North Yorkshire County Council

Flood Investigation Report

February 2020

Business and Environmental Services

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Acknowledgements

North Yorkshire County Council Development Management Team would like to thank the following for their cooperation and assistance in this investigation:

Craven District Council

Harrogate Borough Council

Selby District Council

Hambleton District Council

Yorkshire Water Services Ltd

The Environment Agency

Selby Area IDB

Local County Councilors and Parish Councils

North Yorkshire County Council Highways Department

North Yorkshire County Council Resilience & Emergencies Team

North Yorkshire County Council Major Incident Response Team

National Farmers Union

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Table of contents

1.0 Executive summary

The UK MET Office with records commencing in 1891, reports that February 2020 was the wettest February on record (MET Office UK data). The Pennine fed catchments of the Swale, Ure, Nidd, Wharfe, Aire, Calder and Don received between 320% and 375% of the monthly Long Term Average (LTA) rainfall. The lower Ouse, Rye, Derwent and Hull further east received between 245% and 295% of the LTA.

Initially, Stoms Ciara and Dennis saw the river Ribble in the west of the county, record a highest ever level of 2.87m on the 9th February at Pennybridge. On the same day the Wharfe at Netherside hall also recorded a highest ever peak of 3.91m.record. The above resulted in flooding of properties in the Settle, Gargrave and Skipton areas, as well as Pateley Bridge, Masham and Boroughbridge. Craven District Council recorded up to 25 properties internally flooded with 44 reported to Harrogate Borough Council.

Further downstream on the River Aire, the impacts of the consecutive storm events in February, coupled with the already saturated flood plain, caused the washland areas around Hirst Courtney to reach capacity. Initially the washlands operated as they were designed, to hold and store water from the River Aire to reduce flood risk in the area. The River Aire was however very high as a result of prolonged rain across its catchment and there was overtopping of the river into the communities of West Bank and Hirst Courtney on the 25th February. It is also reported that flooding at Hirst Courtney was attributed to Black Drain not being able to drain into the river Aire because of high water levels. Selby District Council reported 27 properties as flooded internally throughout the district, but mostly along the Hirst Road corridor between the A19 and Carlton.

Numerous flood warnings were issued and re-issued throughout February and into March 2020 due to consecutive storms. Whilst the warnings were issued, nothing could have prepared the Risk Management Authorities for the sheer volume of water that flowed through the catchments, and in particular, the volume of water that reached the Lower Aire. Photographic evidence show areas indicated to be at low risk of flooding (i.e. less than a 1 in 1,000 year) to be under water. The event therefore exceeded all modelled scenarios and was not something that could be effectively prepared for.

As part of this investigation a review has been undertaken of river stage data in addition to literature review of publications from the Environemnt Agency and Leeds City Council. The report acknowledges the limitation of reviewing river gauge stage data as part of the investigation, and therefore recommends further work with partnering Risk Management Authorities to better understand the complex relationship between the washland capacities in relation to the wider catchment, and in particular, to better understand the relationship between the Middle and Lower Aire reaches. This is work that the EA have already started to commission with all RMAs invited as stakeholders.

This report makes a number of recommendations with the aim of improving preparedness, resilience and recovery of communities throughout North Yorkshire and on improving the understanding of flooding mechanism in the lower Aire. It is also recommended that every opportunity is taken to ensure that regular maintenance of existing infrastructure is undertaken to ensure that drainage systems are functioning to their full capacity, particularly in Masham. Given the event has highlighted the risk in the locations and climate change predictions indicating that these type of storm events will become more frequent; it is critical that communities also play an active role in helping themselves to be resilient to the increasingly prevalent risk of flooding.

1.1 Scope/purpose of report

This document has been prepared specifically for the purpose of meeting the requirements of Section 19 of the Flood and Water Management Act 2010.

The purpose of this report is to investigate which Risk Management Authorities (RMAs) had relevant flood risk management functions during the flooding that occurred throughout February 2020, and whether the relevant RMAs have exercised, or propose to exercise, their risk management functions (as per section 19(1) of the Flood and Water Management Act 2010). It does not address wider issues beyond that remit.

The supporting data has been put together based on reports of flooding from a variety of sources. Whilst every effort has been made to verify the locations that were flooded, the nature of the data and the methods used to collate this information mean that it does not include every occurrence of flooding. Private individual properties which flooded are not identified in this report. This data only identifies general areas where flooding has been reported to the Lead Local Flood Authority (LLFA) and is indicative only.

1.2 Flood and Water Management Act (2010)

In his review of the summer 2007 floods, Sir Michael Pitt recommended that local authorities should be given a duty to investigate flooding.

The Flood and Water Management Act 2010 (FWMA), defines the roles and responsibilities of 'Risk Management Authorities' and designates the unitary or upper tier authority for an area as Lead Local Flood Authority (LLFA).

The LLFA has responsibility for leading and co-ordinating local flood risk management. Local flood risk is defined as the risk of flooding from surface water runoff, groundwater and small ditches and watercourses (collectively known as ordinary watercourses). The responsibility to lead and co-ordinate the management of tidal and fluvial flood risk remains that of the Environment Agency (EA).

The Act also implements the recommendations made by Sir Michael Pitt that local authorities should have a duty to investigate flooding from all sources.

1.3 Section 19 Investigation Requirement

North Yorkshire County Council (NYCC), as LLFA, has a responsibility under Section 19 of the FWMA to investigate significant flood incidents in its area. Section 19 states:

(1) On becoming aware of a flood in its area, a lead local flood authority must, to the extent that it considers it necessary or appropriate, investigate —

(a) which risk management authorities have relevant flood risk management functions, and

(b) whether each of those risk management authorities has exercised, or is proposing to exercise, those functions in response to the flood.

(2) Where an authority carries out an investigation under subsection (1) it must —

(a) publish the results of its investigation, and

(b) notify any relevant risk management authorities.

Section 14 of the FWMA grants the LLFA power to request information associated with its functions. These powers have been exercised in the preparation of this report.

1.4 Trigger for Section 19 Report

The incident has been assessed in line with the criteria set out in Section 3 of the North Yorkshire County Council Local Flood Risk Strategy (2015) and has been judged to warrant a formal Section19 investigation on the basis of:

a. The relationship with the functions of other Risk Management Authorities.

b. Number of properties internally flooded.

c. The depth, area or velocity of flooding reported.

d. The nature and extent of critical infrastructure impacted by the flood.

2 Event background

2.1 Location of this investigation and current understanding of risk

Flooding incidents were recorded in over 26 separate communities across the western and southern parts of North Yorkshire throughout February 2020. A high level map is provided in Figure 1 illustrating how the incidents reported to NYCC are spread geographically across the County.

In general, the recorded incidents with the exception of the Lower Aire can be described as number of isolated incidents, but with the February 2020 event as a common factor. Given the isolated nature of the incidents there is a risk of publishing details of individual properties. In order to avoid this, and as some areas were affected worse than others, this report focuses on the settlements that would normally meet the criteria for a Section 19 report as set out in section 1.4 above. The report is therefore split into district areas of Craven, Harrogate, Hambleton and Selby and will focus on the following worst affected settlements of Gildersleets in Craven, Masham in Harrogate Borough, and finally the Lower Aire area along the Hirst Road corridor from the A19 at Chapel Haddlesey to Carlton Bridge in Selby District. The incidents recorded in Hambleton district were mainly relating to individual properties and significant infrastructure such as the A684 at Morton Flats and Dalton Bridge near Dalton industrial estate. NYCC has undertaken further work on the two infrastructure projects and will continue to work with the local communities in Hambleton as part of its LLFA role. All affected areas have been noted and recorded in Section 4 of the report as an accurate and historical record of the event, however the investigation for these areas do not warrant formal publication.

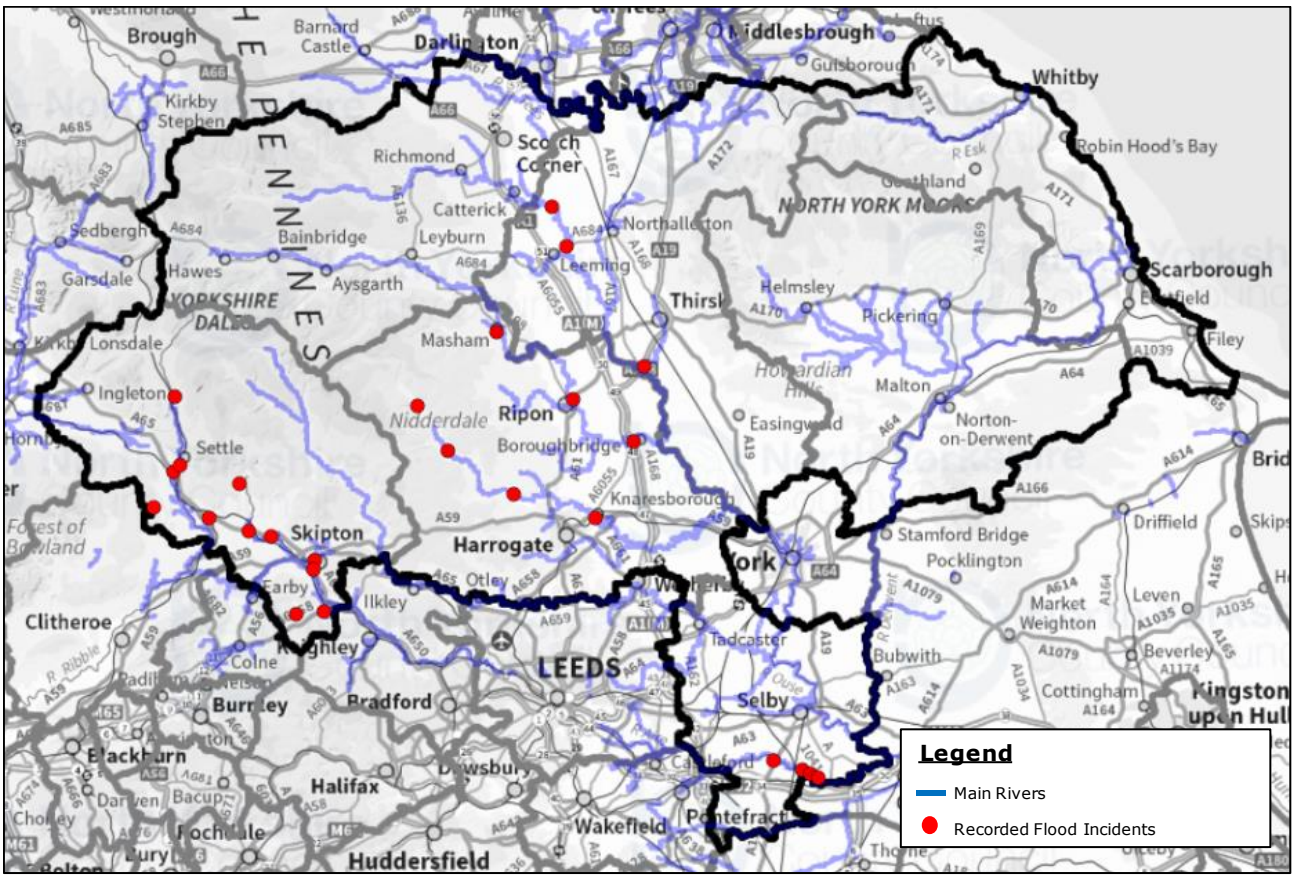


Figure 1: Map of Flooding locations

This section of the report presents the location of each of the above settlements and provides a brief synopsis of the current understanding of flood risk. The understanding of flood risk is based on the best currently publically available data.

The flood map for planning, is a publically available tool for reviewing flood risk from rivers and the sea. The flood map for planning is available to see online at https://flood-map-for-planning.service.gov.uk/

The flood map for planning provides the best available information on fluvial and tidal flooding. It is largely based on modelled data and the information it therefore provides is indicative of the expected flood extent. The information is not sufficiently detailed to demonstrate risk at individual property level, primarily because the Environment Agency do not hold details about properties and their door thresholds and floor levels. Properties with higher floor levels may not always face the same chance of flooding as the areas that surround them. The mapping is also limited to watercourses with a catchment area generally greater than 2km^2. This means that some of the smaller watercourses may not have an indicative flood extent recorded on the system.

It should also be noted that locations may also be at risk from other sources of flooding, such as overland (surface water) runoff from heavy rain, or failure of infrastructure such as sewers and storm drains.

Areas at risk of surface water flooding are harder to understand and demonstrate than areas at risk from tidal or fluvial flooding. Small changes such as raising or lowering a kerb can alter the way surface water flows through a town or village. Notwithstanding this, where smaller watercourses have not been included in the national generalised modelling on the flood map for planning, the risk of surface water flooding maps give an indication of flood risk based upon Lidar imaging.

Surface water risk and risk from reservoirs maps are available to see online at https://flood-warning-information.service.gov.uk/long-term-flood-risk

Water held and flowing within permeable rocks and within the soil below the normal ground level is termed groundwater. Groundwater flooding occurs when the level of the water in the ground – sometimes referred to as the water table - rises above the ground level, or infiltrates underground structures which are designed to be dry. Groundwater flooding would typically occur when sustained periods of heavy rainfall over several months is experienced.

An assessment of risk for each of the investigation areas are set out below.

2.2 Craven District

2.2.2 Gildersleets

Gildersleets (grid reference 380706 462548) is a settlement approximately 1 mile south west of the centre of Settle. The settlement is located immediately adjacent the A65 as shown in the location plan presented in *Figure 2*. Gildersleets and its flood risk is characterised by 3 watercourses. The River Ribble, a designated Main River flows in a southerly direction 100m east of the properties. Tems beck, a designated ordinary watercourse flows in a south easterly direction to its confluence with the River Ribble 130m east of the proprties. A third unnamed watercourse flows from under the A65 along watery lane in a south easterly direction. The watercourse is culverted under Raines Road and flows in a canalised section for 110m north of the properties. This watercourse then confluences with Tems Beck as shown in Figure 2. The River Ribble has a catchment area of 129km^2 upstream of Gildersleets.

