungalow in Fenstanton Village. Taken 04 March 21.

Conclusions

Our investigation clearly shows the implementation of the flood mitigation scheme has failed to meet the neutral impact criteria for the design. The finished height above ground level for the realigned section of West Brook is significantly lower than the connection points to the original brook resulting in a differential in flow capacity. The original brook was embanked on both sides while the realigned section is finished at ground level. During a high flow scenario, the path of least resistance is not via the original West Brook. The height differential is such that significant volumes of water is contained on and flows across lower ground resulting in flooding of areas not previously known to be affected. This buffered water is eventually routed via overwhelmed other ditches and flooded land back into West Brook resulting in an increased flow rate in the main watercourse. It also results in a temporary back pressure on culverts designed to bring water from the south side of the A14. This resulted in new areas of land being flooded to the south of the A14 as seen in picture 4 above.

Fig 5 below shows the flood mitigation scheme with realigned West Brook. Pictures show the northern section of the realigned West Brook and the different finished level compared to original west to east section of original West Brook.



Fig 5. Flood mitigation scheme with realigned West Brook.



6. Northern connection point



7. Realigned West Brook finished at ground level

Recommendations and actions

The following define our recommendations for immediate remedial actions to ensure a neutral impact on surrounding land and property:

1. Construct embankments along total length of realigned West Brook to ensure water is contained to match the original brook.
2. Validate model for flood mitigation scheme with flow and containment measurements taken from actual brooks, ditches and culverts.
3. Implement any further modifications to mitigation scheme and adjoining brooks, ditches and culverts.
4. Carry out dredging and maintenance on adjoining brook, ditches and culverts to ensure conveyance capacity and flow rates are adequate to achieve neutral impact with a one in 100 year, plus margin for climate change.
5. Produce key indicators for Parish and District Councils to monitor effectiveness and ability of scheme and adjoining brooks, ditches and culverts to function within the design criteria.
6. Produce and publish plan for above actions.

Responsibility for monitoring successful completion should be with Cambridge County Council as the Lead Local Flood Authority although we recognise implementation will be the responsibility of Highways England, Environment Agency and HDC.

Analysis of Fenstanton Flood 23/24 December 2020 Addendum

Martyn Crawshaw

Member of Fenstanton Parish Council Flood Working Group



Further evidence

Following the release of version 3.1 of the Flood Analysis Report further evidence has been received showing the extent of flooding over zone 3, 2 & 1 flood zones around West Brook and West End Road, Fenstanton. Properties inundated and the depth of water inside properties is as follows.

1. Old Clayfields, Hilton Road, Fenstanton - 150mm
2. Hollow Farm, Hilton Road, Fenstanton - 600mm
3. Thames Laboratories, Hollow Farm, Hilton Road, Fenstanton - 600mm
4. West End Farm stables, West End Road, Fenstanton - 600mm
5. Fenstanton Bowls Club, West End Road, Fenstanton - 1200mm (outside depth. Club house is above ground level by approx. 600mm)

Figure 1 shows flood water exceeded previous recorded levels due to failure of A14 Flood mitigation scheme.



Fig 1. EA Flood zone map annotated to show extend of 24 December 2020 flooding south of A1307.

Figure 2 shows location and direction of pictures 1, 2 & 3 taken 24 December 2020 and repeated from same location 14 March 2021 for comparison. The depth of water over the land between West End Road and Hilton Road, Fenstanton at the south side of A1307 culvert reached 1200mm. This can be verified by the depth of water inside Fenstanton Bowls club house. This also explains the extreme pressure and volume of water flow out of culvert on north side of A1307.

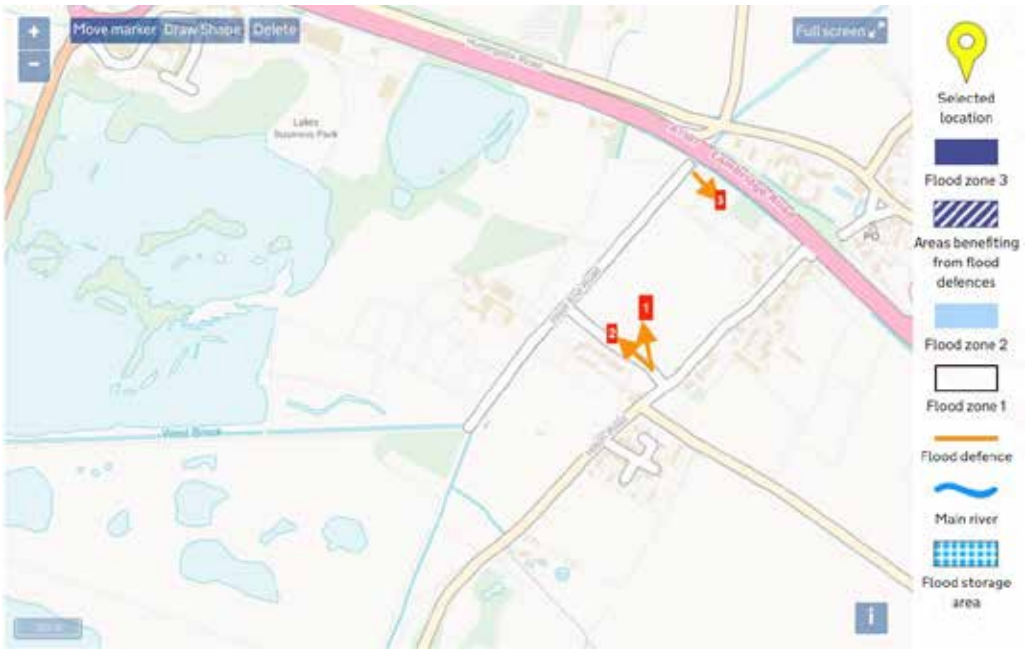


Fig 1. Location and direction of pictures taken 24 December 2020 after water had receded from its peak.



Picture 1. West End Road near Hilton Road direction north west. Taken 24 December 2020.



Picture 1a. West End Road near Hilton Road direction north west. Taken13 March 2021.



Picture 2. West End Road near Hilton Road direction west. Taken 24 December 2020.



Picture 2a: West End Road near Hilton Road direction west. Taken 14 March 2021.



Picture 3. Fenstanton Bowls Club direction east. Taken 24 December 2020.



Picture 3a. Fenstanton Bowls Club direction east. Taken14 March 2021.

Appendix D – Highways England FRA Extract

11 West Brook detailed assessment

11.1 Description

11.1.1 Please refer to *Annex N Figure 11* for a location plan of the West Brook in relation to the scheme.

11.1.2 The West Brook (also known as Hall Green Brook) is located at approximately the centre of the new A14 scheme. The brook is designated as a Main River from west of Hilton village. It flows north-east to its confluence with the river Great Ouse north of Fenstanton (NGR: TL 3208 6985).

11.1.3 A number of Award Drains (including Huntingdon Award Drain to the west and Hilton Drain to the east) outfall into West Brook in the vicinity of the new A14.

11.1.4 The scheme crosses the realigned West Brook at NGR: TL 2964 6767, adjacent to Potton Road (B1040) on a bridge, see *Box 11.1*.

11.1.5 Works on the West Brook at this location would require consent from the Environment Agency under the protective provisions in the DCO. Similarly works to the Award Drains would require consent from Huntingdonshire District Council.

11.2 Existing flood risk

11.2.1 The *SCDC/CCC SFRA* (WSP, 2010) makes reference to historic flooding on the West Brook in March 1947, October 1993, Easter 1998 and October 2001. However, it could be that this flooding was caused more by backing-up from the river Great Ouse than directly from the West Brook itself.

11.2.2 The *2009 FRA* (Highways Agency, 2009a) refers to flooding problems at 'The Nursery' (NGR: TL 3087 6766) resulting from siltation of the Hilton Road Award Drain.