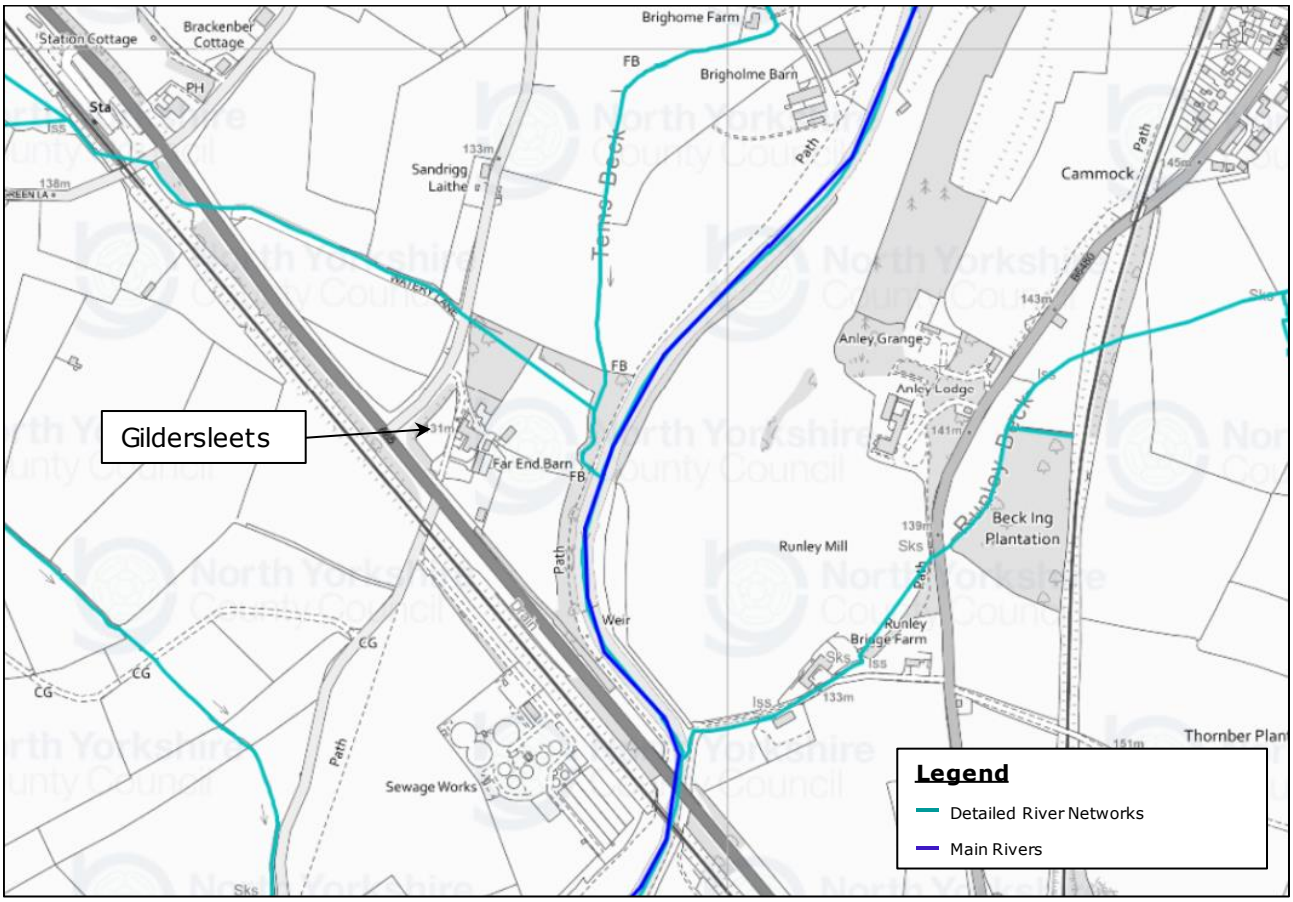
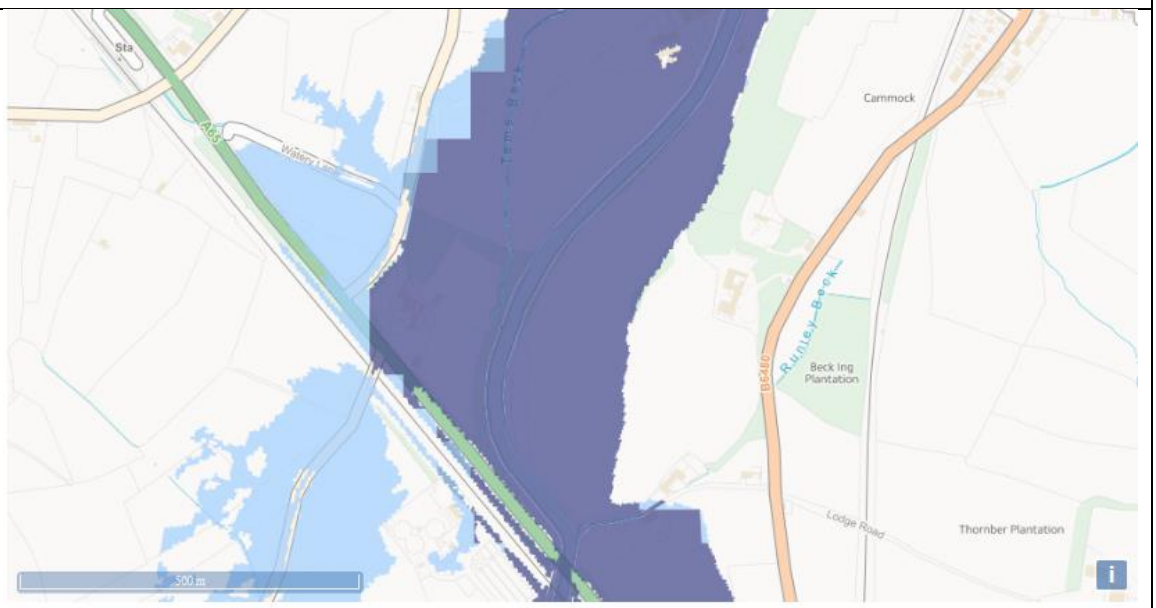
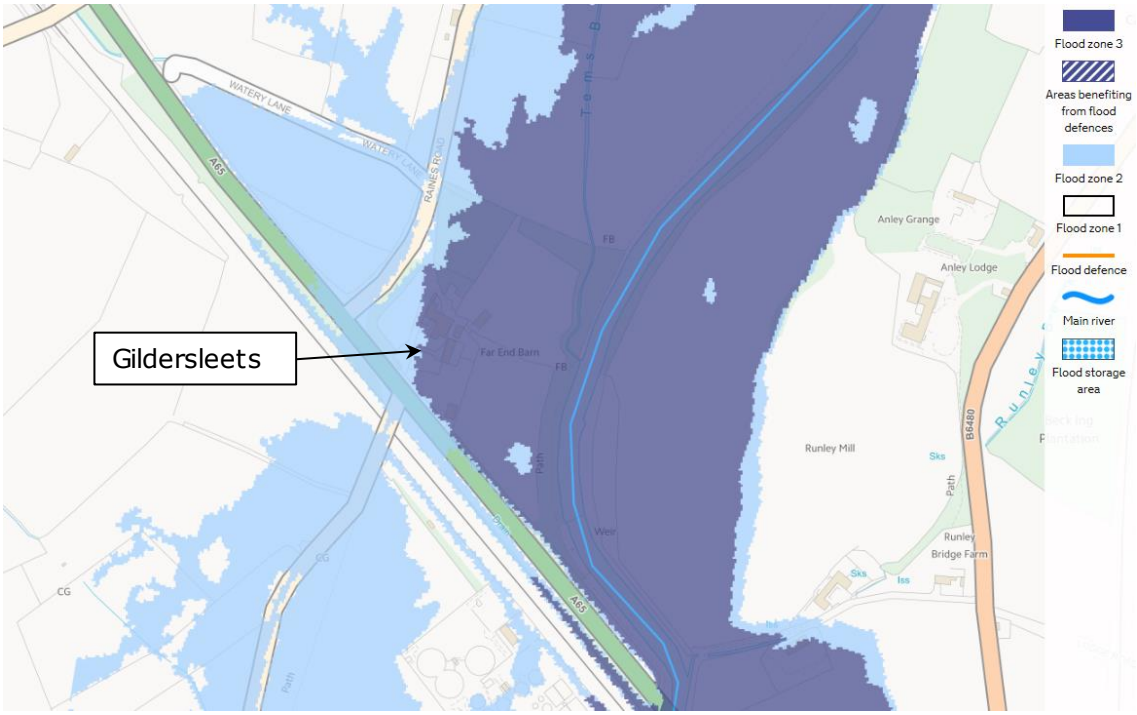
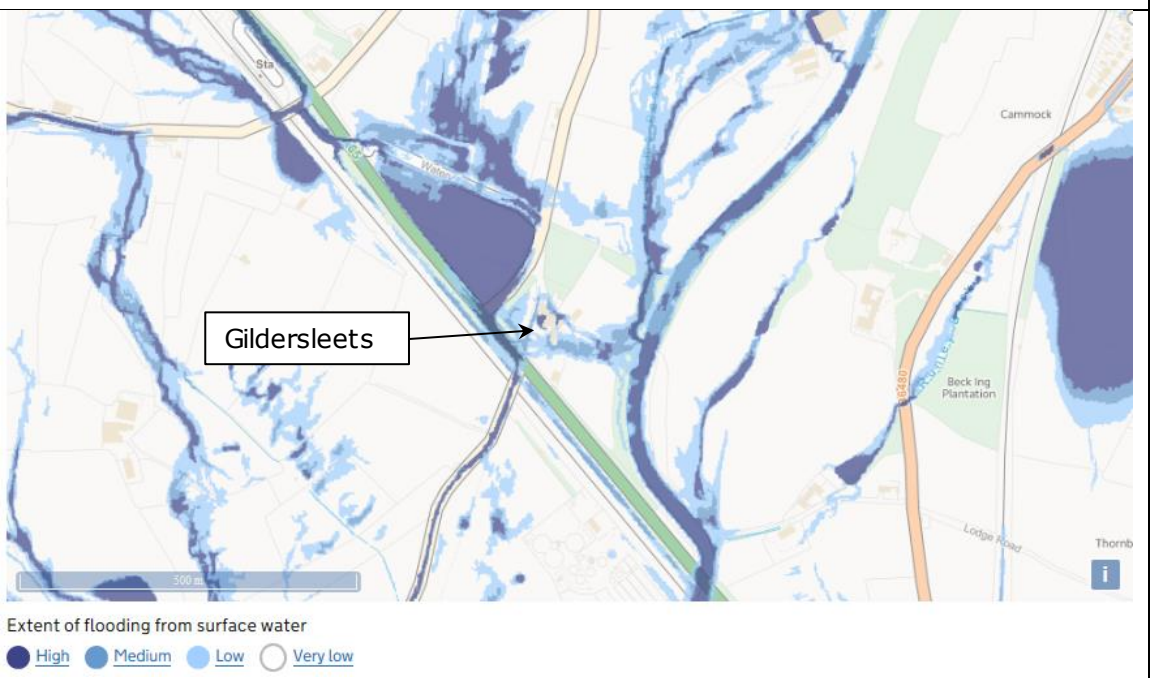
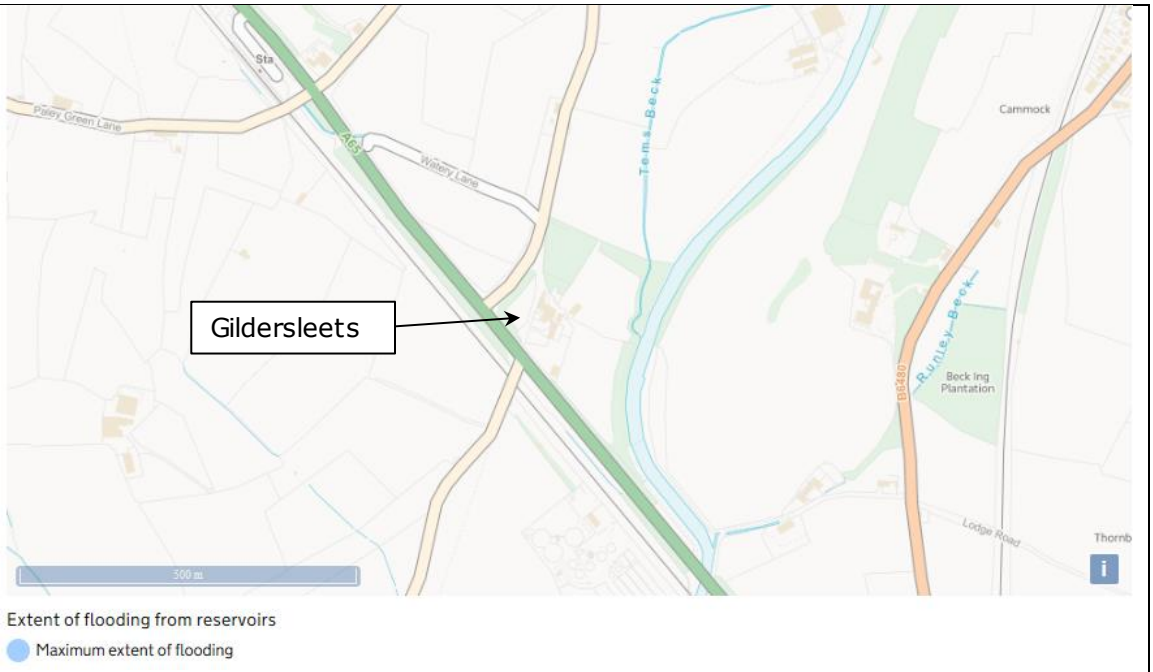


Figure 2 - Gildersleets Location Plan

Table 1: Gildersleets Understanding of Flood Risk

Source of Flooding	Understanding of Risk
Flood Risk from River or the Sea	 Extent of flooding from rivers or the sea High Medium Low Very low The properties at Gildersleets are shown to be at high risk (a frequency more often than 1 in 30 years) of flooding from the River Ribble. The flood water appears to be contained to the

	western side of Raines road. In of low risk event (a frequency of between 1 in 100 and 1 in 1,000 year) floodwater is shown to overtop the Rains Road and flow to the field west.
Flood Map for Planning	 The properties are Gildersleets are shown to be predominately located in flood zone 3. This equates to a high risk of flooding from the River Ribble.
Pluvial Flood Risk (Surface Water)	 The Risk of Flooding from Surface Water maps also shows significant areas of high, medium and low risk of surface water flooding. Particularly the field located north west of the properties and north east of the A65. The properties themselves are shown to be and medium to high risk of surface water flooding.

Reservoir Flooding	 Gildersleets is not shown to be at risk of flooding from reservoirs.
Flood Alert and Warning Areas	Gildersleets is included in the Upper River Ribble Flood Alert Area
Current Flood Defences	There are no formal flood defences to protect the Gildersleets from the River Ribble. A flood defence barrier was installed in a partnership project between NYCC Highways and NYCC Flood Risk Management Team to prevent surface water flows from the A65 flooding the properties. This work was funded by central government flood recovery framework grant in 2015.

2.3 Harrogate District

2.3.2 Masham

According to the visit Masham tourist information page, Masham (central grid reference 422394 480715) – originally Maessa's Ham – probably owed its foundation to the gentle, flood-proof rise on which it stands, near an easily fordable part of the River Ure, together with its proximity to the course of a Roman road and its position on the main route from Wensleydale to York. Whilst the town is set above the River Ure floodplain, a second Main River, Swinney Beck flows in a south easterly direction and confluences with the River Burn and Ure 100 m downstream of the town. The River Burn, a designated ordinary watercourse flows in an easterly direction to the south of Masham confluences with the River Ure at the same location as above. The River Ure and Swinney Beck have catchment areas of 533km^2 and 8.24km^2 respectively upstream of Masham.

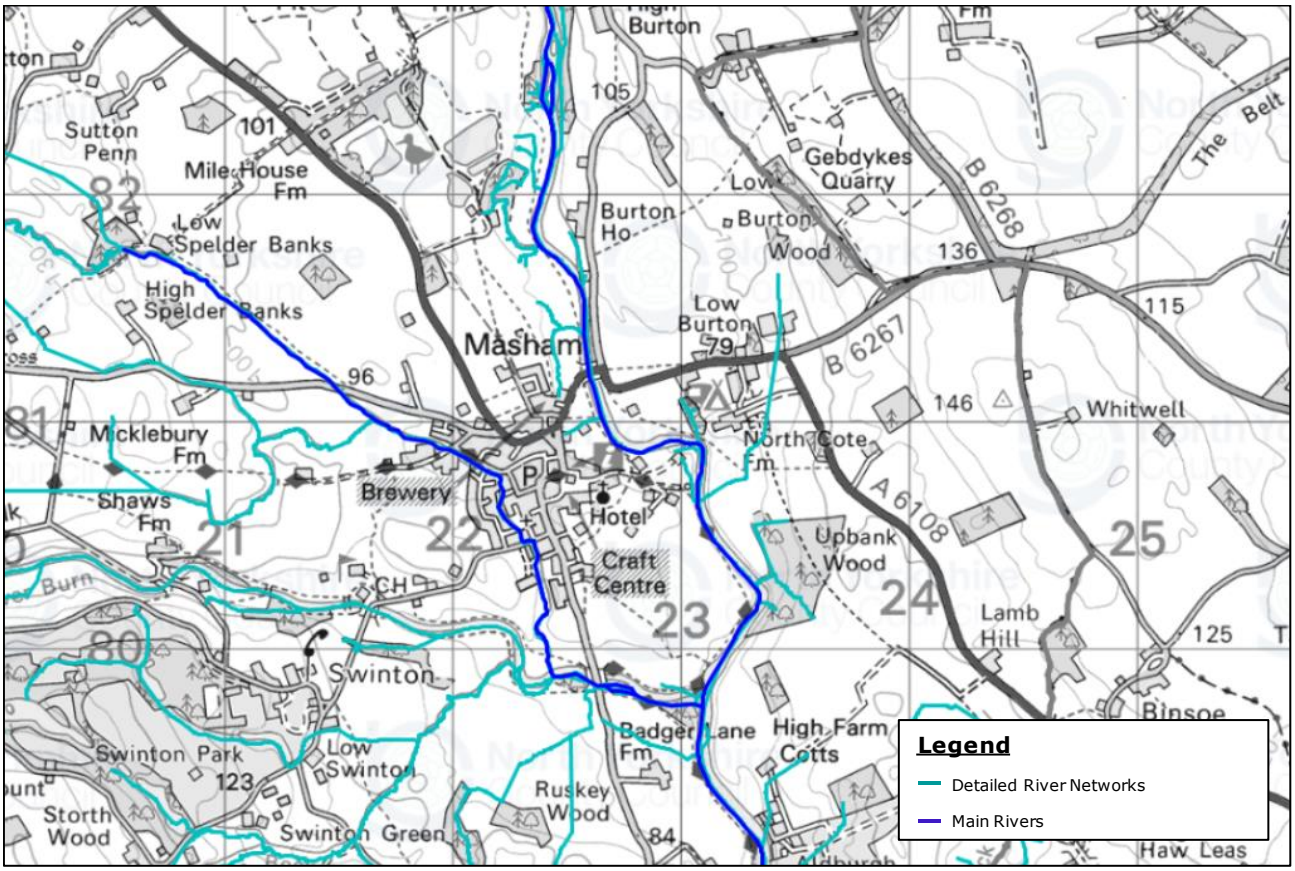
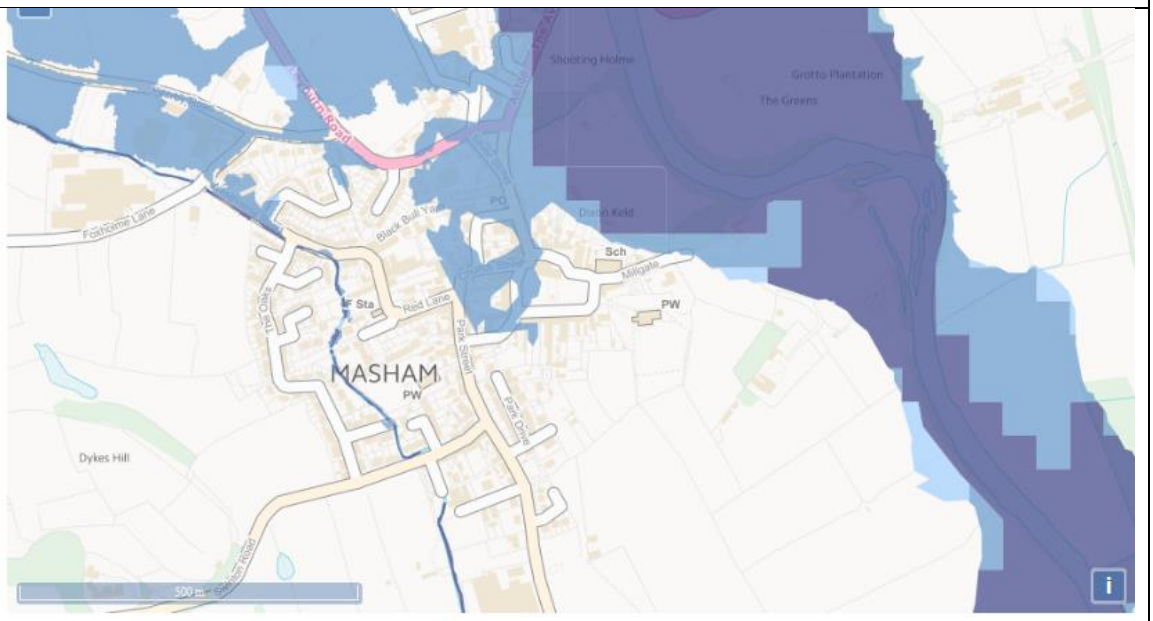
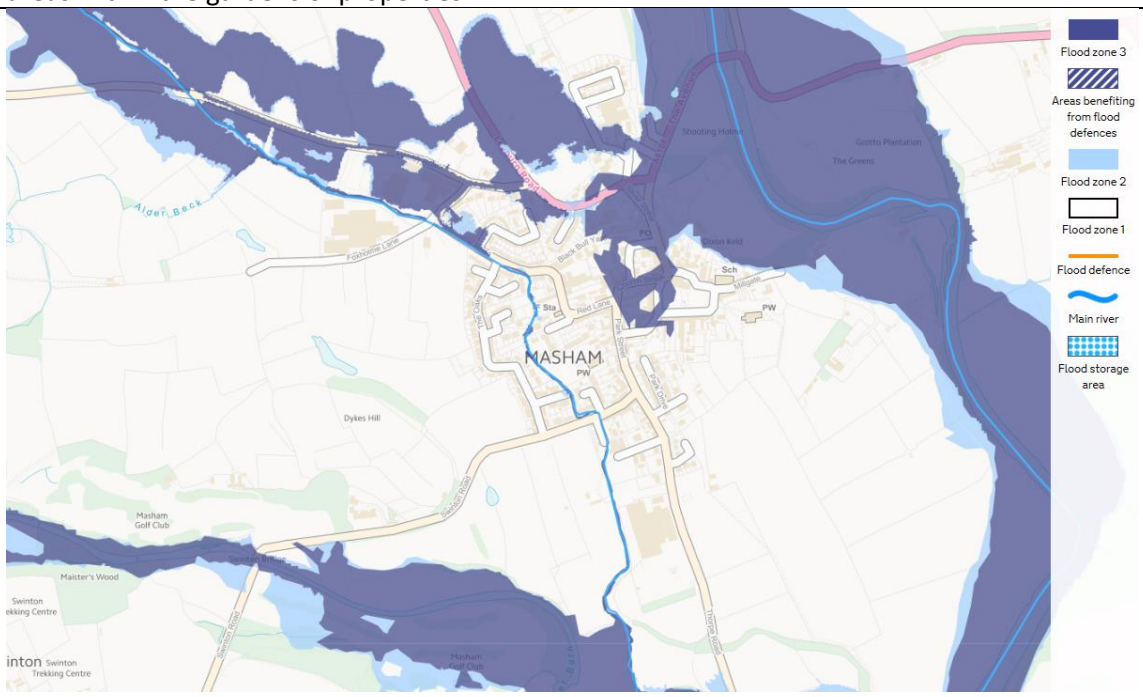
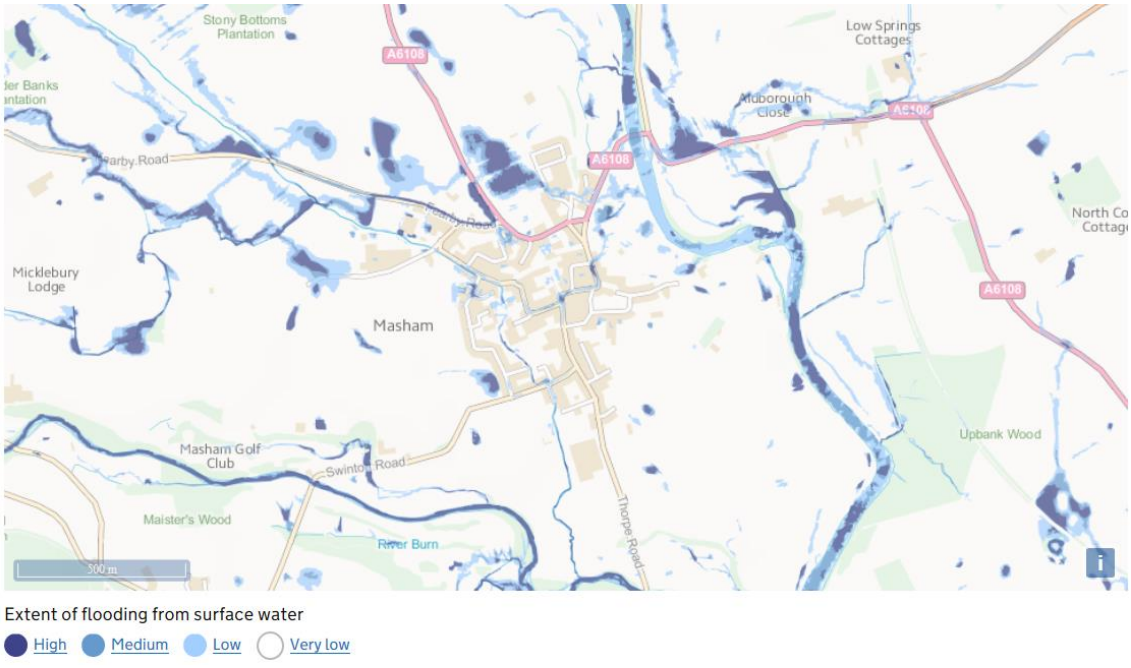


Figure 3 : Masham Location Plan and Watercourse Map

Table 2: Masham Understanding of Flood Risk

Source of Flooding	Understanding of Risk
Flood Risk from River or the Sea	 As per the description of Masham, the majority of the town is located outside of the high risk floodplain of the River Ure. An area of medium risk (a flooding frequency of between 1in 30 years and 1 in 100 years) is shown to affect Silver Street and Church street. Along Swinney

	Beck, the main areas of risk are indicated to be upstream of Westholme Road with isolated areas within the gardens of properties.
Fluvial Flood Risk (River Flooding)	 The flood map for planning is primarily based on the modelling used to inform the rivers and sea (in addition to anecdotal evidence of flooding). The flood zone extents therefore mirror the map above. Both main rivers are easily identifiable in light blue and the map confirms that there are no formal defences in Masham.
Pluvial Flood Risk (Surface Water)	 It is noted the areas shown at most risk within Masham are predominantly contained within the highways and are representative of the flow paths observed in recent event. The map does not however show any links between Swinney Beck and the flow paths (this is likely due to the modelling methodology and we must acknowledge the limitations of modelling). Of particular interest to this study is the high (frequency of more than every 1 in 30 years), medium (frequency between 1 in 30 years and 1 in 100 years) and low (between 1 in 100 and 1 in 1,000

	years) risk shown on Westholme Road adjacent to Swinney Beck, Red Lane, Park Square, Church Street and Silver Street.
Reservoir Flooding	 Extent of flooding from reservoirs Maximum extent of flooding The risk of flooding from reservoirs is shown to follow a similar extent to the risk of fluvial flooding. Overall, the centre of Masham is not shown to be at risk of flooding from reservoirs.
Flood Alert and Warning Areas	Masham is included in the Lower River Ure Flood Alert Area
Current Flood Defences	Masham is not shown to benefit from any flood defences.

2.4 Selby District

2.4.1 Chapel Haddlesey, Hirst Courtney, West Bank and Carlton

Chapel Haddlesey (central grid reference 458289 426091) is a village and civil parish in the Selby District of North Yorkshire, England. The village is just east off the A19 road, which crosses the River Aire on Haddlesey Bridge. Boats used to travel up the River Aire to the south of the village and a weir and lock (Haddlesey Old Lock) were constructed in 1702. The lock became redundant upon the opening of the Selby Canal in 1778, but the weir was kept in place to allow headwaters to build up and keep the mouth from the canal at Selby in deep water.

The River Aire flows in a south easterly direction to the south of the village. The River Aire has a catchment area of 2000km^2 upstream of the village. Chapel Haddlesey is connected to the village of West Haddlesey to the west, on the other side of the A19, along Eastfield lane. To the east along Old Lane ,which runs in a parallel direction to the River Aire ,Chapel Haddlesey is connected to the village of East Haddlesey and further along, the village of Temple Hirst.

Hirst Courtney (central grid reference 461064 424524) lies approximately a mile to the east of the Temple Hirst and 2.8 miles from Chapel Haddlesey . Hirst road continues to the east and again parallel to the River Aire, through the

settlement of West bank and on to the village of Carlton (central grid reference 464780 424192) The village is situated approximately 5 miles (8 km) south-east of the town of Selby on the A1041 road.

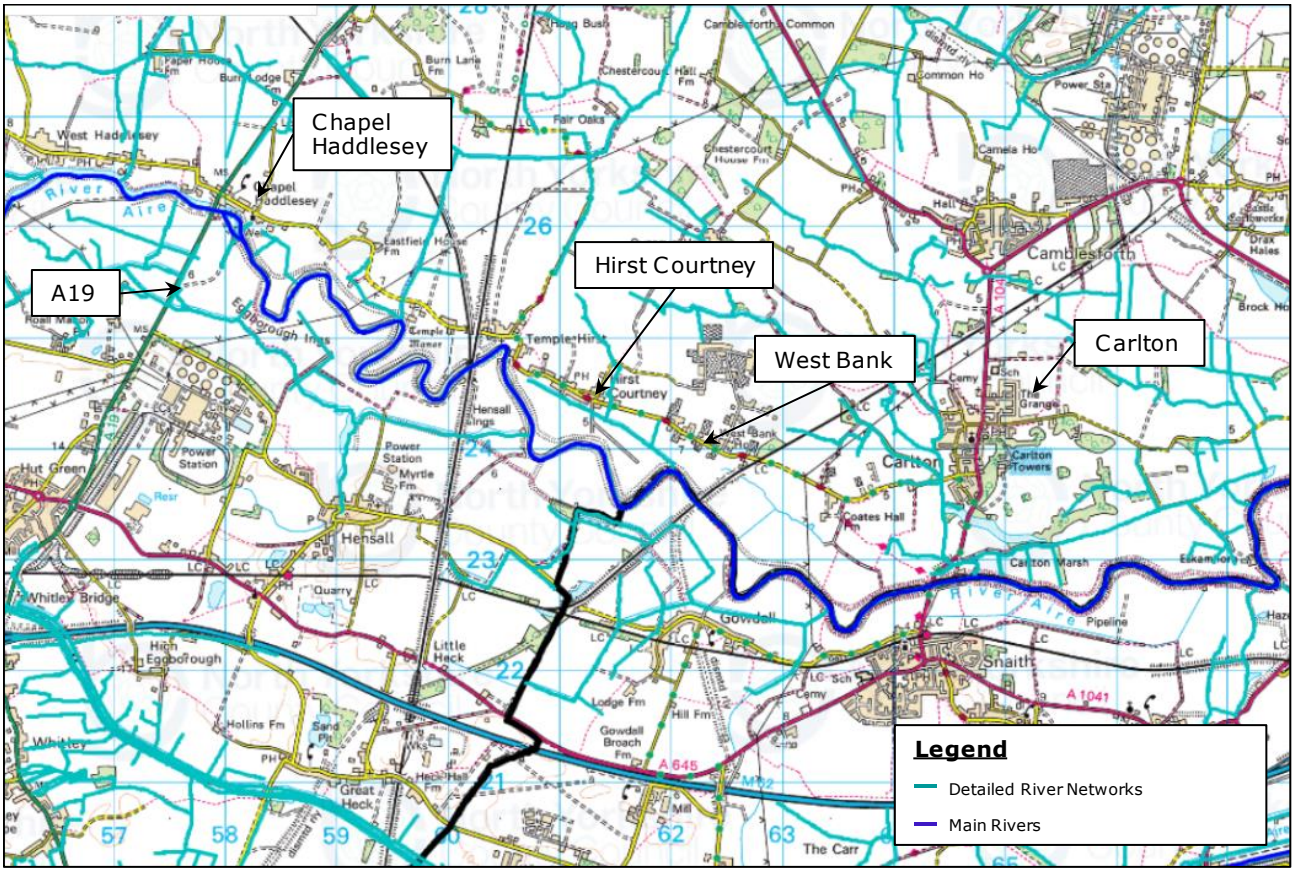
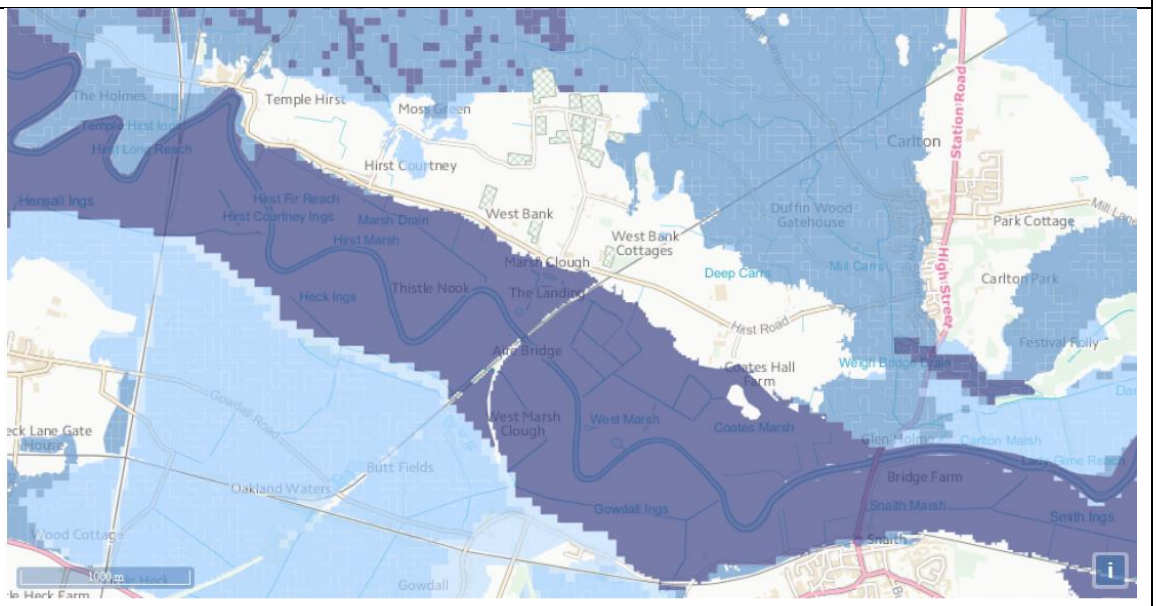
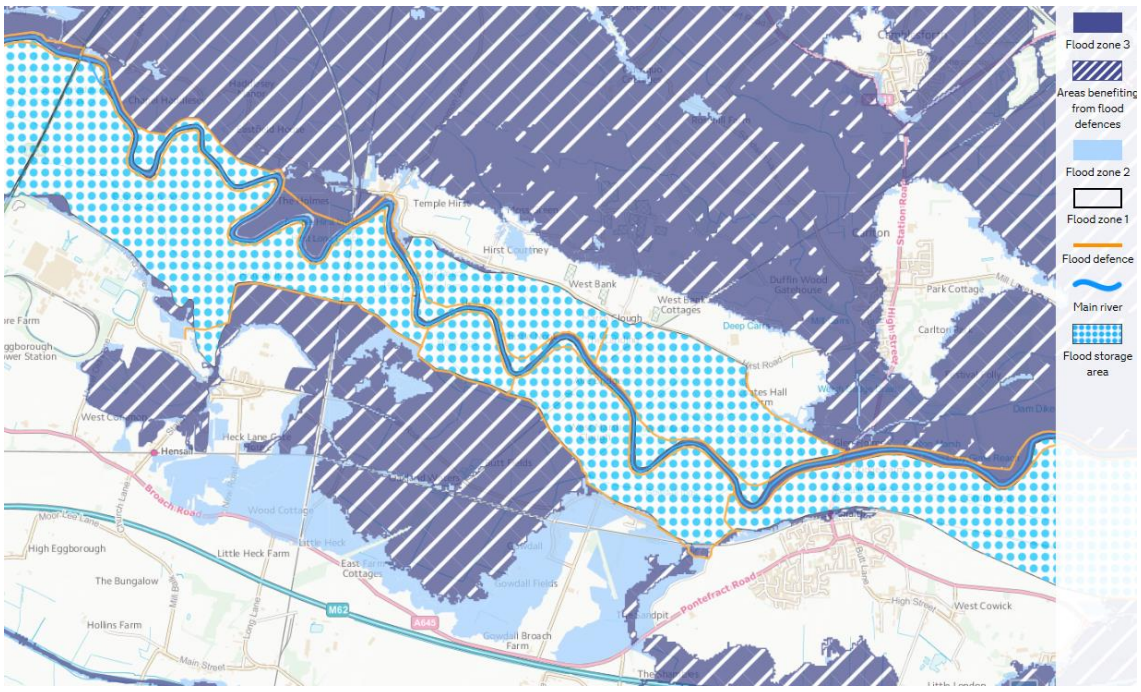
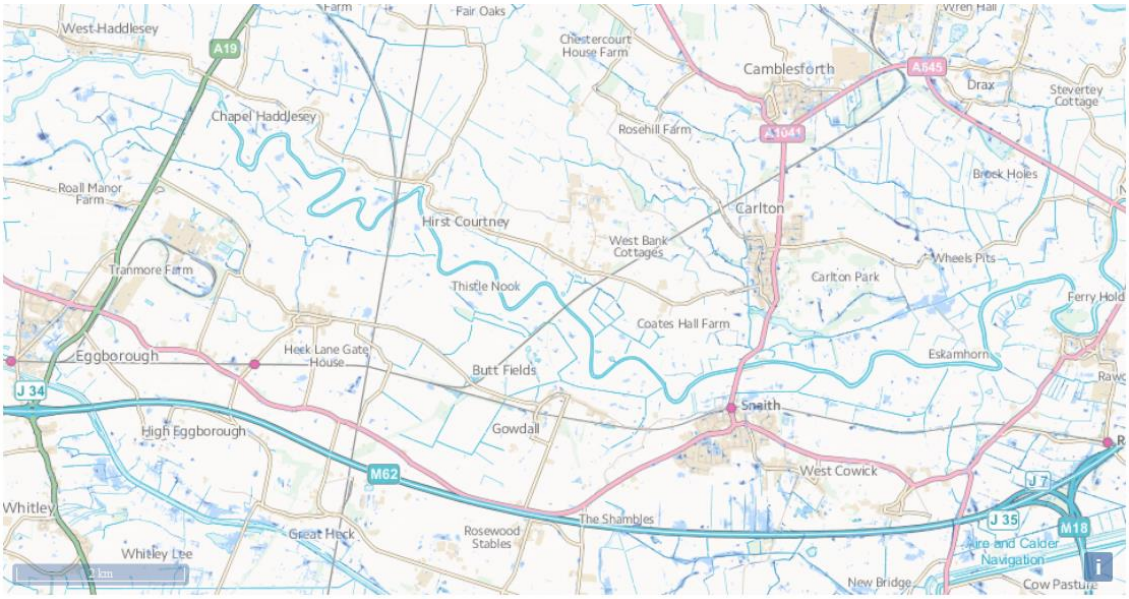
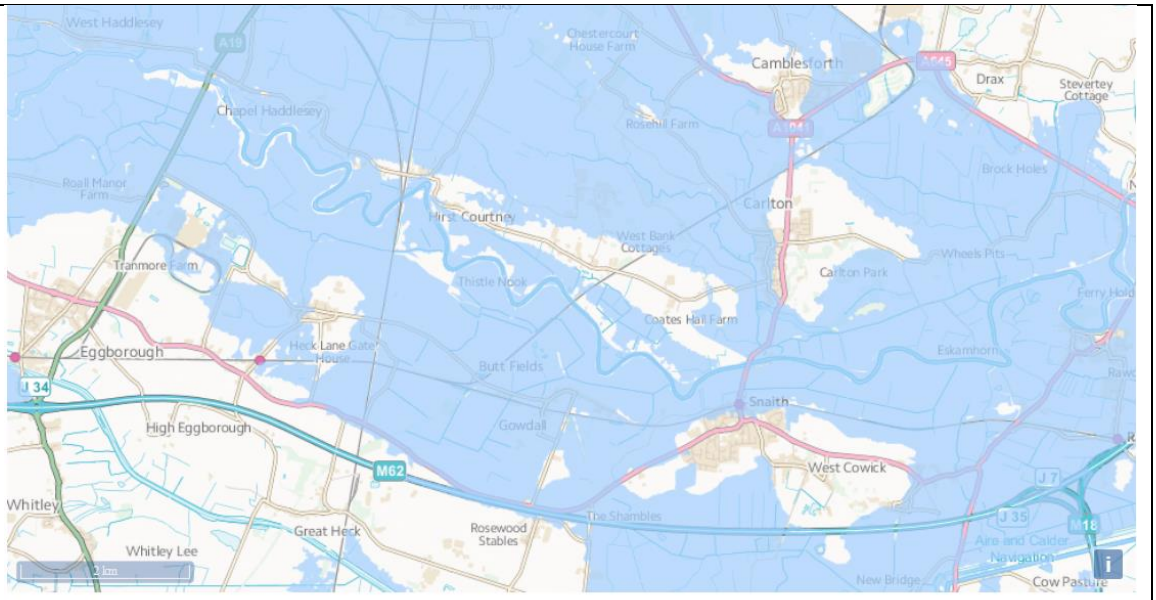