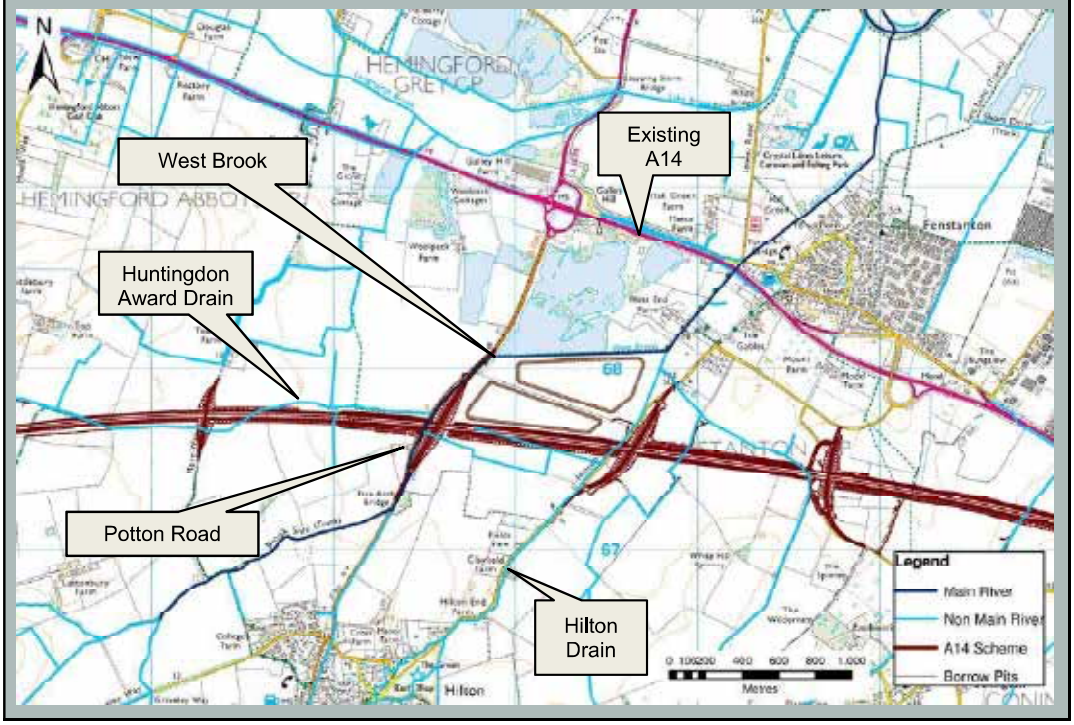
11.2.3 The *2009 FRA* (Highways Agency, 2009a) referred to significant flooding problems in the village of Hilton, in particular during October 2001, when a number of properties were flooded. However, anecdotal reports in the FRA indicate that it was surface water flooding resulting from culvert and/or ordinary watercourse blockage due to insufficient maintenance rather than solely the result of exceedance of channel capacity (i.e. fluvial flooding). The Environment Agency believe that this flooding event in Hilton was not influenced by the West Brook or river Great Ouse.

11.2.4 A new hydraulic model of the West Brook and two Award Drains has been constructed for this FRA which combines the most recent Environment Agency West Brook hydraulic model and the Mike11 model of the Huntingdon Award Drain and Hilton Drain, developed for the *2009 FRA* (Highways Agency, 2009a). They have been augmented with additional topographic channel cross sections completed in 2015. The new model has been used to derive water levels on these watercourses. Please refer to the model build report in *Annex D5* for further details.

11.2.5 Modelled baseline water levels for the West Brook, Huntingdon Award Drain and Hilton Drain are presented in *Table 11.1*.

11.2.6

Box 11.1: West Brook location plan



11.2.7 The hydraulic model produces a revised flood extent to that included on the published Flood Zone map, as indicated in *Box 11.2*. The existing/baseline 1% (1 in 100) AEP flood extent is significantly reduced. The modelled flood extent is particularly reduced west of Potton Road downstream of the scheme; west of Hilton Road, close to The Gables and upstream of the proposed A14. The new flood extents in *Box 11.2* are based on the 'Defended' model scenario (i.e. it includes the effect of flood defences). The 'Undefended' scenario is used to update the published flood zones but the EA has not yet published the flood zones from the new West Brook hydraulic model. A review of the flood defences and Areas Benefitting from Defences, as provided by the Environment Agency, indicates no defences present which would be likely to influence water levels in the West Brook at this location. Those defences that are present appear to be protection from flooding on the river Great Ouse rather than the West Brook. This revised modelling has been used to assess the potential impact of the scheme and consequently any need for mitigation. A full explanation of the changes to the flood zone extent are included in *Annex D5*.

Box 11.2: West Brook existing condition – modelled 1% AEP flood extent between existing and proposed A14.