Figure 4 – Chapel Haddlesey, Hirst Courtney, West Bank and Carlton Location Plan

Table 3: Lower Aire : Understanding of Risk

Source of Flooding	Understanding of Risk
Flood Risk from Rivers and Sea	 Extent of flooding from rivers or the sea High Medium Low Very low The predominant area of risk associated with the River Aire is to the southern side of Hirst Road. The properties on the south side of Hirst Road are at high (a flooding frequency of more often than 1 in 30 years) and medium (a flooding frequency of between 1 in 30 and 1 in 100 years) risk of flooding. It is clear to see when on site that Hirst road is considerably higher that the surrounding area and as such acts as a barrier to the water for the properties to the north side of the road. The land immediately north of the road is shown to be at less than very low risk (frequency of less than 1 in 1,1000 years).
Flood Map for Planning	 The flood map for planning illustrates the location of the formal flood defences (orange lines) in relation to the areas at risk and flood storage areas. The washlands between the River Aire and Hirst Road are clear to see as flood storage areas. The northern extent of the storage area is

	defined by Hurst Road with no formal defences present. Flood storage areas are defined by the EA as those areas that act as a balancing reservoir, storage basin or balancing pond. Their purpose is to attenuate an incoming flood peak to a flow level that can be accepted by the downstream channel. It may also delay the timing of a flood peak so that its volume is discharged over a longer time interval. Flood storage areas do not completely remove the chance of flooding and can be overtopped or fail in extreme weather conditions. The A19 is shown in the far west of the map and can be seen crossing the flood storage area.
Pluvial Flood Risk (Surface Water)	 Extent of flooding from surface water High Medium Low Very low Given the topography and the generally well-draining soils, the surface water flood extents are limited. The predominant risk of flooding in the area is fluvial/tidal.
Reservoir Flooding	

	 Given the number of reservoirs located within the extensive upstream catchments, there is a residual risk of reservoir flooding in the area should one of the reservoirs fail. The flood extents are akin to the fluvial but not as severe around Hirst Courtney and West Bank.
Flood Alert and Warning Areas	There are a number of flood alert and flood warning areas that cover the lower aire reaches. Areas upstream of the East Coast Mainline are located within the River Aire from Brotherton to Chapel Haddlesey flood alert area. Whilst on the downstream side of the railway line Hirst Courtney, West Bank and Carlton are downstream to Airmyn is cover by the Tidal River Aire Catchment flood Alert Area. Chapel Haddlesey has a flood warning area that covers West Haddlesey and Chapel Haddlesey including Millfield Road and downstream to Lock Farm. The Flood Warning Area for Hirst Courtney extends from Temple Hirst through to the eastern side of Hirst Courtney. It includes Main Street and Hirst Road. A third flood warning areas is located at Hirst Marsh and West Marsh. The flood warning area covers the southern part of Higher Road including West Bank to Coats Hall Farm The western extent of Carlton is covered by the River Aire at Carlton flood warning area and includes Carlton from Low Street to Horley Park including Lynwith Lane, Almond Tree Avenue, The pastures, Camm Land and Church Fields.
Current Flood Defences	As discussed above, the flood map for planning shows an extensive network of flood defences, both adjacent to the River Aire channel and within the fluvial floodplain to define and manage the water levels within the washlands. There are no formal defence between the current defences and the properties on the south side of Hirst Road.

2.5 Countywide Maintenance responsibilities

A “watercourse” is any river, stream or channel – including ditches, dikes, drains, culverts, cuts, sluices, sewers (excepting public sewers) through which water flows either permanently or periodically. Watercourses are designated as either being “main” rivers or “ordinary” watercourses. Responsibility for maintenance of a

watercourse rests with the owner or owners of the land through which that watercourse flows. Often a watercourse will be the boundary between two adjacent landowners and where this is the case the boundary is deemed to be the centre of the channel, the owner of the land or property on each side being responsible for maintenance of their side. Culverts under roads are usually the responsibility of the relevant Highway Authority, either Highways England or North Yorkshire County Council.

The Environment Agency has powers, but not a duty, to carry out maintenance on watercourses which have been designated as "Main" rivers and also the power to build and maintain flood defences on these rivers where deemed necessary and proportionate. Within the study areas, the following watercourses have been designated as main rivers:

- Swale
- Ure
- Ribble
- Nidd
- Ouse
- Wharfe
- Aire
- Swinney Beck

Watercourses which are not listed above, such as Tems Beck and the un-named watercourse in Gildersleets, the Marsh Drain and other various filed drainage ditches behind the defences at Hirst Courtney and surrounding areas are all classed as ordinary watercourses, and responsibility for these rests with their riparian owners. North Yorkshire County Council as Lead Local Flood Authority has powers to enforce riparian owners to undertake maintenance, which are exercised proportionally according to the degree of flood risk. Likewise, where an IBD has been formed, such as he Selby Area IDB, under Section 66 of the LandDrainage Act 1991, the IDB will assume the same role as NYCC in the management of risk from the ordinary watercourses.

Yorkshire Water is responsible for managing and maintaining the network of public sewers throughout the investigation area. Public sewer networks are either combined systems, where foul and surface water drain through the same pipes to the local waste water treatment works, or are separate systems where foul water is conveyed to the sewage works and surface water is conveyed either to a local watercourse or other receiving body of water, or to a point at which it joins the combined sewer network. The upper dales are mostly served by combined and Foul Sewer systems.

North Yorkshire County Council as the Highway Authority is responsible for maintaining drainage assets on the road network in the study areas.

2 Investigation

3.1 Rainfall event – location, depth & duration

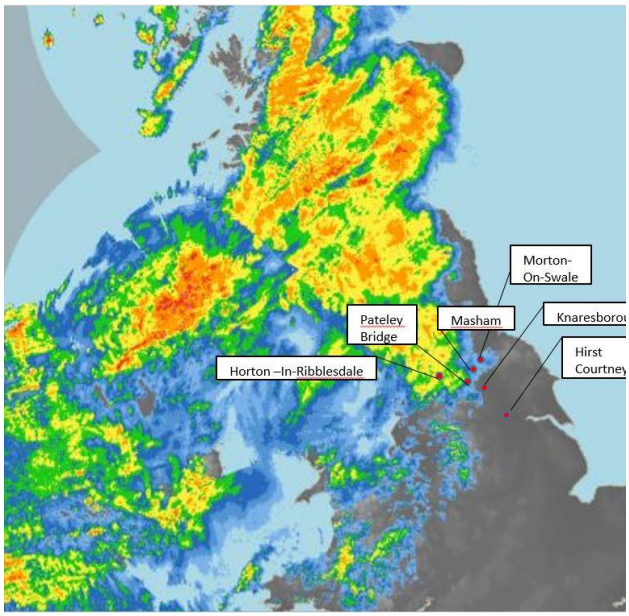
The UK MET Office with records commencing in 1891, reports that February 2020 was the wettest February on record in the Swale, Ure, Nidd, Wharfe, Aire, Calder catchments. (MET Office UK data).

The Pennine fed catchments of the Swale, Ure, Nidd, Wharfe, Aire, Calder and Don received between 320% and 375% of the monthly Long Term Average (LTA) rainfall. The lower Ouse, Rye, Derwent and Hull further east received between 245% and 295% of the LTA.[1]

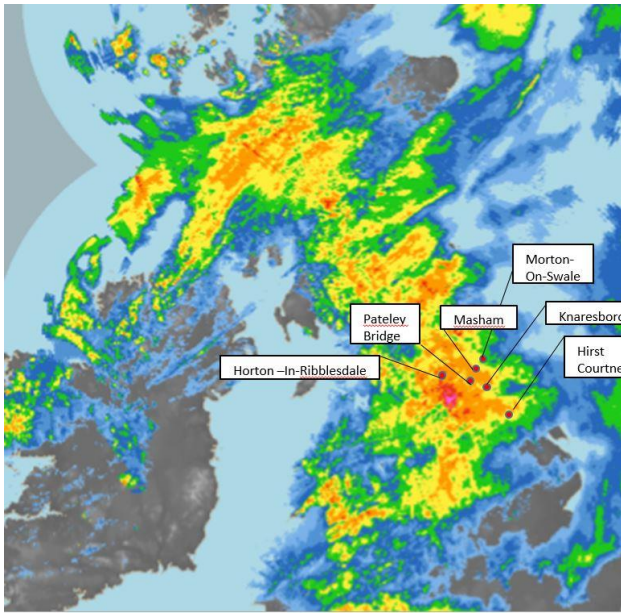
Prolonged and persistent rainfall throughout the month was punctuated by 3 significant rainfall events, 2 on consecutive weekends, with the first being named Storm Ciara, which arrived on February 8th and 9th. Ciara was the 3rd named storm of the winter season and the most severe thus far. Heavy rainfall associated with a frontal weather system was widespread across Yorkshire, with bands of particularly intense rainfall along the Pennine Ridge. Locations in the Aire, Calder and upper Nidd catchments received 106% to 128% of the February LTA in 48 hours.

Rain persisted through the weeks with most days in February observing some rainfall. The following weekend, 15 & 16th February saw the arrival of Storm Dennis, with widespread rainfall on the afternoon of the 15th, followed by two phases of intense rainfall. 60% to 80% of the February LTA was recorded at many locations over 48 hours, particularly over the lower reaches of the Dales catchment.

Storm Jorge, the fifth named storm of the winter, and named by the Spanish meteorlogical service, brought further strong winds and heavy rain between the 28th February and the 1st March. Although the weather impacts from this storm were less than Ciara and Dennis, periods of sometimes intense rainfall occurred throughout the weekend, (the most persistent and prolonged rainfall occurred during the afternoon and evening of Friday 21st).

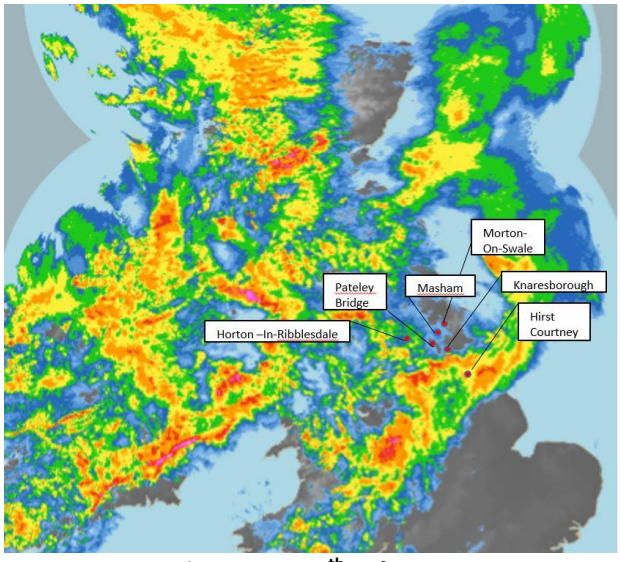


Storm Ciara 18:00 8th February 2020

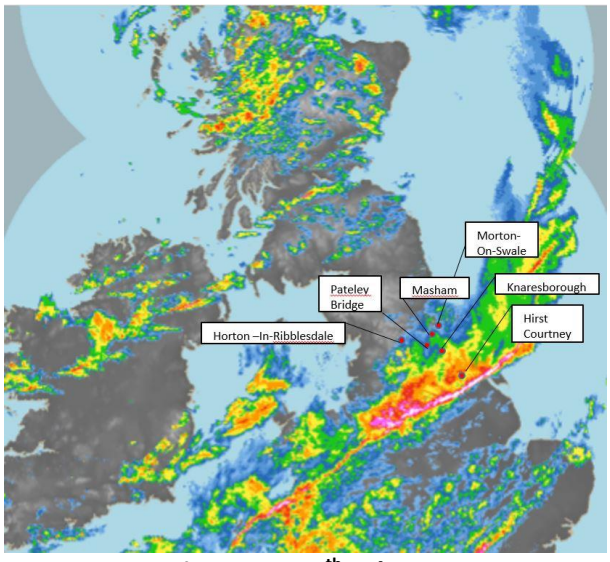


Storm Ciara 00:00 9th February 2020

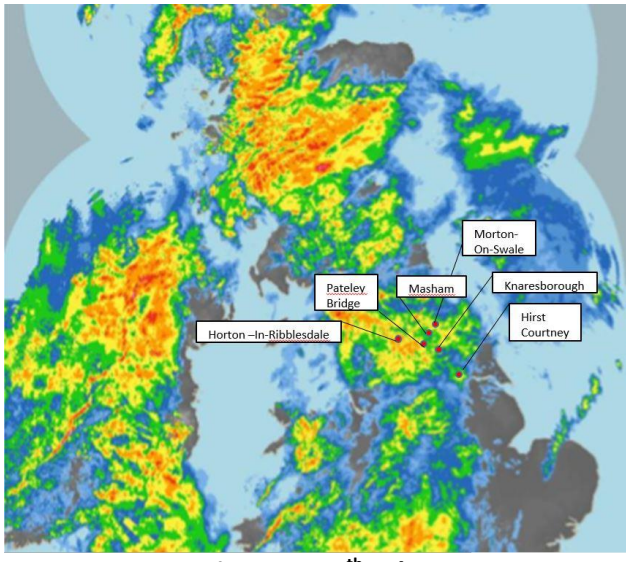
[1] EA data source- Yorkshire water situation report



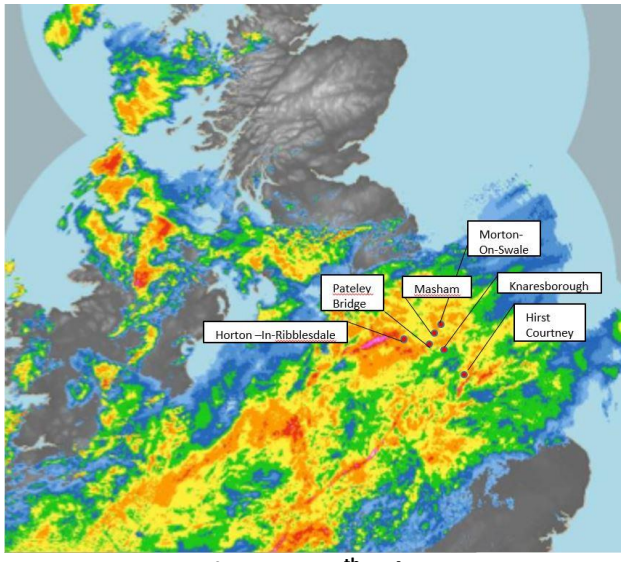
Storm Ciara 06:00 9th February 2020



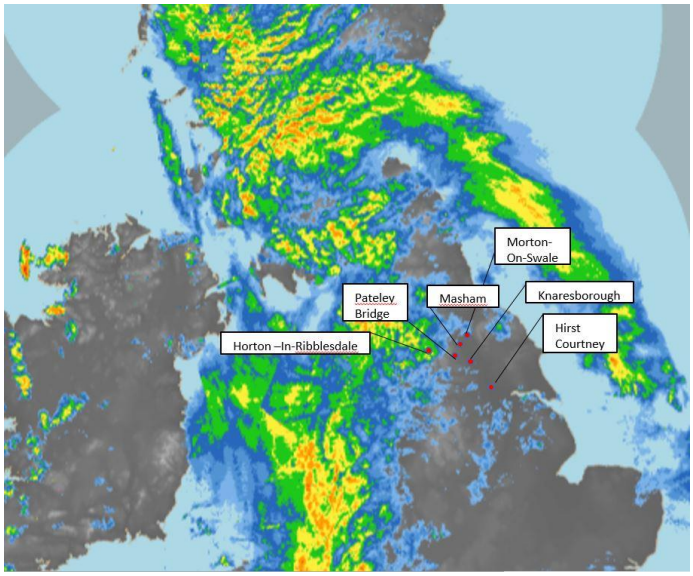
Storm Ciara 00:00 9th February 2020



Storm Dennis 12:00 15th February 2020



Storm Dennis 00:00 16th February 2020



Storm Jorge 02:30 29th February 2020

3.2 EA Rain Gauge

Rainfall totals at selected gauges across the county show that the northern and western parts of the county experienced the highest rainfall totals from late afternoon on Saturday 8th until early afternoon on Sunday 9th February, Storm Ciara. The gauge in the Upper Aire catchment at Skipton had in excess of 70mm rainfall in 48 hours. This is 109% of the February monthly Long term Average (LTA) for this area, with 114% and 117% LTA also recorded at Headingly and Thornton Moor. The River Nidd at Scar house recorded 106% LTA , with over 114mm rainfall in 48 hours between 8th & 9th February

The following weekend of 15th & 16th February, during Storm Dennis, selected sites recorded at least half of their February LTA during the event, with the Nidd at Scar house recording 81 mm rainfall (75% LTA,) and the Upper Swale at Ivelet recording 69mm (83% LTA). The Aire at Thornton Moor recorded 73% LTA. The combined effect of Storms Ciara and Dennis produced between 120 and 180% of the monthly LTA over the two events at many locations.

A further significant rainfall event, prior to Storm Jorge, occurred on the afternoon and evening of 21st February, with the River Swale at Ivelet recording 80mm rainfall (95% LTA), and Arkle Town recording 51mm rainfall in 48 hours. Snaizeholme Town gauge on the River Ure recorded over 100mm of rainfall (80% LTA) in 48 hours, and Scarr House on the Nidd nearly 100mm (90% LTA). On the River Wharfe, Beckmunds and Littondale recorded 106mm and 119mm in 48 hours respectively and Malham Tarn on the upper catchment of the Aire recorded 66mm. The combination of storms Ciara and Dennis had already produced rainfall totals which exceeded 150 to 200% of the February long term average rainfall. Rainfall events on the 21st February added a further 50 to 100% of the monthly average rainfall onto already saturated catchments in North Yorkshire. The most persistent rainfall in the Aire catchment occurred over approximately 18 hours from midday on Friday 21st, which was followed by further periods of sustained rainfall through the night on the 22nd and daytime on the 24th February.

Figure 5 shows how the rainfall throughout the month of February significantly exceeded LTA's in all catchments

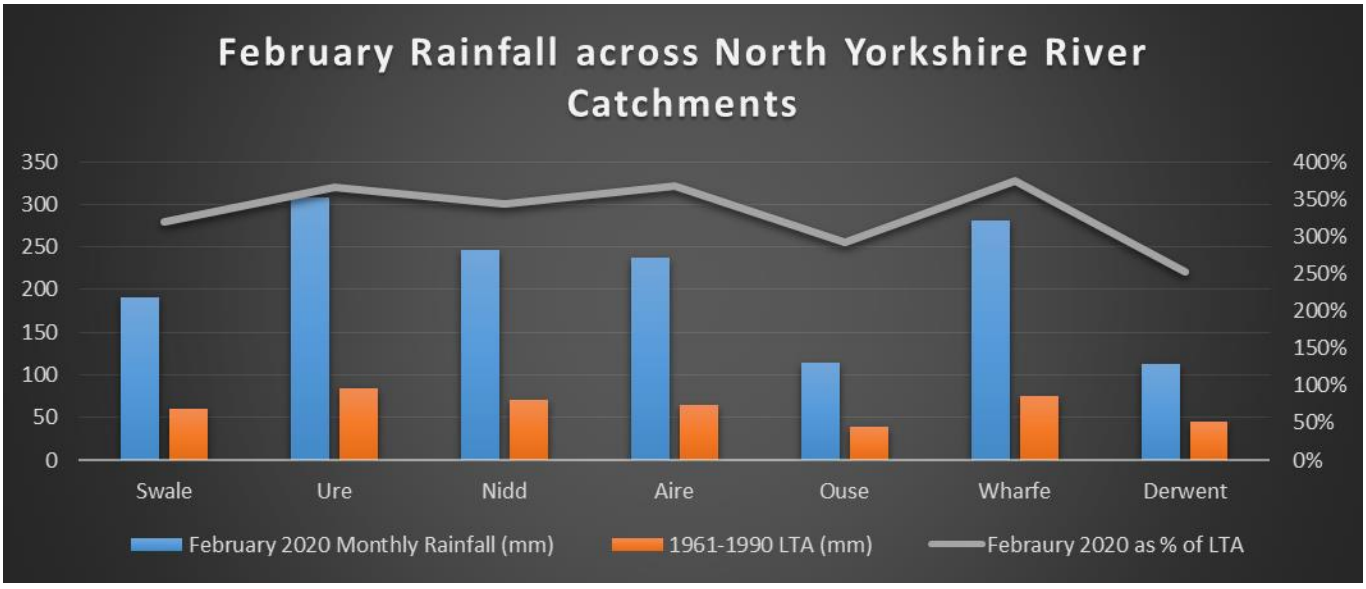


Figure 5: February 2020 Rainfall Totals as %LTA

3.3 River gauge levels and flows.

The levels quoted in the following section and relative to the gauge datum. The Environment Agency operates river flow gauges on all major rivers across the county.

The effect of the prolonged and repeated rainfall throughout February affected most rivers within the county. Starting in the west of the county, River Ribble and Wharfe show 4 significant peaks throughout the month. These peaks correspond with the 3 storms (Ciara, Dennis, Jorge) and the significant rainfall event on the 21st.

The river Ribble at Pennybridge recorded a highest ever level of 2.87m on the 9th February. On the same day the Wharfe at Netherside hall also recorded a highest ever peak of 3.91m. The typical range for these sites are 0.009-2.48 and 0.30-2.20 respectively. The river Wharfe at Kettlewell peaked at 2.39 on the 10th February, and the Ribble at locks weir recorded a monthly peak of 1.5m on the 21st February.

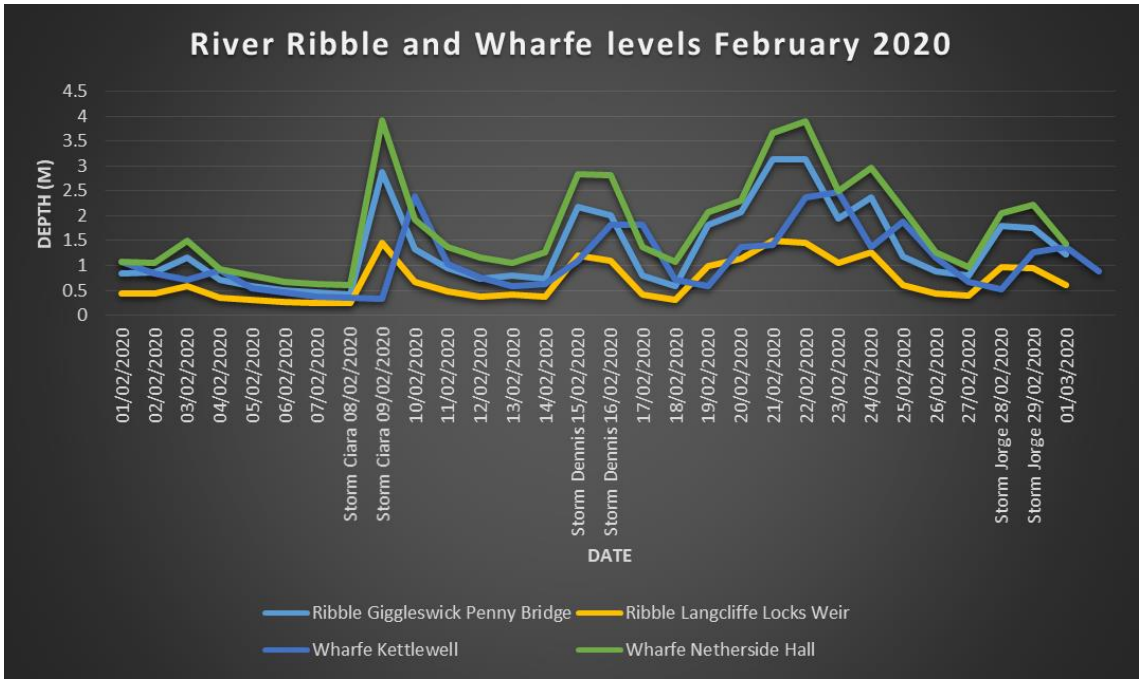


Figure 6: River Levels for February in Craven District

Across the county in Harrogate district, the river Nidd and Ure also show 4 significant peaks, the 3 storms, and the event on the 21st. The river Nidd at Pateley Bridge recorded a highest ever peak of 3.93 m on the 9th during Storm Ciara, typical range for this site is between 0.14 and 2.50m. The Nidd at Knaresborough peaked at 2.1m on the same day. The Ure at Masham also recorded a monthly peak on the 9th February with 3.5m. The Ure at Boroughbridge recorded a monthly peak of 15.6m on the 10th February.

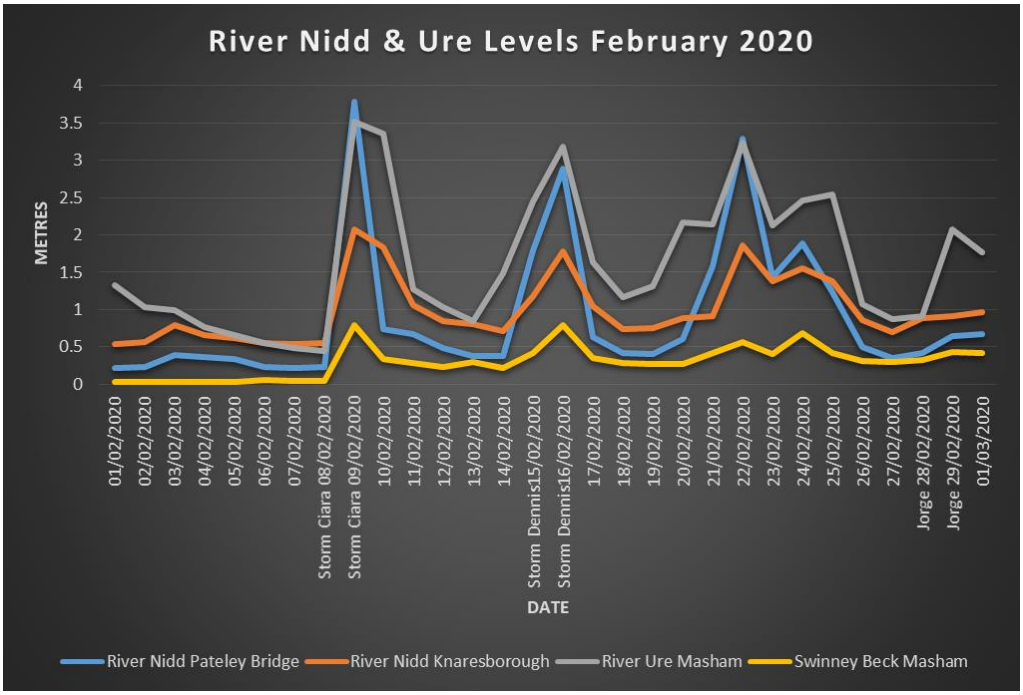


Figure 7: River Levels for February in Harrogate District

Bedale Beck at Leeming peaked on the 9th February at 4.63m and the River Wiske at Romanby recorded 1.99m on the 16th February, after Strom Dennis. All 3 Rivers show the 4 peaks in flow corresponding with storm and rainfall events.

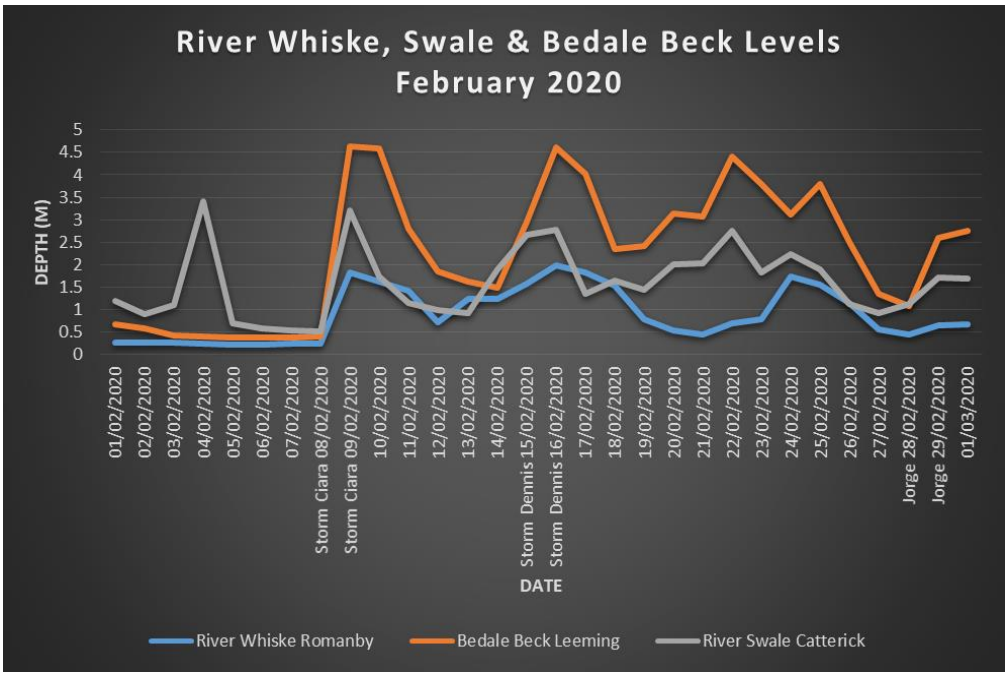


Figure 8: River Levels for February in Hambleton District

The river Aire runs through Selby district, in the southern part of North Yorkshire. The highest peak recorded at Chapel Haddesely was 3.43m on the 25th February. It also peaked on this date at Beal Weir (4.1m) and Birkin Westholme Washalnds (5.4m). Throughout the month, the river has significant peaks at all monitoring sites during storm or significant rainfall events, before dropping down again. Levels at West Bank pond, Wheelan Dyke and Roal Dykeshow an initial rise during storm Ciara, and then continue to rise and record higher peaks at Storm Dennis,

then continue to rise again and record monthly peaks on the 25th February. Roall Dyke recorded 5.95m, West Bank pond recorded 3.38m, the highest level on record, typical levels here are between 0.27 & 1.00m. Wheelan Dyke also recorded the highest level on record at 4.59m, they typical range for this site is -0.61-2.00m. It should be noted that the event of the Lower Aire was volume driven rather than by river levels, this is discussed further in Section 5.

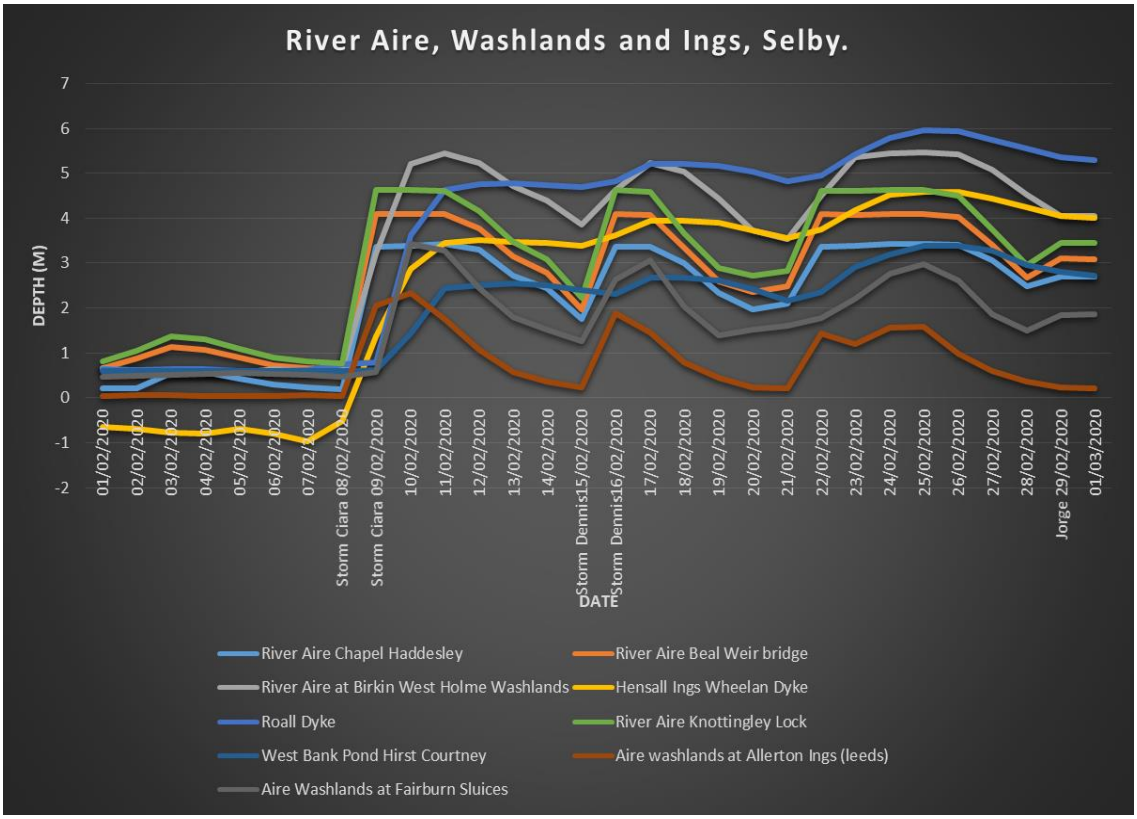


Figure 9: Figure 8: River Levels in the Aire Catchment

3.4 Groundwater levels

Across the Yorkshire area, soil moisture deficit was zero or very close to zero throughout the month. All catchment soils were classified as Wet, representing saturated conditions. Reservoirs were almost at full capacity and increased slightly throughout the month. Overall reservoir stocks were 5% above the LTA (based on records from 1990) by the end of the month. Groundwater levels rose in all but two of the index sites, with more than half of the sites ending the month exceptionally high. At the end of February, the Environment Agency had 23 groundwater Flood Warnings in force. The risk of surface and groundwater flooding from further rain on fully wetted soils remained, and damaging flows in large catchments continued into March.