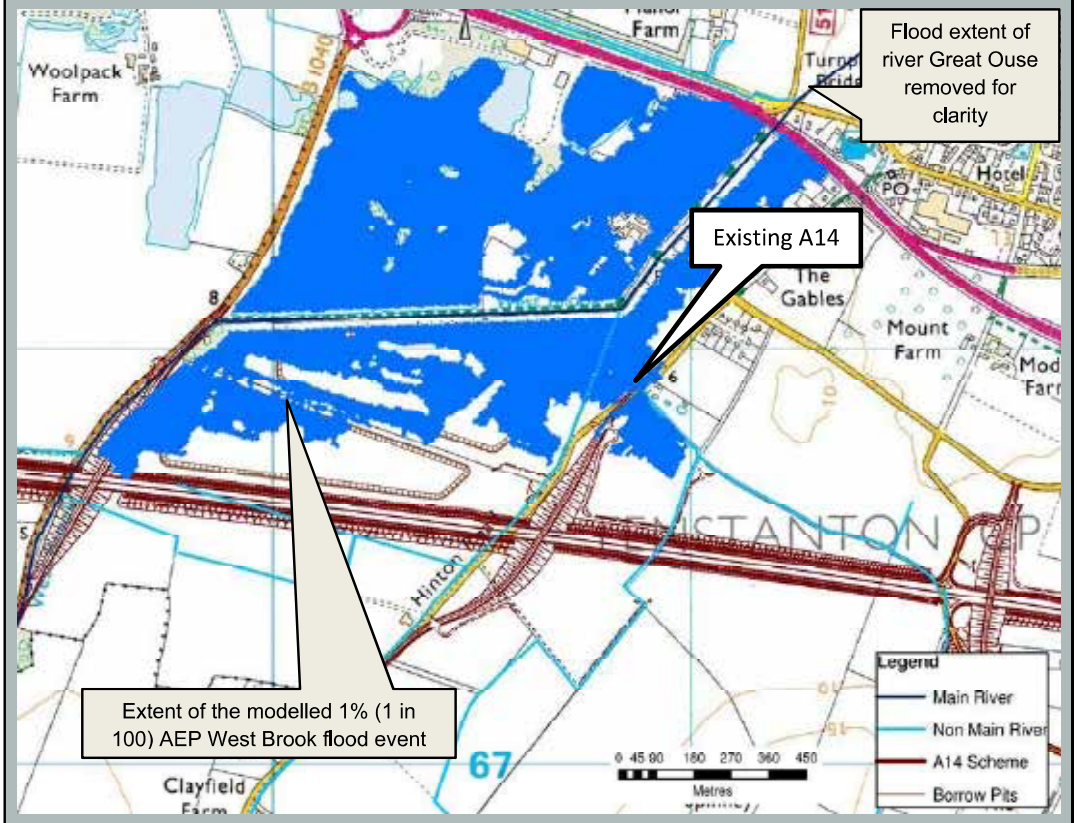


Table 11.1: West Brook existing condition - modelled water levels

Location and chainage	Model node	Peak water level (mAOD)		
		4% AEP	1% AEP	1% AEP + CC
West Brook				
1.94km upstream of new A14	HGB5740	11.43	11.69	11.87
185m upstream of new A14	HGB3985	8.65	8.97	9.15
Immediately upstream A14 crossing	HGB3800	8.35	8.56	8.62
200m downstream of new A14	HGB3600	8.07	8.23	8.28
2.11km downstream of new A14	HGB1686	6.49	6.60	6.76
Huntingdonshire Award Drain				
800m upstream of proposed A14 culvert (Ch12+250)	AWD_2761	20.83	20.93	20.99
Immediately upstream of proposed A14 culvert (Ch12+250)	AWD_1962	14.59	14.72	14.78
Upstream of Mere Way proposed culvert	AWD_1475	12.49	12.62	12.69
Upstream of proposed A14 culvert (Ch13+340)	AWD_1137	11.25	11.41	11.50
491m downstream of proposed A14 culvert (Ch13+340)	AWD_0425	8.66	8.89	9.01
Immediately upstream of Potton Road culvert	AWD_0007	8.25	8.48	8.55
Eastern Award Drain / Hilton Road Drain				
583m upstream of proposed A14	HID_1200	8.09	8.35	8.56
Upstream of proposed A14	HID_0770	7.36	7.69	7.89
Immediately downstream of proposed A14	HID_0558	7.25	7.63	7.84

NB: Scheme chainages have been added where required to aid location identification

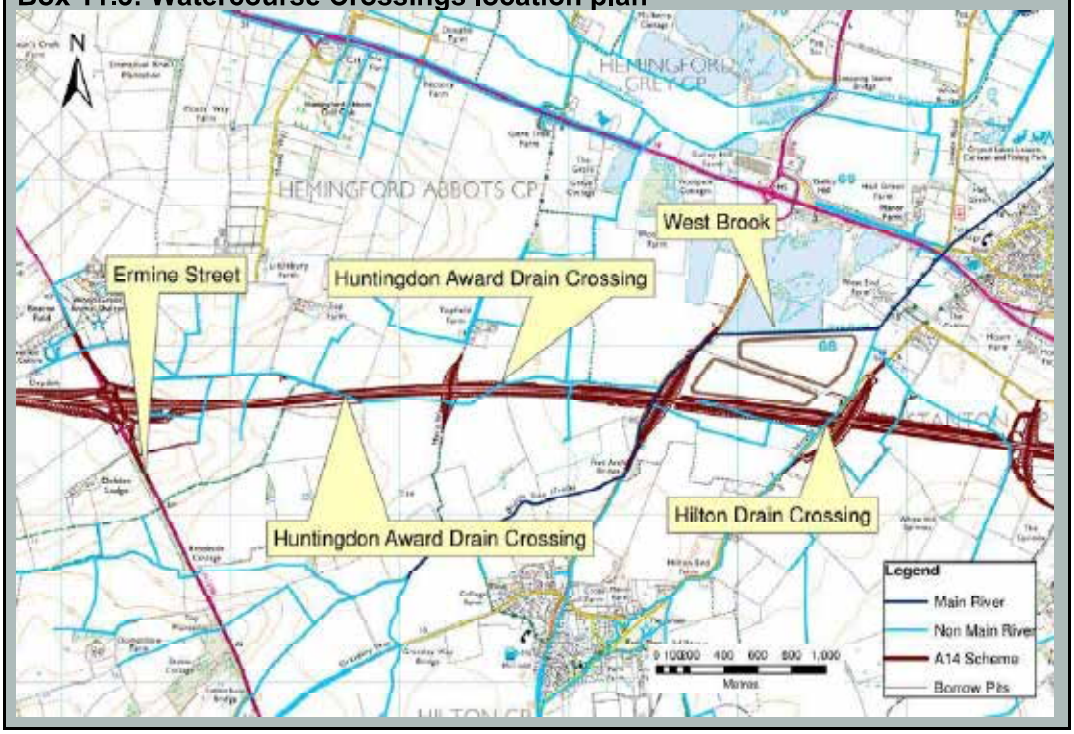
11.3 With-scheme flood risk

11.3.1 The new A14 would cross the West Brook on a new bridge. The bridge would consist of a single span of 11m and would be 31m long (the width of the A14 carriageway). A minor realignment of the brook would also be undertaken in the vicinity of the new A14 to allow for the Potton Road embankment. The re-alignment would follow the embankment toe on the east side. The newly realigned channel would be designed to provide a similar cross-sectional dimension, gradient and floodplain profile to existing. The outline-design for this would be progressed into the next detailed design stage. The crossing and re-alignment have been added to the hydraulic model to test their potential impact on flood risk. Please refer to drawing A14-JCB-BN-14-DR-S-00001 in *Annex H*.

11.3.2 The Huntingdon Award Drain flows parallel with the new A14 to the west of the West Brook, crossing the new road alignment twice approximately 1km and 1.8km west of the West Brook *(See Box 11.3)*. The Huntingdon Award Drain follows the low topography in the areas and therefore all of the surrounding land drains to it. The new A14 would cut off some drainage

paths and to allow for this, drainage ditches would be constructed parallel to the A14 from Ermine Street to their outfall with the West Brook. The changes in land drainage are considered to have a negligible impact and therefore they have not been modelled. This is due to the small catchments affected by each drain, and the minimal change in volume of flow entering the watercourse.

Box 11.3: Watercourse Crossings location plan



11.3.3 The Eastern Award Drain/Hilton Road Drain would be crossed by the new A14 approximately 1km to the east of West Brook. It is proposed to convey this Drain under the new road via an 105m long, 2.7m wide by 2.4m high box culvert (CU182).

11.3.4 Two borrow pits are to be excavated in the area to the north of the proposed A14, within existing floodplain.

11.3.5 The modelling results representing the proposed scenario are summarised in *Table 11.2*.

Table 11.2: West Brook with-scheme condition – modelled water levels

Location	Model node	Peak water level (mAOD)	
		4% AEP	1%AEP
West Brook			
1.94km upstream of new A14	HGB5740	11.43	11.69
185m upstream of new A14	HGB3985	8.61	8.88
Immediately upstream A14 crossing	HGB3800	8.31	8.51
200m downstream of new A14	HGB3600	8.03	8.19
2.11km downstream of new A14	HGB1686	6.46	6.60
Huntingdonshire Award Drain			
800m upstream of proposed A14 culvert (Ch12+250)	AWD_2761	20.83	20.93
Immediately upstream of proposed A14 culvert (Ch12+250)	AWD_1962	14.55	14.67
Upstream of Mere Way proposed culvert	AWD_1475	12.19	12.33
Upstream of proposed A14 culvert (Ch13+340)	AWD_1137	11.23	11.37
491m downstream of proposed A14 culvert (Ch13+340)	AWD_0425	8.57	8.80
Immediately upstream of Potton Road culvert	AWD_0007	8.21	8.45
Eastern Award Drain / Hilton Road Drain			
583m upstream of proposed A14	HID_1200	8.09	8.34
Upstream of proposed A14	HID_0770	7.36	7.59
Immediately downstream of proposed A14	HID_0558RE	6.73	6.90

11.3.6 The with-scheme modelled water levels (*Table 11.2*) have been compared to the existing (*Table 11.1*) to determine the potential impact of the scheme. The difference between the levels is presented in *Table 11.3*.