3.5 Forecasts and flood warnings

The MET office issued multiple weather warnings throughout February. Storm Ciara was named on the 5th February and a national severe weather warning was issued for the whole of the UK for Sunday the 9th February, with much of England and Wales under an amber warning. Yellow wind and rain warnings were issued for north western parts of the country for Saturday 8th February.

Amber warnings for rain for the north west were issued for the 15th and 16th February, and this rose to a red warning for Wales, the first red warning the MET office had issued since December 2015. A yellow warning for rain was

issued for the 19th and 20th February and severe weather warnings were in place for northern England for the 22nd. On the 24th February a yellow warning for snow and ice was issued for the 26th and 27th, with a yellow rain warning for northern England issued for the 27th and 28th February. Storm Jorge was announced on the 28th February and yellow weather warnings for the majority of the UK were issued, with some areas covered by more than 1 warning, indicating multiple weather hazards.

The Environment Agency issued around 580 flood alerts and warnings to the Yorkshire area throughout February. Approximatley 280 of those were in North Yorkshire. On the 8th February a flood alert was issued for the Upper and Lower Swale, the Upper and Lower Ure, the Upper and Lower Nidd, and the Upper and Middle Aire. On the 9th February Flood warnings were issued for Swinney beck, the Swale around Richmond, the Nidd at Knaresborough and the Nidd at Pateley Bridge was issued with a severe flood warning. The Ure at Roecliffe and Masham and the Aire at the Allerton Ings also had flood warnings in place. A flood alert was also issued for the Lower Aire catchment

Flood warnings were issued for the river Aire at Crosshills, Hirst Marsh and West Haddesley on the 10th February. On the 15th February flood alerts were issued for the upper river Aire, the middle Aire catchments, the upper and lower Ure, the lower Swale and the upper Nidd. Flood warnings were issued for the River Nidd at Knaresborough caravan park, the Ure at Roecliffe caravan park and Swinney beck at Masham.

Flood warnings were issued on the 16th February for the river Ure at Masham, river Aire at Allerton Ings, river Swale at Topcliffe ,river Nidd at Knaresborough and the river Ure in Ripon at Ure Bank and the Racecourse. Alerts remained in place from the 16th -20th for the lower river Aire catchment, the river Aire at Hirst Courtney, river Aire at Hirst Marsh and West Marsh, river Aire at Birkin, upper and lower river Nidd, lower river Wharfe, upper river Swale, upper river Aire and the middle and lower river Aire catchments, and the lower river Ure.

Between the 21st and the 24th February further flood warnings were issued for Kettlewell Beck at Kettlewell, river Ure at Masham, Swinney Beck at Masham, river Ure at Roecliffe Caravan Park, river Nidd at Knaresborough Caravan Parks and Goldsborough Mill Farm,, river Swale at Topcliffe, river Ure at Masham, river Aire at Hirst Courtney, river Aire at Allerton Ings, and Swinney Beck at Masham . Flood warnings continued on the 25th for Kettlewell Beck at Kettlewell, river Aire at Gowdall, river Aire at Kellington, river Aire at Hensall, and the river Aire at Temple Hirst.

Flood alerts were issued for upper Aire, upper and lowere Ure and lower Swale on the weekend of the 28-29th February and flood warnings issued for the Ure at Roecliffe caravan park and Swinney Beck at Masham.

4 Flooding consequences

The areas affected by the flooding span an enormous geographical area. Nearly every district within the county reported flooding at some level during the month, whether this be surface water flooding, fluvial flooding or property level flooding of residential or business. There were repeated and prolonged road closures throughout the month, on the 26th February there were approximately 52 roads closed across the county. For the purpose of this report, the most significant events will be highlighted at a district level

4.1 Craven District

The village of Horton in Ribblesdale was surrounded by floodwater on Friday night and left impassable to vehicles.

The Environment Agency reported that incidents on Friday night and Saturday morning had predominantly been on the River Wharfe and the River Ure

North Yorkshire Fire and Rescue Service said that 10 properties had been flooded in the areas surrounding Settle and Giggleswick, including Gildersleets. Four people were been rescued from a vehicle in Skipton while fire crews went to the aid of a number of horses and sheep.

Five properties were recorded to have flooded in Gildersleets, with significant depths of flooding occurring on the A65 as shown in Figure 5. The A65 was not closed during the event. It was noted that the passage of vehicles exacerbated flows towards the properties.

Figure 10: A65 at Gildersleets

Figure 11: Looking north west from Gildersleets towards the A65.

Anecdotal evidence of flooding in Craven can be found via the following links.

- https://youtu.be/3yhVQLtJfCs
- https://www.bbc.co.uk/news/uk-england-york-north-yorkshire-51597105

4.2 Harrogate District

In Harrogate district, Pateley Bridge, Masham, Birstwith, Ramsgill, Boroughbridge Ripon and Knaresborough all reporting incidents of property flooding, both residential and businesses. There are a number of restrictions in terms of the data collected and how authorities data share, which inevitably affects the information gathered. Nevertheless, the data from the information available is that internal property flooding was reported from approximatley 44 addresses within the Harrogate district to various risk management authorities during February.

The extent of the flooding was not only restricted to residential properties or commercial businesses. It also affected farming assets, roads and bridges. Emergency services responded to a variety of call-outs ranging from vehicles in floodwater to manning pumps. The list of the roads which were affected by the flooding includes:

A168 Caravan Park to Roecliffe Road , Roecliffe to Bishop Monkton, Aldborough to Great Ouesburn, A6108 Low burton to Masham bridge, Haggs road Spofforth, Yordale Vets – Masham to Newton-le Willows, Denton road (east of Ilkely), Ripon Race Course Bridge, Church Bank, Kirby Malzeard, High Burton, Masham near Yorvale Vets , Church Lane, Elslack and Knaresborough Road, Littlethorpe

The extent of flooding in Masham can be seen in the following article:

https://www.harrogateadvertiser.co.uk/news/dramatic-footage-shows-extent-masham-flooding-during-storm-ciara-1394132

4.3 Hambleton District

The rainfall events associated with Storm Ciara resulted in the closure of the A684 at Morton and Swale due to flooding on the 10th February, the bridge over the River Swale was also closed at this location. This location was the site of repeated closures during the month as the storms hit the area and flooded the carriageway.

A little further north of this location, Scruton, had a road closure in place on the 13th February, and to the south of the district, York Bridge at Tollerton was also closed. These roads suffered further flooding and were again closed on the 23rd along with the road from Tollerton to Newton on Ouse.

On February 26th in addition to the locations above, Bedale Road , Hunton, Eldmire Lane, Dalton, Kirby Wiske, Helperby to Myton on Swale, Crakehill, Swainby to Osmotherley, and Sandy Field Lane, Holme on Swale, were also closed. Reports of property flooding in Great Langton were also recorded. There was severe disruption to the industrial estate at Dalton due to the closure of Dalton bridge.

Anecdotal evidence of flooding in Hambleton can be found via the following links

- https://www.harrogate-news.co.uk/2020/02/10/motorists-warned-to-beware-of-ice-as-temperatures-drop-following-floods/
- http://www.hambletontoday.co.uk/more-work-needed-on-dalton-bridge-near-thirsk/

4.4 Selby District

18 properties were recorded to have internal flooding in Selby District, concentrated around Hirst Courtney, Carlton and Acaster. The A19 was closed at Chapel Haddlesey on the 19th February and tests carried out to ascertain the damage to the road as it was suspected the water had eroded the carriageway underneath, when the River Aire overtopped and started filling the washland.

The extent of the flooding was not only restricted to residential properties or commercial businesses. It also affected farming assets, roads and bridges. Emergency services responded to a variety of call-outs ranging from vehicles in floodwater to manning pumps. The list of the roads which were affected by the flooding includes:

Cawood Road, Stillingfleet ,Cawood Bridge, Cawood Boggart Lane, Ozendyke from Ulleskelf to Ryther, Ryther Fleet B1223, Ryther ,Intake Lane and Beal Bridge, Beal,Newton Lane, Fairburn,Oxton Lane Oxton, Ousegate, Selby, The Ramparts, Bolton Percy, Old Road, Bolton Percy, New Road/Raw Lane, Ulleskelf,Back Lane, Acaster Selby. As the county continued to be battered by storms throughout the month, the roads below also suffered closures from flooding:

A19 Chapel Haddlesey to Wand Lane, Eggborough ,Roall Lane, Kellington ,Hales Lane, Drax ,West Bank, Carlton / Hirst Courtney,Church End, Cawood to Marsh Lane, Wistow. Hirst Road, Carlton,Ferry Lane, Snaith (A1041) between iron bridge and A645, Church End, Cawood to Marsh Lane, Wistow, A19 Chapel Haddlesey to Wand Lane, Eggborough and A162 & B1223 Towton to Kirkby Wharfe

The events caused damage to a flood bank at Temple Hirst, which required the EA to undertake immediate emergency repairs on the 20th February. The EA and Selby District Council worked together to notify those at risk as a result of the collapse during the day.

A railway embankment also was damaged at Hirst Courtney / West Banks due to damage to the railway delivering wood pellet fuel. The damage was repaired with single track railway operations, but had the potential to cause significant disruption to operations at Drax Powerstation.

Aerial Imagery shows the vast extent of the flooding in the area.

Figure 12: River Aire Floodplain looking west

Figure 13: Submerged A19 at Chapel Hadlessey

A number of social media posts document the events, including the one below which shows the River Aire

- https://www.youtube.com/watch?v=rjUCPm9v6eU

4.2 Flood risk management functions undertaken

The response to any flooding incident is initially conducted by the Emergency Services under the Civil Contingencies Act 2004. Other than the Environment Agency the other Risk Management Authorities, have a reactive duties and powers bestowed under the Flood and Water Management Act 2010. **The immediate response to the incident by emergency services, the Environment Agency and NYCC Emergencies and Resilience team will be de-briefed and reviewed separately to this Section 19 report.**

The requirement of the section 19 report is to is to reflect on the responsibilities of each Risk Management Authority and assesses whether each authority has undertaken the statutory duties leading up to the event, during and after in accordance with the Flood and Water Management Act 2010 (see Appendix 6.1). In accordance with Section 19 of the FMWA, the LLFA has identified the following as Risk Management Authorities with actions and responsibilities in relation to the flooding during February 2020:

- The Environment Agency
- North Yorkshire County Council as Lead Local Flood Authority and Local Highway Authority
- Craven District Council
- Harrogate Borough Council
- Selby District Council
- Yorkshire Water
- Internal Drainage Board
- Riparian Land Owners

4.2.1 Environment Agency

Under the FWMA the Environment Agency (EA) has a strategic overview role for all sources of flooding as well as an operational role in managing flood risk from Main Rivers, reservoirs and the sea. As part of this role the EA must produce a National Flood and Coastal Erosion Risk Management Strategy for England – The latest strategy was published in July 2020. 'The strategy sets out a vision of a nation ready for, and resilient to, flooding and coastal change – today, tomorrow and to the year 2100.' The strategy has 3 long-term ambitions, underpinned by evidence about future risk and investment needs. They are:

- Climate resilient places: working with partners to bolster resilience to flooding and coastal change across the nation, both now and in the face of climate change
- Today's growth and infrastructure resilient in tomorrow's climate: making the right investment and planning decisions to secure sustainable growth and environmental improvements, as well as infrastructure resilient to flooding and coastal change
- A nation ready to respond and adapt to flooding and coastal change: ensuring local people understand their risk to flooding and coastal change, and know their responsibilities and how to take action

4.2.2 North Yorkshire County Council

The Development Management Team which undertakes the LLFA function for the council is not a category responder and instead provides the strategic view on flood risk management activities within the county. The flood risk management functions set out in the FWMA 2010 include (but are not limited to);

- Provision of a Local Flood Risk Management Strategy (LFRMS).

The Local Flood Risk Management Strategy was published in 2015. The strategy sets out how the authority will manage local sources of flood risk within its administrative boundary. This plan focuses on the development of action to meet the six North Yorkshire Flood Risk Management priority objectives:

1. Promoting a greater role for communities in managing flood risk

2. Improved knowledge and understanding of flood risk and management responsibilities for all stakeholders, communities and the media
3. Sustainable and appropriate development
4. Improved knowledge of watercourse networks and drainage infrastructure
5. Flood risk management measures that deliver social, economic and environmental benefits
6. Best use of all potential funding opportunities to deliver flood risk management measures

In addition to the duties and the responsibilities in the FWMA 2010, the conclusions and recommendations of this report will be based upon the local Flood Risk Management Strategy objectives.

- Designation and maintenance of a register of structures or features that have a significant effect on flood risk.

It is recognised in NYCCs strategy that identifying these features and drainage networks is a huge task that presents significant practical challenges and significant potential costs. Nevertheless, in areas where the flood risk is significant, the location and mapping of critical assets has a great potential for assisting in the management of flood risk by highlighting those risks and facilitating preventative actions. NYCC as LLFA intend to take a systematic, risk based approach to this task, identifying those areas of greatest risk and working with riparian owners and local communities to manage that risk. This will be supported by the gathering of information on the recent flooding event in February and the continual development of the Asset Register (see section 5.3).

- Consenting and enforcement works on Ordinary Watercourses.
- Responding to statutory consultations on drainage proposals in planning applications.
- Undertaking Section 19 investigations.

NYCC also has responsibilities as a Highways Authority and as an Emergency Responder (under the Land Drainage Act 1991 and the Civil Contingencies Act 2004 respectively) which may relate to flooding.

Highway Authorities are responsible for providing and managing highway drainage which may include provision of roadside drains and ditches, and must ensure that road projects do not increase flood risk.

The Highways Authority has a duty under the Highways Act 1980 to maintain highways that are maintainable at public expense. This includes a duty to maintain existing highways drainage. Highway drainage systems are designed to take highway surface water. Highway drainage systems are not designed as “storm drains”, and do not have the capacity for the level of rainfall from an extreme flash flood. The Highway Authority has powers to improve drainage systems but no duty to do so.

During the response period, NYCC Highways continued to work alongside the District Councils to deliver sandbags to protect at risk communities.

Following the events, the following works were required to be undertaken by the highways team:

- Minor sign and verge repairs on Cawood Road, Cawood.
- Sandbags were removed from carriageway, and verge and carriageway repairs were undertaken on Hirst Road, West Bank, Carlton
- Most significantly, damage was caused to the A19 at Chapel Haddlesey, meaning that embankment and road reconstruction is required.
- Remedial Works at Dalton Bridge
- Feasibility Study for flood relief works at Morton Flats

In light of the above, the report concludes that NYCC in its capacity as LLFA and LHA has and will continue to undertake its duties in accordance with the FWMA 2010.

4.2.3 District or Borough Council

District and Borough Councils are named as Risk Management Authorities within the Flood and Water Management Act 2010, and are required to comply with the LLFA Local Strategy. Through the planning processes, they control development in their area, ensuring that flood risks are effectively managed.

In addition, in relation to the Civil Contingency Act (2004), the District and Borough Council:

- Are a Category 1 Responder. On a priority basis, they will provide sandbags to residents and businesses where property is at risk of flooding.
- Support the Emergency Services on request by providing Incident Liaison Officers.
- Provide emergency accommodation – i.e. set up rest centre as required and other welfare provision.
- Assist with arranging transport or evacuating areas.
- Participate in vulnerable people searches.
- Assist with co-ordination of recovery.

The NYCC Emergency and resilience team provides support to the District Council

4.2.4 Internal Drainage Boards

Internal Drainage Boards (IDBs) are local operating authorities established in areas of special drainage need (typically low lying areas) in England and Wales.

IDBs have permissive powers to undertake works to secure clean water drainage and water level management in designated drainage districts. In managing water levels IDBs have an important role in reducing flood risk in areas beyond their administrative boundary.

4.2.5 Yorkshire Water

Water companies in England and Wales are named as a Risk Management Authority under the Flood and Water Management Act 2010 and must have regard to the Local Strategy of the LLFA. They are required to manage risks associated with assets or processes that may cause or be affected by flooding, and must share relevant data with other flood risk authorities.

They also have flood risk management functions under the Water Resources Act (1991). Relevant actions of water companies include: the inspection, maintenance, repair and any works to their drainage assets which may include watercourses, pipes, ditches or other infrastructure such as pumping stations.

The Civil Contingencies Act 2004 (CCA) also designates water and wastewater undertakers as statutory category 2 responders to national disasters and emergencies, placing on them duties to share assured information with other responders in an appropriate manner.

4.2.6 Responsibilities of Riparian Land Owners and Individual Property Owners

It is critically important that the extent and nature of each organisation's role in flood risk management is understood and appreciated by the communities and individual residents affected by flooding. It is equally important that we set out the roles that others, including riparian owners, are required to play.

Landowners whose land is adjacent to a watercourse are known as 'riparian owners'.

A landowner can be an individual e.g. home owner or farmer, private business or an organisation e.g. the district council as park owner, on school grounds the county council as property owner.

A watercourse is defined as every river, stream, ditch, drain, cut, dyke, sluice, sewer (other than a public sewer) and feature through which water flows, but which does not form part of a Main River.

Riparian owners have legal duties, rights and responsibilities under common law and the Land Drainage Act 1991 for watercourses passing through or adjoining their land. These responsibilities are to:

- Pass on the flow of water without obstruction, pollution or diversion affecting the rights of others.
- Accept flood flows through their land, even if these are caused by inadequate capacity downstream.
- Maintain the banks and bed of the watercourse and keep structures maintained (this includes flap vales and sluices).
- Keep the bed and banks free from any artificial obstructions that may affect the flow of water including clearing litter, heavy siltation or excessive vegetation.