Table 11.3: West Brook and Award Drains relative change in peak water level

Location	Model node	Peak water level (mAOD)	
		4% AEP	1%AEP
West Brook			
1.94km upstream of proposed A14	HGB5740	0.00	0.00
185m upstream of proposed A14	HGB3985	-0.04	-0.09
Immediately upstream of A14 crossing	HGB3800	-0.04	-0.05
200m downstream of proposed A14	HGB3600	-0.04	-0.04
2.11km downstream of proposed A14	HGB1686	-0.03	0.00
Huntingdonshire Award Drain			
800m upstream of proposed A14 culvert (Ch12+250)	AWD_2761	0.00	0.00
Immediately upstream of proposed A14 culvert (Ch12+250)	AWD_1962	-0.04	-0.05
Upstream of Mere Way proposed culvert	AWD_1475	-0.30	-0.29
Upstream of proposed A14 culvert (Ch13+340)	AWD_1137	-0.02	-0.04
491m downstream of proposed A14 culvert (Ch13+340)	AWD_0425	-0.09	-0. 09
Immediately upstream of Potton Road culvert	AWD_0007	-0.04	-0.03
Eastern Award Drain / Hilton Road Drain			
583m upstream of proposed A14	HID_1200	0.00	-0.01
Immediately upstream of proposed A14	HID_0770	0.00	-0.10
Immediately downstream of proposed A14	HID_0558/ HID_0558RE	-0.52	-0.73

11.3.7 A comparison of the modelled water levels on the West Brook indicate that the scheme would result in no increase to water levels both upstream and downstream of the new crossing for the 1% (1 in 100) AEP event. The change in 1% (1 in 100) AEP water levels is presented in *Box 11.4*.

11.3.8 The scheme would not increase 1% (1 in 100) AEP water levels on the Huntingdon Award Drain.

11.3.9 The scheme would not increase 1% (1 in 100) AEP water levels on the Hilton Drain.

11.3.10 *Box 11.3* indicates that for the 1% (1 in 100) AEP event the scheme results in a reduction in peak water levels in the floodplain against the existing situation. Water levels are predicted to rise within proposed borrow pits, floodplain compensation areas and a small area adjacent to the borrow pits. The borrow pit has been divided into two due to the presence of utilities below ground.

11.3.11 The proposed borrow pit has been modelled as being full of groundwater as a conservative approach. Seasonal fluctuation in groundwater levels could result in the availability of additional flood water storage within the Borrow Pit to that assumed in the model. The borrow pit has not been considered as a flood compensation area. The depth change indicated in the borrow pit in *Box 11.4* includes the groundwater modelled as being present prior to the flood event.