Guidance on the rights and responsibilities of riparian ownership are outlined in the Environment Agency publication 'Living on the edge', available at:

http://www.environment-agency.gov.uk/homeandleisure/floods/31626.aspx

5 Investigation and findings

Craven District

Gildersleets has a history of flooding. In particular, on the 5th February 2015 3 properties in Gildersleets reported internal flooding during Storm Desmond as a result of water flowing off the A65.

Whilst the most prominent source of flooding is indicated to be the River Ribble, and irrespective of the fact that the Ribble reached record levels in February 2020, it is understood from the evidence presented that the properties did not flood from this source. Instead, most recent flood events including the 2015 events, was from the un-named ordinary watercourse that flows adjacent to Watery Lane.

In 2015 a flood barrier was erected along the A65 in a joint project between NYCC Highways and the LLFA funded through the flood recovery grant issued by Central Government in 2015. The flood bund was an attempt at containing the flows that overspilled from the A65. Figure 14 below shows how the flood flows enter the field to the east of the A65 before overspilling onto the A65 and then flow through the properties before flowing into the Ribble.

A site visit was undertaken to inspect the condition of the watercourses. The watercourses appeared to be in an acceptable condition with no impediments or barriers to the flow noted. The rainfall intensity and volume simply exceeded the capacity of the natural land drainage network.

It is apparent from the submitted photographs that significant amounts of water is by-passing structure (Figure 15) erected next to the A65 which is resulting in continued flooding of the properties.

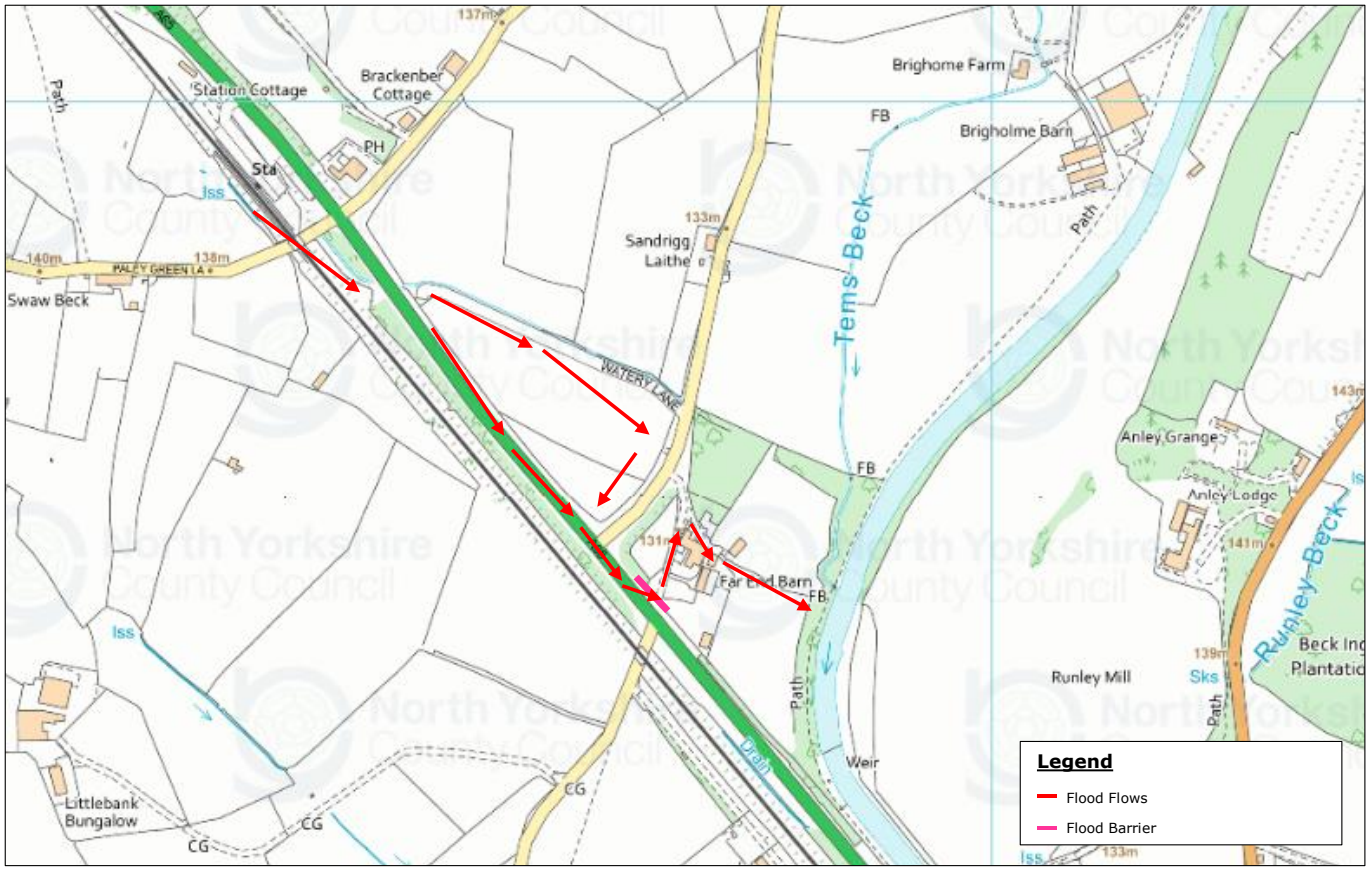


Figure 14: Gildersleets flooding mechanism

Figure 15: Gildersleets - floodwater by-passing bund

Harrogate District

Masham also has a history of localised flooding. Similar to Gildersleets, whilst the larger River Ure flows past the town, the flooding reported in Masham relates to Swinney Beck. Anecdotal evidence provided by the Parish Council to NYCC Highways office states that Swinney Beck breached "*through the residents' garden at 27 Red Lane opposite Theakston's brewery and then flowed down Red Lane, Park Square, Church Street to the low point near Beavers' butchers [*Silver Street*], where the fire brigade valiantly pumped it through to the Shooting Holme".* A map of the flood flow route is presented in Figure 16.

In the case of Swinney Beck, the section of culvert under the publicly maintainable highway is maintained by NYCC in its capacity as Local Highway Authority, however the vast majority of the watercourse is in private ownership, with the responsibilities listed above in section 4.2.6 resting with its riparian owners. As a Main River, the EA would be tasked with monitoring and ensuring that the local land owners/residents are aware of their riparian responsibilities.

There is no responsibility for riparian owners to improve drainage, although there is a duty placed on riparian owners to ensure systems are well maintained. In historic and interlinking systems in locations like Masham, offering an increase in capacity would be extremely challenging and costly for those responsible owners. Climate change projections do indicate that the likelihood of short duration, high intensity storms will increase and there will therefore inevitably remain a heightened risk associated with these locations and given this likelihood, community resilience and preparedness remains key.

Upon being notified, NYCC Highways engineers checked the silt levels in the bottom of The Oaks box culvert (NYCC asset) at The Oaks/Westholme Road and unless advice to the contrary from the Environment Agency, NYCC do not have any plans to remove the silt from the culvert at this time. At the centre of the culvert the silt was 170mm deep and compared to the culvert depth of 1200mm in total.

NYCC highways committed to clearing out the highway drains from where the flooding started behind the Brewery, along Red Lane and back into the town onto Silver Street. The drains on Fearby Road end were also to be cleansed.

The council operates an annual gully cleansing schedule across the county, with a reactive service also in operation for when additional cleansing is required. Inevitably gullies are designed to a finite capacity to take highway surface water. In periods of significant rainfall like those experienced in February, Swinney Beck overtops and this flow exceedance tracks down Red Lane, Church Street and into Silver Street. The road gullies are not designed to take this volume of water and this is not indication that additional cleansing is required. These circumstances inevitably result in a build-up of detritus in the drains, which is why the reactive service is critical in this location to ensure their function following high rainfall events.

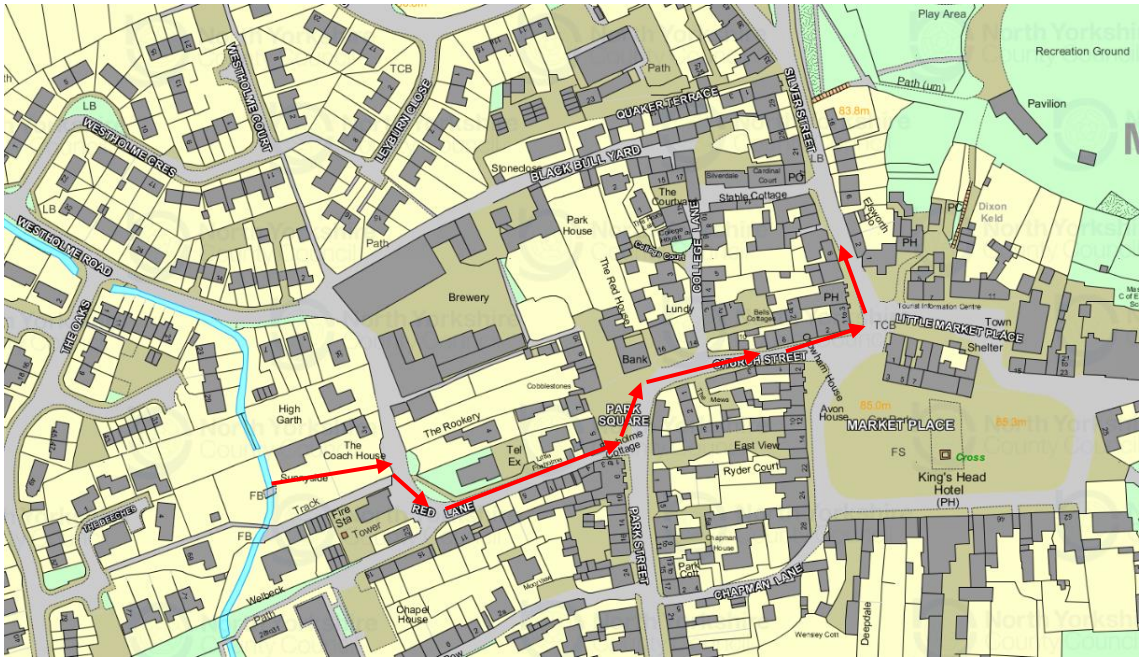


Figure 16: Masham Flood Flow Route 9th February 2020

Selby District

The impacts of the storm events in February, coupled with the already saturated flood plain, caused the Lower Aire washlands to reach and exceed capacity. The washlands operated as they were designed, to hold and store water from the River Aire to reduce flood risk in the area. The River Aire was however very high as a result of prolonged rain across its catchment and there was overtopping of the river into West Bank and Hirst Courtney washlands, as well as the area being filled by the tide.

The EA deployed five pumps to pump water from the washlands into the river Aire to help provide additional capacity. Due to the amount of water the pumping operations were most beneficial when the levels in the river Aire began to fall. On the 25th February the River Aire reached its peak at Carlton Bridge resulting in the extensive flooding of the Lower Aire Reaches, where washlands exceeded capacity. Levels gradually receded in the days following this. The table below demonstrates the chronology of meteorological events and river levels.

Table 4: Chronological Order of Events in Selby Area

Occurrence (2020)	Description
8th - 9th February	Storm Ciara A period of persistent and widespread rainfall hit Yorkshire from late afternoon on Saturday 8th until early afternoon on Sunday 9th, with northern and western parts of the county seeing the highest rainfall totals.
10th February	Peak Stage of 5.977m recorded on the River Ouse at Skelton
	River Aire at Carlton Bridge peak stage 6.052m AOD.
11th February	Peak Stage of 3.436m recorded on the River Aire at Chapel Haddlesey
15th - 16th February	Storm Dennis From around 7pm Saturday evening a line of intense rainfall developed which ran from the upper Don, through the lower reaches of the Aire and Ouse, to the coast at Whitby. This storm then moved south eastwards and moved into north Lincolnshire by around 9pm. The rainfall then ceased until the arrival of Storm Dennis from the south west at around 11:30pm. By the early hours of Sunday 16th there was widespread rainfall across Yorkshire but focussed

	especially over the middle and lower reaches of the Dales catchments draining to the Ouse in York and along the Don valley from Rotherham.
16th February	Knostrop Weir in Leeds lowered
	River Aire peaks again at a stage of 3.37m recorded at Chapel Haddlesey
17th February	River Aire at Carlton Bridge peaks at 5.926m AOD
	River Ouse peaks at a stage of 5.977m recorded at Skelton
21st- 23rd February	Persistent and prolonged rainfall occurred during the afternoon and evening of Friday 21st. Periods of sometimes intense rainfall occurred throughout the weekend
22nd February	Peak Stage of 23.411 at Knostrop Weir Leeds
23rd February	Another peak of 23.393mAOD at Knostrop Weir Leeds
	Peak stage of 5.908m reached on the River Ouse at Skelton
24th February	Third peak in three days at Knostrop Weir at 23.458mAOD
	Knostrop Weir and Crownpoint weirs in Leeds lowered
25th February 3.30am	Third and final peak stage 3.437m reached on the River Aire at Chapel Haddlesey
25th February 22.45pm	River Aire at Carlton Bridge reaches highest level in February 2020 – Stage 6.228m AOD.

A number of questions have been raised by the local communities in the aftermath of the flooding. Of the most significant, was whether or not the affect of lowering the weirs at Leeds exacerbated the Lower Aire flooding.

Further analysis has been undertaken as part of this Section 19 report by way of reviewing the Arup Flood Risk Assessment and Addendum submitted to support the planning application for altering the weirs. In addition further stage (water level) data for the Crown Point and Knostrop Weirs, Beal, Chapel Haddlesey, West Bank Pond and Carlton Bridge is also assessed and presented in Figure 20.

As discussed in Section 3.1, the most persistent rainfall in the Aire catchment occurred over approximately 18 hours from midday on Friday 21st , which was followed by further periods of sustained rainfall through the night on the 22nd and daytime on the 24th February. This resulted in 3 consecutive peaks in a short space of time and sustained water levels in the middle and Lower Aire were observed. Whilst the rainfall was less intense and over a longer period of 4 days. The rainfall total for this period were as significant as the preceding storms, with Malham Tarn and Thornton Reservoirs in the Aire Catchment recoding a higher rainfall totals than Storm Ciara.

Falling on saturated catchments, with sustained water levels resulted in peak stage levels akin to the Storm Ciara and Denis peaks, however with the washlands not emptying at the same rate due to elevated in-channel water levels. The levels at Carlton Bridge are shown to climb steadily up to a peak on 25th February. It can be seen from the graph that the levels continue to rise, with the low tide of each cycle tide being higher than the previous low tide. The increase in water levels and tidal cycle within the channel are also mirrored in the gauge data for the West Bank Pond. This could help explain the “surge” in water levels noted in the anecdotal evidence.

In the wake of the flooding, and the suggestion that the Leeds FAS had a detrimental impact on the Lower Aire levels, a document titled Leeds Flood Alleviation Scheme Snaith Briefing was published by the City of Leeds Council and the EA and is appended to this report. The report states:

- The Leeds FAS Flood Risk Assessment showed, from modelling, that the impact on river levels only reached as far as Woodlesford which is 6km (just under 4 miles) downstream of Leeds. Snaith is 44km (27 miles) downstream of Leeds.

- The ability of river levels in Leeds to influence flood levels downstream on the River Aire is strongly influenced by relative catchment size. The catchment size of Leeds is a very small proportion of the catchment size at Snaith which also includes the River Calder.

The report concludes:

"During recent heavy rainfall, flood peaks have passed through Leeds on 9, 16, 22, 23 and 24 February 2020.

The notable highest flows were on 9 February, the weirs were operated during this period. No flooding occurred to Snaith during this time. Flows in Leeds on 22, 23 and 24 February were a third lower than on 9 February. Conversely Snaith experienced flooding during this time. This shows how far removed flooding at Snaith is from what happens at Leeds.

The high levels at Snaith on the 25 February were caused by filling of the River Aire floodplains over several days, high tidal levels and significant contributing flows from the River Calder. There is no indication that this flooding was made worse by the Leeds FAS.

The Leeds FAS weirs were lowered on a single occasion on the 24 February at 16:00hrs. Gauge information downstream of Leeds, at Castleford, gives no indication of any influence of the weirs on downstream flows".

The operation of the weirs in Leeds can be identified from the stage data presented in Figure 20. It is clear that the weirs were operated during Storm Ciara and Dennis with no ill effects noted in the Lower Catchment i.e. no flooding reported.

The flood risk assessment and addendum discuss in some detail the trigger levels for lowering the weir at Leeds. Section 3.1 of the Addendum states that *"The trigger level at which the weir will be operated was initially set relative to the property at most risk of flooding in the existing case, as follows:*

Threshold level of property, minus

- *An offset for hydraulic gradient between property location and the water level gauge at Crown Point, minus*
- *A 0.30m allowance for freeboard, minus*
- *An allowance for the time it will take to lower the weirs, based on the fastest observed rate of rise*

The trigger level found by this approach was 150m^3/s.

It should be noted that the process of lowering the weirs lowers the water levels faster than the river is rising, such that there is no delay between the weirs operating and having a benefit on water levels…"

The addendum further states, *"The shorter configuration of the Knostrop weir is such that, while the weirs are in the upright position, the water levels have been raised upstream compared to the existing situation. As a result the locations at most risk have been changed by the design and freeboard has been reassessed through the study area. On the basis of this check, the trigger flow for the "Weirs Only" scheme was reduced to 104m^3/s* [i.e. weirs lowered earlier]*….It will be possible to increase the trigger flow to 150m^3/s once later phases of the Leeds Flood Alleviation Scheme are built."*

In section 5.5 Downstream Impacts of the FRA, the report is clear that "*it is the nature of the scheme that it reduces the floodplain through the centre of Leeds. The consequence of this is that flows are increased downstream, with impacts as far downstream as Lemonroyd weir.*

This will cause increases in flood risk that will be mitigated by improvements to local standards of protection. These improvements will be based on flood levels Leeds City Council Leeds Flood Alleviation Scheme Flood Risk Statement from the cumulative development of the full long term flood alleviation scheme objectives as outlined in Section 3.2; the long term objectives will result in higher flood levels than the weir proposals.