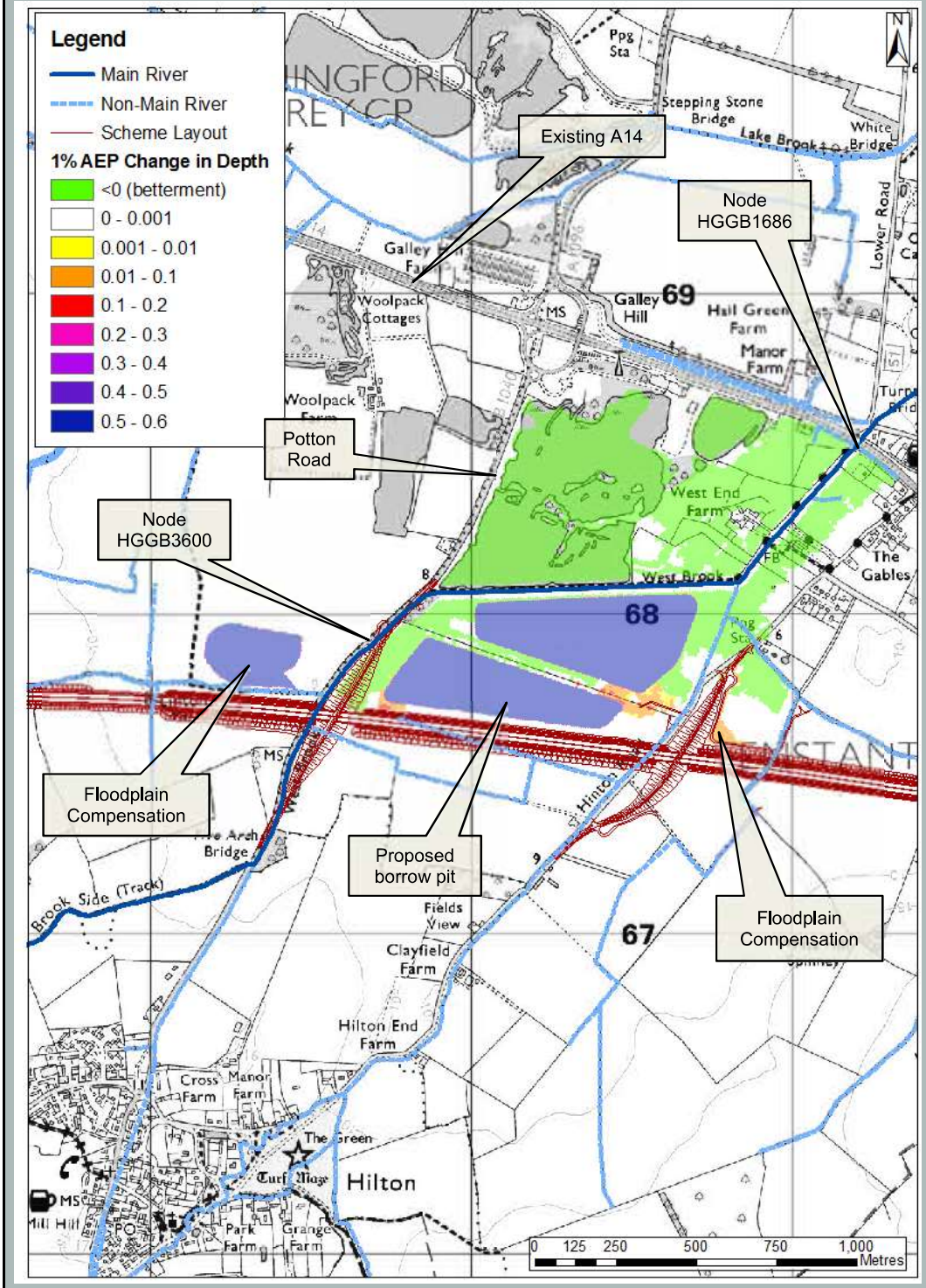
11.3.12 Floodplain compensation has been proposed as mitigation for loss of floodplain as a result of the scheme. It should also be noted that the scheme footprint would only intersect the modelled 1% (1in 100) AEP floodplain on the Potton Road embankment immediately downstream of the crossing.

11.3.13 There is an area of approximately 0.008 km^2 between the borrow pits indicated in *Box 11.4* which is predicted to experience an increase in flood depth greater than 10mm when compared to the existing situation for the 1% (1 in 100) AEP event. This is understood to result from the connectivity of the southern borrow pit with the floodplain for the West Brook. This results in a flow path for flood water from the brook to an existing area of lower ground and is not the result of an increase in water levels in the watercourse. It is not possible to lower ground levels between the two borrow pit sections due to the utilities present in this area. Therefore prevention of the flooding in this area would require bunds or similar raised structures to restrict the connectivity across the floodplain and thus divert flood flows elsewhere which may result in a reduction in the benefits of the scheme downstream. Water levels increase by up to 350mm for the 1% (1 in 100) AEP event in a very small proportion of the area consequently the potential impact of the scheme has therefore been assessed as major adverse at this location. However the water level rise does not affect property and this location is within an area to be permanently acquired by Highways England; consequently no other landowners will be affected. As such the significance of the effect of the scheme is considered slight adverse (summarised in *Table 11.5*). .

11.3.14 Other areas that will experience an increase in flood depth compared to the existing situation are the borrow pit and flood compensation areas. The increase in flood depth in the borrow pit is in part due to the modelled presence of groundwater which has been assumed to fill the borrow pit. The maximum modelled depth of flood water above this assumed groundwater level in the borrow pits is 0.17m in the 1% (1 in 100) AEP event.

11.3.15 An area of approximately 0.65km^2 experiences a decrease in peak water level of 10mm or greater for the 1% (1 in 100) AEP event as a result of the scheme. This area includes sections of floodplain close to properties on Hinton Road.

Box 11.4: West Brook with-scheme change in 1% AEP peak water levels



NB: Comparison water levels are in metres.
Scheme beyond Hilton Road embankment not included within model as no out of bank flooding in the vicinity.

11.4 Proposed mitigation

11.4.1 With-scheme peak water levels in the West Brook are included in *Table 11.3* and are either reduced or remain the same as for the existing situation.

11.4.2 Floodplain compensation storage will be provided to mitigate for the minor encroachment into the floodplain. The floodplain compensation has been included within the with-scheme modelling.

11.4.3 Floodplain compensation would also be provided to mitigate for the minor encroachment into the floodplain for the Hilton Drain by the Hilton Road embankment.

11.4.4 The location of the areas of floodplain loss and compensation are indicated in *Annex N Figure 11*. A schedule of the floodplain compensation areas is included in *Table 11.4*.

Table 11.4: West Brook and Award Drain floodplain compensation summary

Watercourse	Loss volume	Design flood level	Min. loss level	Compensation area ref	Max. level	Min. level
	(m^3)	(mAOD)	(mAOD)		(mAOD)	(mAOD)
West Brook (Potton Road Embankment)	9.414	8.37	7.63	FpC35	8.37	7.90
West Brook (A14 Embankment)	2,498	8.00	7.42	FpC35	8.37	7.90
Hilton Drain	582	6.88	6.70	FpC50	6.88	6.50

11.4.5 Floodplain compensation area FpC35 has been located as close as practicable to the area of loss on the West Brook and FpC50 Hilton Drain. However, FpC35 is located on the Huntingdon Award Drain rather than on the West Brook. It was not possible to identify any areas appropriate for level for level floodplain compensation on the West Brook in close proximity to the scheme, which were not already in the flood zone and where bank and water levels on the West Brook would allow the floodplain compensation to be constructed without impacting on flows outside of flood events. The hydraulic modelling of the FpC's has indicated that provision of floodplain compensation storage on the Huntingdon Award Drain does still result in a reduction of peak water level on the West Brook downstream of the confluence with the Huntingdon Award Drain.

11.4.6 The main body of FpC50 is located approximately 220m from the Hilton Drain, with a narrow channel connecting the two. This is due to a shortage of available land at a higher level close to the watercourse that is not part of the existing floodplain or that would open up new flow paths and result in flooding in other areas. The compensation areas were modelled as connected to the watercourses as described above.

11.4.7 The detailed calculations are included for each area of floodplain loss and each floodplain compensation area in *Annex F*.

11.5 Conclusion

11.5.1 The flood risk impact of the scheme has been assessed as negligible on Hilton Drain and Huntingdon Award Drain and major adverse on the West Brook.

11.5.2 The scheme does not impact upon flood risk in the village of Hilton upstream/south of the A14.

11.5.3 The provision of floodplain compensation as mitigation for areas lost and the reduction in water levels due to the scheme will result in a number of areas with a reduction in flood risk due to the scheme. A small area between the proposed borrow pit sections will experience an increase in flood depth in the 1% (1 in 100 year) AEP event due to the scheme. This is attributed to the connectivity of the borrow pit and the floodplain, subsequently introducing a flow path to an area of existing low ground. There is no property within the area affected by this rise in levels. This area is to be permanently acquired by Highways England for the scheme.

11.5.4 Overall the scheme is considered to have a neutral effect on flood risk for the Huntingdon Award Drain and the Hilton Road Drain, and a slight adverse effect locally on flood risk for the West Brook. This is due to the area of West Brook floodplain with increased flood depth of greater than 100mm, resulting in a major adverse magnitude of impact, but as this occurs in an area to be permanently acquired by Highways England for the scheme and it does not affect property, the significance of this is considered to be slight, *Table 11.5* provides a summary.

Table 11.5: West Brook summary

Watercourse	Importance	Flood Risk Issue(s)	Proposed Mitigation	Magnitude of impact	Significance of effect
West Brook	Medium	Loss of floodplain Area of floodplain with increased depth	Floodplain compensation	Major Adverse	Slight Adverse
Hunts Award Drain	Low	Loss of floodplain	Floodplain compensation	Negligible	Neutral
Hilton Road Drain	Low	Loss of floodplain	Floodplain compensation	Negligible	Neutral

Quality Control

Action	Name
Prepared	Freya Green
Checked	Dr Alexandros Tsavdaris
Approved	Dr Alexandros Tsavdaris

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Version	Date	Amendments	Issued to
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