The most notable impact is to Thwaite's Mill, where flood levels would be increased by up to 0.18m in the 1 in 100 year flood event. Downstream of this location, increases in water level will be < 0.07m downstream of Skelton weir, and <0.04m downstream of the M1, and continue to reduce farther downstream. All levels based on the cumulative development scenario.

It would appear from the above, that the decision to open the weirs is dictated by flow conditions at Leeds. Since the modelling shows that with further mitigation measures downstream there is no discernible impact below Castleford, it is logical that there would be no need to consider the tidal conditions because the flow downstream of Castleford would be the same as prior to the Leeds FAS.

What is clear from the above is that the Leeds FAS weirs have been operated on a number of occasions, which has not resulted in any flooding in the Lower Aire. Analysis of the peak stage data does not immediately raise any concerns over the operation of the weirs at Leeds, instead the peak stage hydrographs shows a gradual increase in water levels at Carlton Bridge exacerbated by the tidal cycles. The gauge at Beal does not appear to show any double peaks or a jump in water levels as a result of the lowering of the weirs in Leeds.

There is no reason to question the validity of the flood risk assessment undertaken to support the FAS scheme particularly for a standalone event. For example, the modelling indicates that with empty washlands the effects of the removal of the Leeds floodplain have been completely compensated for by Castleford. The considerations and assumptions were, and still are, industry standard. What is not currently industry standard is to model consecutive rainfall/fluvial events with saturated catchments and full washlands. The likelihood of this has historically been low and is therefore is not a usual consideration. Any change in the assumptions and the scenarios required for a flood risk assessment will need to change nationally, not locally. However, this event is clear evidence that this scenario is not impossible.

The limitations of reviewing stage data for the this purpose must be acknowledged. For example, the last river stage gauge on the Aire that does not appear to be tidally dominated is the gauge at Chapel Haddlesey. The flat top of the Chapel Haddlesey peaks occurs when water overtops the embankments and floods the washlands. Any increase in water levels or some sort of surge would not be observed in the stage data as the water would overtop the embankments.

The stage data does not accurately reflect the conditions within the washlands and is only a representation of water levels at the selected gauges. There is a complex relationship between the water levels and volumes stored within the washlands and the in-channel level. Furthermore the stage data does not tell us about the inter-relationships between storage areas. For example, questions were raised during community engagement regarding why flooding did not occur at Brotherton, where the washlands have historically exceeded their capacity, but not in February 2020. Without further modelling, we cannot decisively ascertain how and why the washlands' behaviours were different or how far the impacts of the Leeds FAS were transferred downstream, if at all because of the full flood storage areas.

Refining the existing models for the River Aire, will take a considerable length of time – at least 12 to 18 months from the publication of this report and at considerable cost. The Environment Agency have already started the process of commissioning the work and NYCC as the LLFA will support this work as a stakeholder. A recommendation will be made to look into any exacerbating issues as part of this work.

Other concerns raised were regarding the makeshift defence erected along Hurst Road at West Bank by local residents. Helicopter images (Figure 17 and Figure 18) show the considerable length of defence (approx. 300m) constructed from impermeable membrane (visqueen a or similar) and rubble (see Figure 19). Understandably opinions and tensions on the matter are high, with concerns being raised by residents on the south side of Hirst Road that the defence exacerbated the flooding to their properties, whilst other praised the work of the local community to protect the properties on the northern side of the Hirst Road.

It must be made clear that the defence was not authorised or endorsed by any of the risk management authorities. However once erected and holding back water, this introduced a residual risk of breach. As such posed significant risk to life and property. The decision was therefore made to retain and re-enforce the defence where practicable to minimise the risk.

In terms of exacerbating the flooding, again it is impossible to say without further modelling how much impact, if any the makeshift defence had on water levels. Given the enormous expanse of floodplain, a bund of this sort is unlikely to raise water levels at all, if only by a few millimetres, certainly not enough to cause further damage than had already been caused. Whilst the Section 19 cannot make comment on the immediate emergency response, the uncertainty about where or not it increased flood risk to the south of the river and the introduction of residual risk associated with breach is considered unacceptable and a bund of this sort should not be attempted in future unless endorsed by the EA as part of its emergency response.

Figure 17: West Bank - Makeshift Defence Extent

Figure 18: West Bank - Makeshift Defence

Figure 19: West Bank Visqueen and Rubble Defence

Issues regarding the maintenance of flap vales and other water level management structures have also been raised. It is understood that from the public engagement that no risk management authority was prepared to take responsibility for the failed flap valves on the drains, which threatened several properties on the north side of the road. It is noted that the Fire brigade pumped for long enough for residents on the northern side to source pumps for themselves. This saved 5 properties and Yorkshire Salads depot. The valves have now been repaired by local residents. The residents felt that the valves should have been maintained by a risk management authority since the land owners pay money to the Drainage Board each year. As per section 4 of this report which sets out the maintenance responsibilities, the formation of a drainage board and the permissive powers held by the risk management authorities do not remove the land owners riparian responsibilities. Although a Land owner may pay rates to the drainage board, the drainage boards must still prioritise its maintenance in accordance with risk. Land

owners should be aware of which assets the internal drainage board formally maintains, and to ensure that all other non-maintained assets are in a serviceable condition.

Concerns were also raised about the use of sandbags. The use and distribution of sandbags is recurring theme county wide, and not exclusive to the February 2020 event. Sandbags are delivered by the district authorities where residents have reported flooding, or to where flooding of property is imminent. The delivery of sandbags may therefore seem un-coordinated. Again, the section 19 report cannot make comment on the recommendations on the emergency response duties of the district authorities, however this issue is a clear demonstration that many communities that are at bordering high flood risk are not fully resilient to climate change and flood risk. Whilst the use of sandbags may not be sufficient for some properties in similar extreme flood incidents, the LLFA recommends that all RMAs work with the communities to encourage and promote improved property level resilience, including the purchase of re-usable alternatives to sandbags. This would allow residents to deploy their own resilience measures in a timely manner.

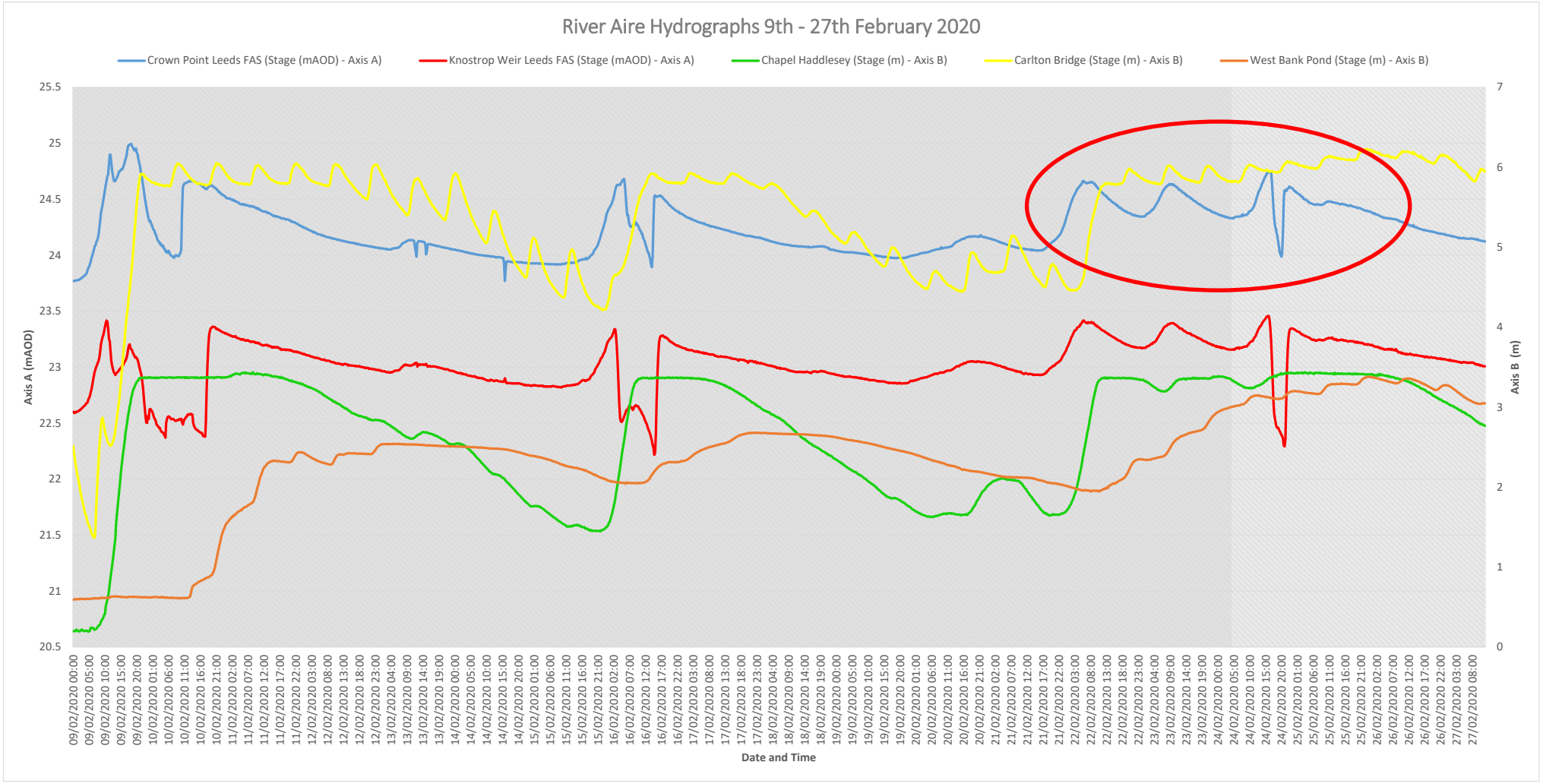


Figure 20: River Aire and West Bank Pond Levels

6 Conclusions

Flooding incidents were recorded in over 26 separate communities across the western and southern parts of North Yorkshire throughout February 2020. In general, the recorded incidents with the exception of the Lower Aire, can be described as number of isolated incidents, but with the February 2020 event as a common factor. Harrogate Borough Council recorded 44 incidents of flooding within its district with Selby and Craven Districts recording 27 and 25 properties respectively.

Given the isolated nature of the incidents there is a risk of publishing details of individual properties. In order to avoid this, and as some areas were affected worse than others, this report has focused on the settlements that would normally meet the criteria for a Section 19, these being Gildersleets, Masham and the Lower Aire communities.

The flooding reported in February can be placed into two categories. The flooding that occurred as a result of Storms Ciara and Denis in the upper catchments of the River Ribble, Aire, Ure, Wharfe, Nidd and Swale and the subsequent flooding of the lower Aire following the rainfall event of the 21st – 24th February.

The events of Storm Ciara alone were significant in that it resulted in the River Ribble reaching its highest ever recorded levels in Pennybridge and caused significant flooding over the western Pennines. The intensity and volume of water associated with Storm Ciara was significant enough to result in localised flooding across the county.

The flooding in Gildersleets was a result of the unnamed ordinary watercourse flooding on to the A65 which then overspilled and flowed through the properties. An inspection of the watercourse did not identify any obstructions to the natural flow. The primary cause of flooding was that the watercourse networks in the area were simply overwhelmed.

Similarly, in Masham, inspection of NYCC owned structures confirmed that there we were no significant defects or obstruction and that the capacity of Swinney Beck was exceeded due to the high river flows.

Further downstream on the River Aire, the impacts of the consecutive storm events in February, coupled with the already saturated flood plain, caused the washland areas around Hirst Courtney to reach capacity. Initially, the washlands operated as they were designed, to hold and store water from the River Aire to reduce flood risk in the area. The River Aire was however very high as a result of prolonged rain across its catchment and there was overtopping of the river into the communities of West Bank and Hirst Courtney on the 25th February.

Analysis of the peak stage data does not immediately raise any concerns over the operation of the weirs at Leeds, instead the peak stage hydrographs shows a gradual increase in water levels at Carlton Bridge exacerbated by the tidal cycles. The limitations of reviewing stage data is acknowledged and a recommendation is made that further analysis should be undertaken in Partnership with all risk management authorities to study the relationship between the Middle Aire, Lower Aire and its washlands.

7 Recommendations

The following recommendations are made as a result of the conclusions of this report:

1. LLFA and NYCC Highways to work with the community of Gildersleets to review the feasibility of any flood alleviation or improved resilience scheme for the community.

2. All risk management authorities to continue responsive service and the monitoring of Swinney Beck in Masham.

3. The Environment Agency to undertake a review and further assessment of the flows and capacity of the River Aire and its washlands. (This work is already in progress since the February 2020 events)

4. NYCC to support the work of neighbouring LLFAs and the EA where practicable to model scenarios that reflects the chronological order of events, rainfall volumes and timescales of the February 2020 event.

5. All risk management authorities to work with the communities to encourage and promote improved property level resilience. With the impacts of climate change becoming ever more clear, it is critical that communities play an active role in helping themselves to be resilient to the increasingly prevalent risk of flooding.

February 2020 Flood Investigation Report – what happens next?

The Section 19 Report tells us about the conditions that led to the flooding of February 2020. It sets out the roles and responsibilities of Risk Management Authorities and the actions they took to prepare and respond to the events. The report makes a number of recommendations based on this analysis for the progression of future work.

This is not the end of the process. In many ways, it is the document that marks the commencing of work to better understand and prepare for similar events in the future, based on what we have learnt from previous experiences.

This addendum to the report details what the recommendations it makes mean in terms of positive actions for our communities.

Recommendation	Actions
Lead Local Flood Authority and North Yorkshire County Council Highways to work with the community of Gildersleets to review the feasibility of any flood alleviation or improved resilience scheme for the community.	• A community meeting will be organised with representatives from the parish council to progress this work. • Opportunities to include the work in future North Yorkshire County Council flood risk programme will be explored • Resilience planning and preparedness will be key. This could include establishing a flood group to support the work or liaising with existing representatives.
2. All risk management authorities to continue responsive service and the monitoring of Swinney Beck in Masham.	• The event has increased understanding of the drainage system and where responsive action may be beneficial. • Understanding the constraints of the system, North Yorkshire County Council Lead Local Flood Authority Officers will engage with the responsible parties to ensure that the drainage system is maintained and systems are working properly.
3. The Environment Agency to undertake a review and further assessment of the flows and capacity of the River Aire and its washlands. (This work is already in progress since the February 2020 events)	• Existing hydrological models to be tested to replicate February flood conditions and to provide the evidence to better understand the flood mechanisms. • This will provide potential opportunities to improve the operation of assets and flood response and preparedness • It will also inform and give opportunity to refine flood maps and flood warnings to reflect the risk as experienced in February. • This work is critical to offer the underlying evidence to inform future changes and decision making • The Environment Agency And North Yorkshire County Council are to organise meetings with county councillors and community representatives during December to update on this work and engage with those affected on the work and the future actions leading from it.
4. North Yorkshire County Council to support the work of neighbouring Lead Local Flood Authorities and the Environment	• North Yorkshire County Council will continue to meet regularly with neighbouring authorities and the Environment Agency to understand the results of modelling work and the chronology of events to ensure

Agency where practicable to model scenarios that reflects the chronological order of events, rainfall volumes and timescales of the February 2020 event.	that any opportunities for refinement of actions and operations is explored and captured. • North Yorkshire County Council to analyse what the findings mean for North Yorkshire and to relay further information to the community and its representatives.
5. All risk management authorities to work with the communities to encourage and promote improved property level resilience. With the impacts of climate change becoming ever more clear, it is critical that communities play an active role in helping themselves to be resilient to the increasingly prevalent risk of flooding.	• Lead Local Flood Authority Officers will work with first responding Risk Management Authorities to identify communities where resilience planning and targeted work to enhance this will be of most benefit. • Community meetings will be set up by North Yorkshire County Council, in those locations to identify the specific actions which would assist in future flood response • This will involve joint working with the Environment Agency and district councils and other relevant Risk Management Authorities. • Action plans for each targeted locality will be created. • Opportunities to include communities in the future North Yorkshire County Council flood mitigation programme will be explored • Where inclusion in the North Yorkshire County Council programme is appropriate, additional feasibility work or options to deliver improved flood management, led by the Lead Local Flood Authority may be required. • The work will include identifying critical assets to flood risk and identifying those responsible for maintenance and engaging in active response planning • It will include resilience planning specific to that particular community • Community input will be key to this. Actions will arise from the engagement with those who are at risk. • Where it is identified through feasibility work that it will be beneficial, Property flood resilience measures will be explored. • Communities will be supported and empowered, to undertake appropriate resilience measures and to plan and coordinate actions for their own specific needs.

8 Appendices

8.1 Useful contacts & links

Flood Forecasting Centre

The Flood Forecasting Centre (FFC) is a partnership between the Environment Agency and the Met Office, combining our meteorology and hydrology expertise into a specialised hydrometeorology service. The centre forecasts for all natural forms of flooding - river, surface water, tidal/coastal and groundwater.

ffc-environment-agency.metoffice.gov.uk/

Online Flood Risk Mapping

This service uses computer models to assess an area's long term flood risk from rivers, the sea, surface water and some groundwater.

https://flood-warning-information.service.gov.uk/long-term-flood-risk/map

National Flood Forum

A charity to help, support and represent people at risk of flooding.

https://nationalfloodforum.org.uk/

North Yorkshire Local Resilience Forum

NYLRF is a partnership of local agencies working together to prepare for, respond to and recover from potential major incidents and emergencies via the duties stated in the Civil Contingencies Act 2004 (CCA).

http://www.emergencynorthyorks.gov.uk/

NYCC Resilience & Emergencies Unit

The resilience and emergencies unit is responsible for planning for a wide variety of potential incidents and emergencies that could affect the population of North Yorkshire.

northyorks.gov.uk/resilience-and-emergencies-unit

NYCC Flood & Water Management

As lead local flood authority, we investigate and assess flood risks, including flooding from surface water, groundwater and existing watercourses. We work with partners involved in flood and water management to protect communities from the impact of flooding.

https://www.northyorks.gov.uk/environment-and-neighbourhoods/flooding/flood-and-water-management

8.2 Leeds Flood Alleviation Scheme Snaith Briefing